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National Research Project on Logistics & Supply Chain Program on Industry (Division 5)


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โครงการวิจัยประเมินศักยภาพขั้นตอนกระบวนการจัดการโลจิสติกส์ และใช้สุ่มทางของอุตสาหกรรมในประเทศไทย
(โดยการสนับสนุนจากสำนักงานกองทุนสนับสนุนการวิจัย  สธ.)

โดย รศ.ดร.ดวงวรรณ  กริชานนท์ ศุภารัตน์ บัววิทยาลัยมหิดล

ที่ตั้งหน่วยงาน

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Proceedings of
The 3rd International Conference on Logistics and Transport &
The 4th International Conference on Operations
and Supply Chain Management

"Creating the Future Logistics and
Supply Chain in the Asia-Pacific Region"

15-17 December 2011
Kurumba Maldives Resort, Malé, Maldives

Organized by

In Cooperation with

Sponsored by

Edited by
Asst. Prof. Dr. Ungul Laptaned, University of the Thai Chamber of Commerce
Assoc. Prof. Dr. Ruth Banomyong, Thammasat University

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Opening Address from President of Malé Municipality

It is a great pleasure and honor for me, on behalf of the 3rd International Conference on Logistics and Transport and the 4th International Conference on Operations and Supply Chain Management 2011, to welcome you all to this beautiful city of Malé. First of all, I would like to thank the co-organizers, namely the Thai Research’s Consortium of Value Chain Management and Logistics (Thai VCML), Sepuluh Nopember Institute of Technology (Indonesia), the Chartered Institute of Logistics and Transport (India), and National Institute of Industrial Engineering (India) for organizing this conference, which is a major logistics regional platform and important event in the Asia-Pacific region.

It is now nearly three years since we gathered for the 1st International Conference on Logistics and Transport in Chiangmai, Thailand on 17-19 December 2009, and the 2nd International Conference on Logistics and Transport & the 1st International Conference on Business and Economics in Queenstown, New Zealand on 16-18 December, 2010. At the ICLT & ICBE 2010, the highlight was its main forum entitled “Managing Finance and Risk in Global Supply Chain”.

In a present and future issue, we will cover more on the following topic as “Creating the Future Logistics and Supply Chain in the Asia-Pacific Region”, including some of the things that are being done, and some of the things that could be done. The remarkable growth of this region in recent decades owes much of the expansion of its international trade, including intraregional trade. Also, the cooperation has been made among countries in the region spanning the spectrum of international transport (land, air, and sea), terminal handling, cargo consolidation, customs clearance, warehousing, payment systems, to final delivery - makes it especially challenging for logistics businesses in Asia-Pacific region.

To support the Maldives destination for international visitors, the organizers selected Malé as a conference venue due to its world’s best backdrop for all these things. There are endless ways to let the magic of the islands dazzle all visitors. The warm seas of Maldives have high visibility throughout the year, with water clear enough to see the passing fish as far as fifty meters away at times. Add to that the marvelous formation of over 3000 coral reefs and the free flowing tides of the monsoons. The result of these perfect conditions has created one of the world’s richest diving coral reef areas with the countless number of reefs found among the 26 atolls in the Maldives.

To conclude my address, I would like to thank the Thai VCML, ITS (Indonesia), CILT (India), and NITIE (India) that have assisted in the organization to this conference to promote a tourist destination at Malé to our delegates and guests from 31 countries around the world.

I wish good results in your deliberations.

Adam Maniku
President of Malé Municipality, Malé, Maldives
Welcome Address from Conference Honorary Chairs

On behalf of the Thai Research’s Consortium of Value Chain Management and Logistics (Thai VCML), Sepuluh Nopember Institute of Technology (Indonesia), the Chartered Institute of Logistics and Transport (India), and National Institute of Industrial Engineering (India), we would like to welcome you to participate in the 3rd International Conference on Logistics and Transport & the 4th International Conference on Operations and Supply Chain Management, 2011.

The conference will be an exciting event bringing international and interdisciplinary expertise in a rapidly developing field together for three days. It will provide an opportunity for experts in operations, and supply chain and logistics system from the Asia-Pacific region and worldwide to exchange and discuss ideas and information.

In addition to the conference, there is the opportunity to experience Maldivian culture and participate in various social events and outings.

We look forward to welcoming you in Malé.
Welcome Address from Conference General Chairs

On behalf of the organizing committee, I feel very delighted and would like to extend our warmest welcome to all participants to the 3rd International Conference on Logistics and Transport (ICLT) & The 4th International Conference on Operations and Supply Chain Management (OSCM). This is the 1st time that these 2 international conferences related to logistics and supply chains are organised jointly. Hopefully it will not be the last time.

This conference is hosted by the Thai Researchers’ Consortium on Value Chain Management and Logistics (Thailand), Sepuluh Nopember Institute of Technology (Indonesia), the Chartered Institute of Logistics and Transport (India), and National Institute of Industrial Engineering (India) at the Kurumba Maldives Resort, Malé, Maldives.

Logistics and supply chain is recognised as a critical discipline in enhancing connectivity within and between the Asia-Pacific Region. The Thai VCML, Sepuluh Nopember Institute of Technology (Indonesia), the Chartered Institute of Logistics and Transport (India), and National Institute of Industrial Engineering (India) is grateful for the opportunity to play an important role in advancing the logistics and supply chain body of knowledge through the organisation of such an international conference.

The conference theme for this year was “Creating the Future Logistics and Supply Chain in the Asia-Pacific Region” and many of the submitted manuscripts reflected the inter-disciplinary nature of global supply chain research, especially in the Asia Pacific region. Potential authors were invited to submit an abstract to the conference chairs. All abstracts were reviewed by two experts from the advisory committee. As a result almost eight manuscripts were included in this proceeding volume with contributing authors coming from over 31 countries.

The recent floods in Thailand has disrupted numerous regional and global supply chain and it is important that a better understanding of relief and emergency logistics is developed, not only within the region but also the rest of the world. The future of logistics and supply chain in the Asia Pacific region cannot be shaped without considering all these new challenges. It is hoped that more research will be conducted on related topics without lessening the importance of more traditional subject areas.

I would like to take this opportunity to also express my sincere thanks to all the presenters, delegates, reviewers, advisory committee members, local organization committee members, and guest speakers for their interesting and valued contributions.

This conference offers an opportunity for researchers and practitioners to share ideas, research findings and future research and teaching directions. The best research papers from this conference will be selected for publication in special issues of the International Journal of Logistics and Transport (IJLT) and the Operations and Supply Chain Management (OSCM): An International Journal. The selected research papers will undergo further rigorous blind peer review from our panel of expert referees.

Last but not the least, on behalf of the organizers, I would like to personally apologise for any difficulties you might have encountered while attending this conference and wish all of you a very successful and fruitful deliberations. There is no knowledge without research.

Assoc. Prof. Dr. Ruth Banomyong
Thammasat University
ICLT 2011 & OSCM 2011’s General Chair

Prof. Dr. I Nyoman Puwawan
Sepuluh Nopember Institute of Technology
ICLT 2011 & OSCM 2011’s General Co-Chair
Welcome Address from Conference Program Chairs

Welcome to the 3rd International Conference on Logistics and Transport and the 4th International Conference on Operations and Supply Chain Management in Malé, Maldives. This professional meeting is thought to provide an excellent opportunity for faculty, scholars, Ph.D. students, administrators, and practitioners to meet well-known experts from all over the world and to discuss innovative ideas, results of research, and best practices on various topics of Production, Operation, and Maintenance, Inventory, Supplier Relationship, Outsourcing, and CRM, Logistics and Supply Chain, Distribution, Transportation, and Traffic, Operation Research, Information Technology, Risk, Financial, and Strategy Management, and many other related issues.

The ICLT and OSCM conference continues to be highly competitive and very well perceived by the international community, attracting excellent contributions and active participation. This year, researchers from more than 35 countries have submitted their papers to the ICLT 2011 & OSCM 2011 international conference. After a careful review process by members of the international program committee, 90 quality papers from 31 different countries (Australia, Austria, Canada, Czech Republic, China, Cyprus, France, Germany, Greece, Hong Kong, Iceland, India, Indonesia, Iran, Ireland, Italy, Japan, Malaysia, Morocco, New Zealand, Pakistan, Singapore, Slovakia, Slovenia, South Korea, Taiwan, Thailand, The Netherlands, United Arab Emirates, United Kingdom, and United States of America) have been accepted for presentation at the conference. We thank all authors who dedicated a particular effort to contribute to the conference.

Each submitted paper has been reviewed by several members of the international program committee and international external referees. We would like to thank all of them for their help with review process of submitted papers. We expect the ICLT 2011 & OSCM 2011 international conference to be an outstanding international forum for the exchange of ideas and results on logistics, transport, business, economics, and provide a baseline of further progress in such areas.

We hope you will enjoy your stay in Malé and be able to spend some time to visit various points of the world’s best backdrop.

Asst. Prof. Dr. Ungul Laptaned
University of the Thai Chamber of Commerce
ICLT 2011 & OSCM 2011’s Program Chair

Asst. Prof. Dr. Thananya Wasusri
King Mongkut’s Institute of Technology Thonburi
ICLT 2011 & OSCM 2011’s Program Co-Chair

Prof. Dr. Narayanasamy Sambandam
National Institute of Industrial Engineering
ICLT 2011 & OSCM 2011’s Program Co-Chair
Speaker Background

Professor Dr. Paul T.W. Lee

Professor Dr. Paul T-W Lee is Fulltime Invited Professor at Department of Logistics and Shipping Management and Director of Shipping, Port and Logistics Research Centre at Kainan University in Taiwan. He is also currently holding Invited Research Fellowship at Jungsook Research Institute of International Logistics and Trade, Inha University in Korea. He received the Award for the Best Exemplary Professor, Korea Maritime University (1994), the Academic Great Award, Korea Maritime University (2002), Chojeong Academic Award (for the special best paper), Korea Association of Shipping and Logistics (2002), and the Academic Award from the Korea Port Economic Association (2006).

He has published more than 200 papers on national and international journals, with five books in English, which are mostly related to maritime logistics. Professor Lee is a founding member of Asian Logistics Round Table (2007) and International of Association Maritime Economists (1992) and served as Secretary-General and co-opt vice-president for the association. He served as advisor or committee member for central and local governments, including the Prime Minister’s Office and Ministry of Foreign Affairs and Trade. He was President of Marine Transportation Policy Foundation under the central government of Korea. He was also Guest Editor or Co-Guest Editor of Maritime Policy and Management (1999, 2002, and 2008) and International Journal of Logistics: Research and Applications (2009). He was Editor-in-Chief of Journal of Korean Shipping and Logistics and Journal of Marine Transport Policy Studies. He has been also serving for Judge Panel of Asian Logistics Awards under Supply Chain Asia. He is currently Organiser and Chairperson of IAME 2012 Taipei Conference (www.iame2012.org).
Speaker Background

Professor Dr. I Nyoman Pujawan


He is a Board Member of Asia Pacific Industrial Engineering and Management Systems Society (APIEMS. Professor Pujawan worked in industry before moving to the academic world and has been actively delivering professional courses and consultancy services to Indonesian companies in the area of operations and supply chain management. He is now a member of committee responsible for designing national logistics systems under the Coordinating Minister for the Economy, Republic of Indonesia.
Conference Organization

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Duangpun Kritchanchai, Mahidol University and Thai Researchers’ Consortium of Value Chain Management and Logistics, Thailand
Ir. Triyogi Yuwono, Sepuluh Nopember Institute of Technology, Indonesia
K. C. Jena, Chartered Institute of Logistics and Transport, India
Amitabha De, National Institute of Industrial Engineering, India

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Nyoman Pujawan, Sepuluh Nopembe Institute of Technology, Indonesia

Program Chairs
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Local Chair
Narayanasamy Sambandam, National Institute of Industrial Engineering, India

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Vinod Singhal, Georgia Institute of Technology, USA
Zhang Wuyi, Kunming University of Science and Technology, China

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Chatchalee Ruktanonchai, National Science and Technology Development Agency, Thailand
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Voratas Kachitvichyanukul, Asian Institute of Technology, Thailand
Walailak Atthirawong, King Mongkut’s University of Technology Ladkrabang, Thailand
Session Schedule
### Thursday (T) 15 December 11

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### Friday (F) 16 December 11

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Saturday (S) 17 December 11

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**Thursday, 15 December 2011**

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Proceedings of The 3rd International Conference on Logistics and Transport & The 4th International Conference on Operations and Supply Chain Management
15-17 December 2011, Kurumba Maldives Resort, Male’, Maldives
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**0077** 15:45 16:00 Improved Sales Planning Methodologies for Stochastic Events in the Supply Chain

G. Schönwetter and O. Mausz

**0078** 16:00 16:15 Logistics Requirements as a Key to Successful Product Ramp-Up Phases

Gerald Schönwetter

**0080** 16:15 16:30 The Study of Thai Solar Thermal Supply Chain

Poon Thiengburanatham, Chinnavorn Chavasint, Sate Sampattakul, Jutamat Jintana, Kulwadee Kulsoontorn, Sakgasem Ramingwong, and Wassanai Watanutchariya

**0081** 16:30 16:45 On Supply Chain Integration Model for Thai Food Product in Japan Market

Sakgasem Ramingwong, Ruth Banomyong, and Apichat Sopadang

**0089** 16:45 17:00 A Case Study of Logistics Improvement in Healthcare Industry

Boontariga Kasemsontitum
## Friday, 16 December 2011

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**Chair:** Prof. Dr. Abdellatif Ben Abdelhafid

**Room:** VIP 2

**Start:** 14:45  
**Finish:** 16:45

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**Closing Address:**  
Asst. Prof. Dr. Ungul Laptaned,  
Program Chair, University of the Thai Chamber of Commerce, Thailand

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**Saturday, 17 December 2011**

**Code:** SFT  
**Session:** Full-Day Tour  
**Chair:** Thai VCML’s Organizing Committee

**Room:** Hotel Lobby

**Start:** 07:00  
**Finish:** 18:00

**Speed Boat**  
**Lobby**  
**Lunch**  
**Tour**  
**Expense**

**Full-Day Tour**  
Fisherman's Island, Uninhabited Island, Virgin Island  
(Contacting Travel & Tour Services with Personal Expenses)  
**Start:** 08:00  
**Finish:** 18:00

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**Closing Remarks**  
Asst. Prof. Dr. Ungul Laptaned,  
Program Chair, University of the Thai Chamber of Commerce, Thailand

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**Closing Address:**  
Asst. Prof. Dr. Ungul Laptaned,  
Program Chair, University of the Thai Chamber of Commerce, Thailand
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MATHEMATICAL MODEL FORMULATION SOLVING MULTI - STAGES MULTI – OBJECTIVES LOCATION PROBLEM:
CASE STUDY IN FINDING LOCATIONS OF PALM COLLECTOR CENTERS
AND PALM OIL FACTORIES IN NARATHIWAT PROVINCE, THAILAND

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**ABSTRACT**

The aim of this research was to find out the location of oil-palm palm collector centers in Narathivat province in deep south area of Thailand. Three objectives considered in selecting suitable locations. First objective was economic which finding the shortest path from palm fruit growing area to selected palm fruit collector centers and continue move to selected palm oil factory. The second objective was environmental aspect which consider carbon emission rate during the transportation off all routes. The last factor was risk of terrorist in Narathivat province. This objective take account the frequency of explosion occurred in each transportation route due to Narathivat province is one of three provinces that have terrorist problem in deep south of Thailand. Thus, these three objectives formed a multi objectives -multi – stages locations problem (MMLP). Firstly, batches of oil-palm fruits, raw materials, were delivered from plantations of agriculturists to palm collector center (PCC) then palm fruit from PCC will be transported to selected palm oil factories. This article we present a Mathematical models to solve MMLP then we solve this problem by LINGO V.11. In the mathematical model we have 10 different sets of weight varied between each objective. From the computational results, we found that different weights made different decision making in selecting PCC.

**KEYWORDS**
Multi Objectives Problem, Multi Stage Location Problem, Mathematical Model Formulation, Palm Oil Industry
INTRODUCTION

The energy crisis is a major problem over the world and is likely to be more and more severe. Thailand has been affected by the energy crisis because the main imports are gas and oil converted into energy used in economic development, social life and security protection. Particularly in industrial and transportation section, energy is likely to be used higher as well as costs higher following as the oil price of world market. For this reason, the government has a policy to find a source of alternative energy from agricultural products as ethanol and biodiesel, etc. to reduce energy imports (Department of Renewable Energy and Energy Conservation, Ministry of Industry, 2008).

Narathiwat province composes of 13 cities which composed of 77 districts. All districts have 136,000,000 m² of palm oil tree cultivated area. All palm fruit will be delivered to palm oil collecting centers before it will be transported to palm oil factory.

Due to Narathiwat province is one out of three provinces that has problem of terrorism. Government tries to improve the social income of people around these area. As we mention above that it has more than 136,000,000 m² of palm cultivated area, thus it can produce more than 230.8141 tons per day (show in Table.1)

Palm fruit will be deliver from the cultivated area to palm collector centers to reduce transportation cost from direct shipping from the farmers to Oil palm plant (OPP) which only get raw material (palm oil) from palm collector centers. Our problems here is to find palm oil collector centers which minimize total distance travelled from the cultivated area to palm collector centers (PCC) and from PCC to oil palm plant (OPP). Not only total distance that is considered but also the sabotage risk during the transportation of the palm fruit because Narathiwat province is in terrorism area (three deep south provinces of Thailand). The environment needs also to be consider because during the transportation of the truck it release Co2 to increase the global warming parameter. Figure 1 shows the generic frame work of our problem statement to be more understandable for the reader.

FIGURE 1
GENERIC FRAME WORK OF PROBLEM STATEMENT

We formulate mathematical model represent figure one then we solve our model using LINGO v.11 which will be present in detail in a next session.

From Figure 1 we can see that this model can be interpreted as multi echelon location allocation problems (multi objectives). In this area of research there plenty of articles has been published such as Revelle and Eiselt [2] indicated that the problems of location selection were characterized by the four types: (1), the definite position of customers in somewhere or transportation routes, (2) the location of factories required, (3) both locations of customers and factories required (4) the distance or travel time among the factories and customers.

Michandani [3] explain a multi-dimensional p-median problem and Verter and Dincer [4] extension to production-distribution problem. Daskin [6] discusses multi-echelon facility location models and outlines interacting facility model where considered relationship between levels explicitly. Narula[7] explain relationship among the different facility types and the flow of goods/service allowed among them. ReVelle and Eiselt [2] said that facility location problem composes of four components of location problem including; (1) customer who are already located at points or on the routes, (2) facilities that will be located, (3) a space where customers and facility located, and (4) a metric that indicates distances or times between customers and facilities. Normally facility location problem has been study in single objective

Nevertheless, this study was the selection of two level location similar to the problems presented by Jacobsen and Madsen [8]. He showed that the problem of the newspapers delivery from printing house to the distribution centers and then to the customers eventually consisted of: (1) finding the location of distribution centers, (2) designing
transportation routes from the printing company to the centers, (3) the number of customers for each the distribution centers and (4) the designing of proper routes from the centers to the various customers.

This study is determined as multi echelon multi objectives decision making problem. In general, the decisions on logistics have a single objective such as to reduce the transportation distance and time, to increase profits, or to decrease the truck loads, etc. However, if the decision based on more than one purpose, it usually happens that some objectives may conflict within themselves. Therefore it must be transformed to the multi-objective problem (Jozefowiez [9]), in this study the objectives are the economic, environment, and risk of sabotage as we mention above. In the next session we will present the methodology that we used to solve the problem which compose of the mathematical model formulation and the detail of case study that we use in this research. Result and conclusion will be present in session 3 and session 4 will be the discussion of the article.

**REA ONTOLOGY**

The study started from collecting the data in the case study. The detail that we collect is coordinate of cultivated area, volume that can be produce in each area etc. These data were used as the input parameters of mathematical model which is form as an integer linear programming. This model aims to determine the location of the palm collector center under various objectives to make the lowest operating cost which minimize environmental impacts, risk of sabotage and transportation cost under some constraints as show in session 2.1

**Mathematical model for selecting locations.**

index

- $i$ is palm three cultivated area (PCA)
- $j$ is palm collector center (PCC)
- $k$ is oil palm plant (OPP)

**Decision variables.**

- $n_{ij}$ is amount of palm fruits moved from cultivated area ($i$) to palm collector center ($j$).
- $C_{jk}$ is amount of palm fruits transported from PCC ($j$) to oil palm Plant (OPP)

$$Y_{ij} = \begin{cases} 1 & \text{if palm fruit is sent from area } i \text{ to PCC } j \\ 0 & \text{otherwise} \end{cases}$$

$$Z_j = \begin{cases} 1 & \text{if PCC } j \text{ is opened} \\ 0 & \text{otherwise} \end{cases}$$

$$r_{jk} = \begin{cases} 1 & \text{if palm fruit is send from PCC } j \text{ to OPP } k \\ 0 & \text{otherwise} \end{cases}$$

**Parameter.**

- $m$ is palm oil price purchased from farmers, (Baht / ton).
- $Q$ is palm oil price sole to OPP, (Baht / ton).
- $\alpha$ is proportion of land used per ton of palm fruit, (rai / ton).
\( f \) is emission factor of greenhouse gas from transportation of the goods between the cultivated area \( i \) to the palm collector center (PCC) \( j \) and from PCC \( j \) to palm oil plant (OPP) \( k \).

\( g \) is area that affected by the sabotage risk (bomb) calculated from \( r^2 \) where \( r \) is radios of the sabotage area.

\( d_{ij} \) is distance between cultivated area \( i \) to the PCC \( j \).

\( DD_{jk} \) is distance between PCC \( j \) to OPP \( k \).

\( L_j \) is land cost of opened PCC \( j \) (Bahts/rai).

\( CE_j \) is cost of land preparing for PCC \( j \) (baths/rai).

\( CF_j \) is other expenses for opening PCC \( j \) (Baths/rai).

\( R_{ij} \) is the probability of explosions occurred between cultivated area \( i \) and PCC \( j \).

\( RR_{jk} \) is the probability of explosion between PCC \( j \) to OPP \( k \).

\( POP_{ij} \) is population density along with the transportation route between cultivated \( i \) and PCC \( j \).

\( CapK_j \) is capacity of OPP \( k \).

\( Cap_j \) is capacity of PCC \( j \).

\( PA_i \) is amount of palm fruit available which cultivated area \( i \).

\( PP_j \) is population density at PCC \( j \).

\( NN_j \) is the probability of explosion occurred at PCC \( j \) when it is opened.

\( PPO_{jk} \) is population density along with the transportation route between PCC \( j \) and OPP \( k \).

\( I \) is number of palm tree cultivated area.

\( J \) is number of PCC.

\( K \) is number of OPP.

**Objectives function**

**Economic Objective Function**

Minimize \( \sum_{i=1}^{I} \sum_{j=1}^{J} d_{ij}Y_{ij} + \sum_{j=1}^{J} \sum_{k=1}^{K} DD_{jk}r_{jk} + \sum_{i=1}^{I} \sum_{j=1}^{J} mn_{ij} + \sum_{j=1}^{J} \sum_{k=1}^{K} QC_{jk} + \sum_{i=1}^{I} \sum_{j=1}^{J} n_j \alpha L_j Z_j + \sum_{i=1}^{I} \sum_{j=1}^{J} \sum_{j=1}^{J} \sum_{k=1}^{K} n_j \alpha CE_j Z_j + \sum_{j=1}^{J} \sum_{j=1}^{J} \sum_{k=1}^{K} CF_j \) \hspace{1cm} (1)

**Environmental Objective Function**

Minimize \( \sum_{i=1}^{I} \sum_{j=1}^{J} f_dY_{ij} + \sum_{j=1}^{J} \sum_{k=1}^{K} fDD_{jk}r_{jk} \) \hspace{1cm} (2)
Sabotage objective function

Minimize \[ \sum_{i=1}^{I} \sum_{j=1}^{J} R_{ij} \cdot g \cdot PoP_{ij} \cdot Y_{ij} + \sum_{j=1}^{J} \sum_{k=1}^{K} R_{jk} \cdot g \cdot PoPO_{jk} \cdot r_{jk} + \sum_{j=1}^{J} NN_{j} \cdot PP_{j} \cdot gZ_{j} \]  

Constraint

\[ \sum_{j=1}^{J} n_{ij} = PA_{i} \quad \forall j \]  
\[ \sum_{i=1}^{I} n_{ij} \cdot y_{ij} = Cap_{j} \quad \forall j \]  
\[ \sum_{j=1}^{J} y_{ij} = 1 \quad \forall i \forall j \]  
\[ y_{ij} \leq Z_{j} \quad \forall i \forall j \]  
\[ \sum_{j=1}^{J} Z_{j} \geq 1 \]  
\[ \sum_{i=1}^{I} n_{ij} \cdot y_{ij} \leq Cap_{K} \quad \forall j \]

The economic objective function consists of seven terms: (1) and (2) is cost function of transportation distance between PCA i and PCC j and from PCC j to OPP k respectively. (3) and (4) is raw materials cost which depending on the amount of raw materials transported from i to j or from j to k. (5) is function of cost associated with land prices of the opened PCC while (6) is costs related to the price of constructing the PCC which depends on size of the PCC. (7) is cost function related to investment which is not depend on the size of the opened PCC.

The second objective function is the environmental function based on the amount of greenhouse gas emitted from the process of raw materials transport consisted of two terms: (1) is amount of gas occurring from the usage of diesel in the transportation of raw materials through path (i, j) while (2) is amount of greenhouse gases arising from the use of diesel in the transportation raw materials through path n (j, k).

For the objective function of the sabotage risk (bombs) in transportation routes consists of three terms: (1) is function of risk of bombs during the transportation routes (i, j) while (2) is function of risk of bombs during the transportation routes (j, k) and (3) is function of safety risk of bombs when the PPC j is opened. From these three function we can see that all sabotage functions depends on density of the population involved in each area.

The Constraint (4) indicates that amount of material transported from i to j must not exceed amount of material available on cultivated area i . (5) shows that number of raw materials sent to j (from all i) must not exceed maximum capacity of PCC j. (6) confirm that a particular i send palm fruit of our there cultivated area to at most 1 PCC. (7) makes sure that the transportation from i to j can happen only when j is opened. (8) indicates that at least one PCC has to be opened and when it is opened it can send palm fruit to OPP k not exceed OPP capacity and this constraint show in (9). From this model we ignore fixed cost of K because from our case study which will be explained in session 2.2 it has already enough OPP in this area which calculated from total amount of palm fruit which is available in Narathiwat province.
Case Study: Narathiwat province

Narathiwat province composes of 77 districts and the coordinate of each district is shown in Figure 2. One or more district will be selected to open to be Palm collector center (PCC). Palm fruit from all 77 district will be delivered to opened PCC(s) then palm fruit from PCC will be delivered to Oil Palm plant (OPP).

FIGURE 2
SHOW LOCATION OF 77 DISTRICTS AND ONE OIL PALM PLANT EACH DISTRICT HAS ITS OWN PALM FRUIT AVAILABLE CALCULATE FROM NUMBER OF PALM TREE CULTIVATED AREA. AMOUNT OF PALM FRUIT AVAILABLE PER DAY IS SHOWN IN TABLE 1. OTHER DATA WHICH COMPOSE OF PARAMETERS IN OBJECTIVES FUNCTION WERE COLLECTED FROM SEVERAL GOVERNMENT AGENCIES IN NARATHIWAT PROVINCE AND STUDY OF NATTHAPONG (2009).

TABLE 1
THE NUMBER OF PALM FRUITS AVAILABLE IN EACH PALM TREE CULTIVATED AREA.

<table>
<thead>
<tr>
<th>code</th>
<th>Sources of palm fruit cultivated area</th>
<th>Amount of palm fruits (tons per day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Bang Nak district.</td>
<td>2.65</td>
</tr>
<tr>
<td>2</td>
<td>Lam Phu district.</td>
<td>3.564</td>
</tr>
<tr>
<td>3</td>
<td>Manang Tayo district.</td>
<td>0.00581</td>
</tr>
<tr>
<td>4</td>
<td>Bang Po district.</td>
<td>1.975</td>
</tr>
<tr>
<td>5</td>
<td>Kaluwo district.</td>
<td>0.45</td>
</tr>
<tr>
<td>6</td>
<td>Kaluwo Nuea district.</td>
<td>2.926</td>
</tr>
<tr>
<td>7</td>
<td>Khok Khian district.</td>
<td>50.436</td>
</tr>
<tr>
<td>8</td>
<td>Chehe district.</td>
<td>0.889</td>
</tr>
<tr>
<td>9</td>
<td>Phrai Wan district.</td>
<td>12.373</td>
</tr>
<tr>
<td>10</td>
<td>Phron district.</td>
<td>3.027</td>
</tr>
<tr>
<td>11</td>
<td>Sala Mai district.</td>
<td>0</td>
</tr>
<tr>
<td>12</td>
<td>Bang Khun Thong district.</td>
<td>6.46</td>
</tr>
<tr>
<td>13</td>
<td>Ko Sothon district.</td>
<td>0.946</td>
</tr>
<tr>
<td>14</td>
<td>Na Nak district.</td>
<td>0</td>
</tr>
<tr>
<td>45</td>
<td>-----------------------------</td>
<td>---------</td>
</tr>
<tr>
<td>74</td>
<td>Chanae district.</td>
<td>0.438</td>
</tr>
</tbody>
</table>
Proceedings of The 3rd International Conference on Logistics & Transport and The 4th International Conference on Operations and Supply Chain Management
15-17 December 2011, Kurumba Maldives Resort, Malé, Maldives

<table>
<thead>
<tr>
<th></th>
<th>Dusongyo district.</th>
<th>Phadung Mat district.</th>
<th>Chang Phueak district.</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>75</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>76</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>77</td>
<td></td>
<td></td>
<td>0.1027</td>
<td></td>
</tr>
</tbody>
</table>

(Source: Summarized Report of the development of palm oil business projects, Narathiwat and 3 southern provinces, Cooperatives Promotion Department, Ministry of Agriculture, 2551).

The mathematical model is solved using LINGO v.11 using all input parameters addressed in the case study. The experiments were performed in 10 different weight of each objectives function as shows in Table 2.

**EXPERIMENTAL RESULT AND CONCLUSION**

Using LINGO v.12 we get the result of 10 different weight of each objective function shown in Table 2.

**TABLE 2**

**THE EXPERIMENTAL OF CHANGE THE WEIGHT FACTOR OF THE OBJECTIVE FUNCTIONS**

<table>
<thead>
<tr>
<th>Case</th>
<th>economic</th>
<th>Environment</th>
<th>Safety</th>
<th>Risk of palm collector center (*)</th>
<th>Number of opened palm collector center</th>
<th>Value of the objective function</th>
<th>unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>10</td>
<td>10</td>
<td>80</td>
<td>38</td>
<td>1</td>
<td>42.561</td>
<td>MillionBaht</td>
</tr>
<tr>
<td>2</td>
<td>20</td>
<td>20</td>
<td>60</td>
<td>66</td>
<td>1</td>
<td>42.627</td>
<td>MillionBaht</td>
</tr>
<tr>
<td>3</td>
<td>30</td>
<td>30</td>
<td>40</td>
<td>13</td>
<td>1</td>
<td>42.591</td>
<td>MillionBaht</td>
</tr>
<tr>
<td>4</td>
<td>40</td>
<td>40</td>
<td>20</td>
<td>61</td>
<td>1</td>
<td>42.616</td>
<td>MillionBaht</td>
</tr>
<tr>
<td>5</td>
<td>50</td>
<td>50</td>
<td>0</td>
<td>2</td>
<td>1</td>
<td>42.792</td>
<td>MillionBaht</td>
</tr>
<tr>
<td>6</td>
<td>80</td>
<td>10</td>
<td>10</td>
<td>70</td>
<td>1</td>
<td>42.657</td>
<td>MillionBaht</td>
</tr>
<tr>
<td>7</td>
<td>60</td>
<td>20</td>
<td>20</td>
<td>70</td>
<td>1</td>
<td>42.657</td>
<td>MillionBaht</td>
</tr>
<tr>
<td>8</td>
<td>40</td>
<td>30</td>
<td>30</td>
<td>47</td>
<td>1</td>
<td>42.708</td>
<td>MillionBaht</td>
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<tr>
<td>9</td>
<td>0</td>
<td>50</td>
<td>50</td>
<td>52</td>
<td>1</td>
<td>42.836</td>
<td>MillionBaht</td>
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<tr>
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<td>80</td>
<td>10</td>
<td>67</td>
<td>1</td>
<td>42.621</td>
<td>MillionBaht</td>
</tr>
</tbody>
</table>

* identity code of district in Naratiwat reference from Table 1

From Table 2 we can concludes that when we vary weight of each objective PCC will open in different location accept case 6 and 7 which has weight of economic or than 60%. When we look in detail of PCC code 70 we found that this district seem to be in the center of all other districts. Thus, the solution head to open PCC to minimize the total distance. All remaining weight has no significant conclusion that direct to the same conclusion. In Figure 2 we present the diagram which shows the relationships between objective functions and various weight in three dimension created by Minitab 15.
FIGURE 3
THE RELATIONSHIP BETWEEN THE OBJECTIVE FUNCTION AND THE WEIGHT FACTOR GIVEN TO EACH OBJECTIVES.

SUGGESTION

The research was performed by using LINGO v.11 to solve the case study but it performs quite slow. For each case (a set of weight of each objective function) it need around 3-7 hours run time. For further study, we recommends that the heuristic method should be developed to solve bigger problems in shorter computational time.

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THE ROLE OF THE PORT OF KOPER AS AN INTERMEDIARY IN LINKING THE EAST TO THE WEST

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THE ROLE OF THE PORT OF KOPER AS AN INTERMEDIARY IN LINKING THE EAST TO THE WEST

by

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ABSTRACT

To what extent the Port of Koper will exploit its good geographic transport position will depend on a cluster of circumstances. Importance will also be laid on how Port of Koper will present itself and what it will offer to Europe and the rest of the world. The Port of Koper could become the main gateway primarily for the countries of Eastern and Central Europe. To acquire cargo (containers, cars, etc.) the installation and modernisation of port infrastructure and a rise in the quality of services should be permanently improved. As well, efforts must be directed more to the hinterland and to the foreland to initiate and organise various participants of the transport-logistics chain (the trends in maritime transport and modern forms of transportation have to be considered). The growth of container traffic in the Port of Koper as well as the beginning of construction on the new container terminal has made the reconstruction and extension of the current container terminal an absolute priority. The extension is in line with the estimated growth of traffic as well as with the exploitation of present and future terminal capacities. The year 2009 was a difficult year for business, especially due to the uncertain international economic situation. The container terminal handled 344086 TEUs which is 3% less compared to 2008 (358654 TEUs). In the first nine months of 2010, 16 % more goods were handled in the Port of Koper than in the same period in 2009. The container transport has especially exploded in tons (45% increase) as well as in container units (40% increase). Within this period they have handled 355000 TEUs (new record). This paper aims to present and analyse: (I) supply chains of the flow of containerised goods through the Port of Koper to/from the countries of Central and Eastern Europe (II) the changes which enable this container boom, current state and strategies to handle even more containers in the future, (iii) market potential, current and future investments in new capacities.

KEYWORDS
Port of Koper, Nord Adriatic Ports Association (NAPA), New Transport Services, Containers, New Investments
INTRODUCTION

For the Port of Koper is the Central and Eastern Europe market very important. Many manufacturing companies especially major vehicle and also vehicle parts producers, but also many smaller ones as well have invested in the NMS (New Member States of Europe), partly following their main customers but also to take advantage of the qualified and cheap labour force for export production. This development has led to larger bi-directional East-West flow within the European Union of raw materials and consumer products. The traditional ‘blue banana” is approaching the shape of a boomerang as a result of extensions to central and east Europe and significant investments in the Mediterranean (Notteboom 2009).

The global container transport increase amounts to about 8-10% on a yearly basis. According to BRS-Alphaliner (http://www.infomare.it) the entire number of newly constructed container ships should increase by 27%, the number of ships over 7500 TEU by up to 40% between 2005 and 2008. Ships of over 7500 TEU are to have a major influence on container terminals because these terminals will need to adjust their infrastructure and reconstruct their suprastructure. Today, ports should be conceived as logistics and distribution centres that not only optimise the movement of goods and services within the entire transport and logistics chain, but also provide and add value to ultimate customers and users (Bichou 2009).

THE PORT OF KOPER

The entire area of the Port of Koper (Figure 1) including the development area extends over 1,600 hectares.

FIGURE 1
LOCATION OF THE PORT OF KOPER

The Port of Koper is one of the most relevant generators of the development of transport. The economic effects of port activity are multiplicatively reflected in direct surroundings and wider environment. These effects are most visible in the activities of maritime, road and railway carriers, in freight forwarding, agencies, and in trade, catering, tourist, financial and other services. Per one unit of generated value in a direct port activity, eight additional value units are generated in the whole Slovenian economy.
THE PORT OF KOPER - MEMBER OF NAPA (NORD ADRIATIC PORTS ASSOCIATION)

The five NAPA seaports (ports of Koper, Trieste, Venice, Ravenna and Rijeka) are located at the northern tip of Adriatic sea, a natural waterway that penetrates deep into the middle of the European continent, thus providing the cheapest naval route from the Far East via Suez to Europe.

FIGURE 2
MAIN TRANSPORT CORRIDORS IMPORTANT FOR THE NAPA SEAPORTS

Source: NAPA (www.portsofnapa.com)

More than 100 million tonnes of water-borne cargo are handled in the NAPA seaports every year. The cargo consists mainly of general cargo, containers, cars, ores and minerals, fossil fuels, chemicals and others types of cargo. Due to huge variety of logistic services and the extensive traffic network, NAPA forms a perfect multimodal gateway to the key European markets. The near-by fifth Pan-European transport corridor (Figure 2) provides a quick-link to 500 million European consumers. Large commercial and industrial hubs like Vienna, Munich and Milan are just few hours drive away. The five entities combine their strengths in order to promote the Northern Adriatic route and present themselves as an alternative to the North-European ports. In addition, the association anticipates cooperation in the development of maritime and hinterland connections, visits from cruise lines, environmental protection, safety and information technology. (www.portsofnapa.com)

TABLE 1
CONTAINER TRANSPORT OF THE NORTH ADRIATIC PORTS IN THE YEARS 2007 – 2009 IN TEUs

<table>
<thead>
<tr>
<th></th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
</tr>
</thead>
<tbody>
<tr>
<td>KOPER</td>
<td>305,648</td>
<td>353,880</td>
<td>343,165</td>
</tr>
<tr>
<td>TRIESTE</td>
<td>265,863</td>
<td>335,943</td>
<td>277,245</td>
</tr>
<tr>
<td>RIJEKA</td>
<td>145,040</td>
<td>168,761</td>
<td>130,740</td>
</tr>
<tr>
<td>VENEZIA</td>
<td>329,512</td>
<td>379,072</td>
<td>369,403</td>
</tr>
<tr>
<td>RAVENNA</td>
<td>206,580</td>
<td>214,324</td>
<td>185,022</td>
</tr>
</tbody>
</table>

Source: NAPA (www.portsofnapa.com)
In addition to pursuing the intensive promotion of the southern gateway to the European continent, the Association is also active in national and European institutions which tailor European transport policy. Thanks to NAPA’s efforts, the Adriatic-Baltic corridor (Figure 2) was finally included among the nine high-priority corridors encompassed by the EU directive for the development of railfreight.

RECENT DEVELOPMENT OF THE CONTAINER TERMINAL

The container transport increase was of 400% in the years from 2000 to 2008. In 2008 there were 358654 TEUs transported. Because a further increase in orders of ships of 7500 TEUs and over was expected (http://www.infomare.it) an extension of 146 m of the first pier began to be built so that the entire length of the coast amounts today to 596 m (Figure 1,4). In 2009 the port gained two transtainers and four post – panamax cranes (Figure 3) for transport with ships of 7500 TEUs capacity.

FIGURE 3
NEW FOUR POST-PANAMAX CRANES IN THE PORT OF KOPER

The annual transport capacity increased to 600,000 TEUs with the purchase of new storing bridge cranes with stacking capacity of 4 or 5 containers in height, the repositioning of empty containers to new locations and acquiring new areas for full containers by doing so and with faster working of containers from the ship to the terminal and vice versa.
Connections of the container terminal

The terminal is connected with the Far East weekly with regular direct lines and through feeder service with important HUB ports in the Mediterranean (Malta, Piraeus, Gioia Tauro, Haifa) from where regular connections lead to all the continents of the world. As the maritime connection of the port is important so is also the so called land connection. In this way the Port of Koper is connected to important trade centres of the middle and east Europe by regular railway connections and the highway cross. The railway transport of containers out and into the container terminal of the Port of Koper is performed by six different transport companies. Today 7 block trains are daily executed from the Port of Koper to various destinations like: Ljubljana, Budapest, Žilina, Graz. The execution of road freight transport is left to the local transport companies.

The transport of containers in the year 2008 was 358,654 TEUs, in the year 2009 – 344,086 TEUs and in the year 2010 – 476,731 TEUs (Table 3). Despite the global recession the decline in container transport in the year 2009 was minimal. A great increase in transport followed in the year 2010 which was also a consequence of the introduction of the direct line between Asia and the north Adriatic. Beside the great increase in transport also the portion of container import and export states is changing. The Slovenian portion in the entire transport is steadily decreasing, partly also because of the crisis in the Slovenian economy. The transport in transit is increasing, especially with Austria, Slovakia and the Czech Republic. The transport with Italy and Germany does not reach the desired growth. A lot of unexploited possibilities are still in the transport of goods with Germany or Bavaria and Austria because they perform the major part of their container transport through north European ports.

Container services – direct services out/in Koper

The terminal connectedness is one of the key information for business partners. Regarding maritime routes the container terminal is connected with other ports and regions on the basis of 14 so called services.

We can separate the maritime connectedness into two categories namely to direct services from/to the Far East (such are two) and the rest of 12 services of which the ports are located in the Mediterranean. These services are also called “feeder” services because they visit among others also important Mediterranean HUB ports like Gioia Tauro, Malta, Piraeus, Haifa, Taranto, etc. from which maritime routes lead to all the continents of the world.

On Figure 5 a newly implemented service (from June 2010 on) with the Far East is shown, which has been established together by four shipping companies namely Hanjin Shipping, Hyundai Merchant Marine, United Arab Shipping Company and Yang Ming Marine Transport Corporation. This is a very important service for the container terminal because it flourished in the crisis or post crisis period. In the aforementioned service eight different ships sail – two per each shipping company, which weekly visit the Port of Koper.
The other direct service (Figure 6) is performed by the shipping companies MAERSK LINE and CMA CGM. The container line between Asia and the north Adriatic is supplying markets in Slovenia, Slovakia, the Czech Republic, Austria, south Germany, Serbia, Bosnia and Herzegovina, Hungary and Croatia. The entire route takes 63 days. The ships capacities are from 6200 to 7000 TEUs. The weekly service is maintained with 9 ships between 16 ports - Shanghai, Pusan, Hong Kong, Chiwan, Tanjug Pelepas, Port Kelang, Port Said, Trieste, Koper, Rijeka, Trieste, Damietta, Port Said, Suez Canal, Jeddah, Port Kelang, Singapore in Shanghai.
For the container business on this line that is intended for the automobile industry (JUST IN TIME) is typical that:

- Freight comes from South Korea
- Freight presents automobile parts destined to the “Kia” and “Hyundai” factory
- It is approx. 140,000 TEUs on an annual level (approx. 1,250,000 tons of cargo)
- It is 2 ship services (2x a week)
- Containers have priority when unloading from ships holds
- Freight “starts” from port in a few hours after unloading from the ship – certain containers even in 30 minutes!!!
- The quantity increases from year to year and similar strategy is introduced also in other freights – electronics

**TABLE 3 AND GRAPH 1**
CONTAINER TRANSPORT IN THE PORT OF KOPER IN THE YEARS 2001 – 2010 IN TEUs

<table>
<thead>
<tr>
<th>YEAR</th>
<th>2001</th>
<th>2002</th>
<th>2003</th>
<th>2004</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
</tr>
</thead>
<tbody>
<tr>
<td>All world</td>
<td>93,187</td>
<td>114,863</td>
<td>126,237</td>
<td>176,458</td>
<td>212,025</td>
<td>256,265</td>
<td>303,524</td>
<td>358,654</td>
<td>344,086</td>
<td>476,731</td>
</tr>
<tr>
<td>Far east</td>
<td>16,211</td>
<td>25,348</td>
<td>33,144</td>
<td>48,136</td>
<td>59,357</td>
<td>73,100</td>
<td>118,962</td>
<td>130,391</td>
<td>102,848</td>
<td>200,132</td>
</tr>
</tbody>
</table>

In the first six months of the year 2011- 302000 TEUs were handled, the plan for this year is 537000 TEUs, prognosis at the moment cca. 600000 TEUs.

**TABLE 3**
CONTAINER TRANSPORT ON THE CONTAINER TERMINAL OF THE PORT OF KOPER PERFORMED BY THE SHIPPING COMPANIES (%)

<table>
<thead>
<tr>
<th>Shipping Company</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>CMA CGM</td>
<td>28.55</td>
</tr>
<tr>
<td>MAERSK</td>
<td>27.58</td>
</tr>
<tr>
<td>MSC</td>
<td>19.01</td>
</tr>
<tr>
<td>ZIM</td>
<td>7.41</td>
</tr>
<tr>
<td>HANJIN SHIPP.</td>
<td>4.71</td>
</tr>
<tr>
<td>HYUNDAI</td>
<td>3.40</td>
</tr>
<tr>
<td>EVERGREEN</td>
<td>2.32</td>
</tr>
<tr>
<td>HAPAG LLOYD</td>
<td>1.46</td>
</tr>
<tr>
<td>HAPAG LLOYD</td>
<td>1.40</td>
</tr>
<tr>
<td>COSCO</td>
<td>1.33</td>
</tr>
<tr>
<td>OTHER</td>
<td>2.83</td>
</tr>
<tr>
<td>TOTAL</td>
<td>100.00</td>
</tr>
</tbody>
</table>

Source: Port of Koper
CONDITION TO HANDLE EVEN MORE CONTAINERS IN THE FUTURE

In the future developmental possibilities are seen in the construction of the new third pier (Figure 7) to be able to receive the latest container ships which are not presently able to dock on the pier one due to its shallowness. From the point of view of infrastructure the minimal standards to be met are 350 metres of shore, 14, 5 metres of sea depth as well as shore area capable of carrying «post-panamax» cranes.

The construction of the third pier is planned to be carried out in two phases:
1. 700 m of the quay area in length enabling transhipment of 800,000 TEU.
2. 350 m in length (total 1050 m) enabling total transhipment of 1,000,000 TEU.

FIGURE 7
PRESENT AND THE FUTURE PIER III

Source: Port of Koper

Today, whole supply chains are competing, not just ports among themselves. Ports are important elements in the logistics chain and their level of integration with inland transport is very important. Main reasons for this need is that costs for inland transport are generally higher than maritime transport costs and many delays can occur in the inland side of the chain such as congestion, limited infrastructure etc. The portion of inland costs in the total costs of container shipping would range from 40% to 80% (Notteboom 2004).

Moreover, there are some important developmental reserves as far as the effectiveness of railway transport is concerned. These should be brought about by the privatisation and by the restructuralisation of the sector itself, which can mostly be seen in the Central and Eastern European countries. For one thing, organising the so called »block trains« in the Adriatic basin is a strategy that hasn’t been exploited to the fullest. In this respect the northern ports have the upper hand. In order for the Port of Koper to be able to load more container number of »blocks trains« should increase. In the near future modernisation of the Koper-Divača railway connection will increase cargo flow by 30%. The construction of the second railway track has a net worth of 700 Million Euro and forms a part of the Fifth Corridor from Lyon to Kiev, which puts it on the priority list of projects co-funded by the European Union.

Beside the aforementioned activities, the Port of Koper wishes to develop new activities from which the cooperation of the Port of Koper with existing inland terminals (logistic centres) and establishing of new ones positioned between eastern and western Europe stand out. The Adria Terminali (Sežana), regional logistics center “Panonija” (Lipovci), inland container hub-rail port Arad as well as Adria transport d.o.o. will give a strong support to the terminal activities in the Port of Koper providing efficient logistic solutions for south transport route (Figure 8).
CONCLUSION

Today, the countries of Central and Eastern Europe (CEE) have developed into a fast growing and promising part of Europe. The vision of the NAPA seaports is to form a European logistics platform with regard to servicing these markets as well as the markets of the Far East. To obtain better service the ports of NAPA are going to invest efforts into the coordinated planning of road, rail and maritime infrastructure, as well as the harmonisation of regulations and procedures in the field of port service provision.

What is noticeable today is the obvious increase in orders of ships of over 7500 TEUs, which in turn means a larger margin for ship-owners sending their ships to transport containers on the main East-West, Asia-Europe, and Asia-North America routes. That’s why the business orientation of the Port of Koper to develop principal infrastructure and acquire new business partners in the container transport area has proved to be correct. Great financial investments in the extension of the container shore, expansion of storing space and purchasing of specialized transport equipment has proved in the big increase in transport in the year 2010. Despite the global crisis the increase of transport was approx. 40%. The quantity of transported containers is reaching enviable numbers but the future growth is threatened. That is why construction of the third pier with 1 mill. TEUs capacity, a second railway track from Koper to Divača and the upgrade of the rest of the railway tracks in Slovenia is necessary.

New projects and potential investments are important steps within the development of the Port of Koper enhancing it’s performance and increasing the market share.
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The longterm strategy of the Port of Koper (Port of Koper), 2006
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SYSTEMATIC DISTRIBUTION MANAGEMENT OF HUB-SPOKES FOR THE GREATER MEKONG SUBREGION: A REVIEW LITERATURE

by

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ABSTRACT

With a clear objective of the collaboration in strengthen economy, infrastructure, energy, telecommunication, it is anticipated to drive economy and logistics activities. Road transportation within the GMS sub-regions has recently become a vital strategy of linking to other countries. Therefore, logistics cost has still remained high, compared to developed countries. Furthermore, the problem of the regulation and agreement of cross border becomes inevitable, and the problem of the road side of driving car between each country. In order to solving the above problem, logistics management has become a solution in enhancing products transportation by implementing efficient infrastructure. Using a concept of Hub-Spokes may provide economies of scale and then decrease a total logistics cost by reason of fewer distance of transportation and more quantity carried per shipment. The efficient hub-spokes system asks for a well systematic distribution management. Distribution Management is defined as overseeing the movement of goods from supplier or manufacturer to point of sale. Distribution management is an overarching term that refers to numerous activities and processes such as packaging, inventory, warehousing, supply chain and logistics. The need for more detailed distribution planning led to the emergence of distribution requirements planning (DRP). Then, distribution firms can minimize inbound inventory by using MRP in conjunction with other schedules. Key elements of DRP may include the following elements: forecast demand for each stock-keeping unit (SKU), current inventory level of the SKU, target safety stock, recommended replenishment quantity, and replenishment lead time. This paper reviews the literature detailing Greater Mekong Subregion, logistics infrastructure, distribution systems and management, distribution requirements planning.

KEYWORDS
Greater Mekong Subregion, Logistics Infrastructure, Distribution Systems and Management, and Distribution Requirement Planning

INTRODUCTION

The Greater Mekong Subregion (GMS) project focuses on a development of numerous projects in all sub-regions to support transportation, energy, development, telecommunication development, human resource, tourism, environmental responsibility, agriculture and transportation. Such development will facilitate logistics activities in all six nations across the GMS with strategic framework of year 2002 to 2012, in order to develop a collaborative framework with systematic and clarify procedure and support operational activity.

With the bilateral agreement between member countries, a plan, processing, and agreement of six nations had been initiated collaboratively to facilitate international shipment across country to achieve the same strategic and objective. The plan also introduces Single-Window Customs system for products movement and immigration system for people crossing border, aimed at a reduction of procedure and relinquishment of inspection, or partial insurance deposit.
The most important thing is that developing fundamental infrastructure such as standard road and bridge may make possible of international transport of the member countries. The agreement was also made available on main route and main hub among these six countries for comfort and cost reduction, resulting in increasing efficiency of international shipment. Such agreement was signed and ratified by all countries in the GMS in December, 2003. Benefits that have been happened after that can be described as follows: cost reduction, less lateness of international shipment, and less time spending on road transportation due to infrastructure improvement in the sub-regions to other regions in Asia. By using a strategy of Logistics Hub to facilitate economics cooperation, the member countries have heavily invested more funding on transportation, energy, and telecommunication that may lead to economics expansion and sustainability in the future. Ultimately, expanding and sustaining economy may result in a reduction of poverty. Figure 2 illustrates three economics corridors in the GMS sub-regions, with more detail as follows:

1. **North-South Economic Corridor: NSEC**

   - R3 was Thailand- Burma-Lao-China link together comprised of three main routes as follows:
     1) R3 E route; Kun Ming – Yuxi - Yuanjiang – Mo Hei – Simao – Xiaomengyang – Bohan (China) – Boten – Houayxay (Lao) – Chiangkong – Chiangrai – Tak – Bangkok (Thailand)
     2) R3 W route; Chiangtoong – Tachilek (Burma) – Maesai – Chiangrai – Tak – Bangkok (Thailand)

2. **East West Economic Corridor: EWEO**

   This corridor is located in the area linking Eastern Vietnam through Lao on R9 route, crossing Mekong Bride through Thailand and Myanmar. This route links between South China Sea and Andaman Sea, with a total distance of 1,450 kilometers. R9 route is run from Mawlamyine - Myawada (Burma) Maesod – Phitsanuluk - Khon Kaen - Kalasin – Mukdahan (Thailand) - Savannakhet- Dansavan (Lao)- Lao Bao – Hue – Dong Ha – Da Nang (Vietnam)

3. **Southern Economic Corridor: SEC**

DEVELOPING A DISTRIBUTION CENTER AND LOGISTICS HUB IN THE GREATER MEKONG SUBREGION

With a clear objective of the collaboration in strengthen economy, infrastructure, energy, telecommunication, it is anticipated to drive economy and logistics activities. Road transportation within the GMS sub-regions has recently become a vital strategy of linking to other countries. Nevertheless, the cooperation of land transportation has limitations due to insufficient infrastructure such as Laos, Cambodia, or Myanmar. Therefore, logistics cost has still remained high, compared to developed countries. Furthermore, the problem of the regulation and agreement of cross border becomes inevitable, and the problem of the road side of driving car between each country (i.e., Thai drivers drive on the left hand side, but Laotian, Cambodian, Vietnamese, Burmese, and Chinese drivers drive on the right hand side). In order to solving the above problem, logistics management has become a solution in enhancing products transportation by implementing efficient infrastructure. Following the initiative of the ADB in enforcing a network of logistics system in the GMS, a development of the distribution center as a logistics hub of Indo-China region is expected to add value of several activities for the supply of particular products such as agricultural products. Using a concept of Hub-Spokes may provide economies of scale and then decrease a total logistics cost by reason of fewer distance of transportation and more quantity carried per shipment.

Furthermore, agricultural products are a main product that is grown across the six nations in the GMS. Therefore, this research study investigated a feasibility study of developing distribution center and logistics hub in the GMS region by using a case study of agricultural products such as rice, corn, and longan. The main objectives of this research are: 1) to study how to develop a distribution center and logistics hub in the GMS region with agricultural products, 2) to investigate a general condition of road transportation to further analyze an appropriate location of the distribution center in the GMS, 3) to propose a way in which transportation can be improved by implementing new trade lanes and logistics network optimization, resulting in integrated logistics network and system that enhance a role of Thailand becoming the logistics hub in the GMS region.

LOGISTICS INFRASTRUCTURE

Category of Logistics Infrastructure

1. Logistics direction

Logistics direction includes inbound and outbound logistics

1) Inbound logistics

Inbound logistics represents one of the major business processes in transportation planning. Beyond excellence in operations, the main challenge is to plan inbound logistics jointly with outbound transportation volumes to increase consolidation where ever possible.

2) Outbound logistics

Outbound logistics represents the process related to the movement and storage of products from the end of the production line to the end user.
2. Logistics line

There are three categories logistics line such as transportation, distribution, delivery and Cross Docking.

1) Transportation

Transportation consists of several forms or modes and effective as well as efficient mode selection is key to a successful logistics function. Modes under the strategic and usually tactical control of the transportation include air, water or ocean, truck, and rail. Transportation is usual longer distance.

2) Distribution

The activities associated with the movement of material, usually finished goods or service parts, from the manufacturer to the customer. These activities encompass the functions of transportation, warehousing, inventory control, material handling, order administration, site and location analysis, industrial packaging, data processing, and the communications network necessary for effective management. It includes all activities related to physical distribution, as well as the return of goods to the manufacturer. In many cases, this movement is made through one or more levels of field warehouses.

3) Delivery

The activities associated with a carrier to pick up finished goods at a logistics node and deliver them to end user. In other words, we also can define delivery to be the “Last Mile” transportation.

4) Cross docking

A distribution system in which merchandise received at the warehouse or distribution center is not put away, but instead is readied for shipment to retail stores. Cross docking requires close synchronization of all inbound and outbound shipment movements. By eliminating the put-away, storage, and selection operations, it can significantly reduce distribution costs.

3. Logistics node

There are four categories Logistics Network Infrastructure in China, such as Hub, Central Distribution Center & Cross Docking Center, Regional Distribution Center and Distribution Center.

1) Hub

According to DOD in USA, Hub refers to an organization that sorts and distributes inbound cargo from wholesale supply sources (airlifted, sealifted, and ground transportable) and/or from within the theater. Suppliers can arrange material and product in Hub to supply the large Hub or logistics center in service destination by long distance transportation to concentrate the supply, take advantage of common transport and combined loading, improve the logistics active efficiency and productivity, and decrease the procurement and supply cost.

2) Central Distribution Center & Cross Docking Center

Cross Docking Center is the facility where the material or products are received from suppliers, sorted directly to be shipped to a consolidated batch (often including other orders from other suppliers) to the customers by the same vehicle or different without putting them in storage. Its particular advantages reside at the minimization of warehousing and economies of scale in outbound flows (from the Distribution Center to the customers), and it helps reduce operating costs, increase throughput, reduces inventory levels, and helps in increase of sales space. The material or products handled in Central Distribution Center & Cross Docking Center are usually of large-size, small-item, and lowfrequency.

3) Regional Distribution Center

A Regional Distribution Center is a collection and consolidation center for finished goods, components and spare parts to be distributed to the Distribution Center belongs to dealers, importers or other unrelated organizations within or outside the region. Among the functions involved are information network service, repackaging and labeling, and distribution. The material or products handled in Central Distribution Center & Cross Docking Center are usually of small-size, multiple-item, and personality.
4) Distribution Center

Distribution Centers are foundation of Logistics Infrastructure, which usually is a model “warehouse” or other specialized building which is stocked with products to be redistributed to retailers or wholesalers. In the Logistics Infrastructure discussed in this paper, up-level facilities will ship truckload of products to the Distribution Center, and then the Distribution Center will store the product until needed by the retail location and ship the proper quantity to the retails, stores, even the end users.

**DISTRIBUTION SYSTEMS AND MANAGEMENT**

**Distribution**

A DC is found to be one the important components in logistics system. The DC can be instrumental to reduce the logistics cost and improve services. Generally, a key role that it plays is to support a movement of products from one place to another place in business activities. A DC is acting as an interchange of products during inter-modal transshipment facility, such as transporting by a truck and changing its mode to a ship. Therefore, the DC needs to be prepared with supporting resources and equipment used for facilitating the movement of products from one mode to another mode. For consolidation facility, the DC is functional as a collection center to collect products from different locations to a customer. Transportation service provider may move products to the DC or move products out of the DC. Moreover, a role of distribution point is opposite to the collection center. The distribution point is utilized as a center to distribute products from a supplier to other destinations. The purpose is to reduce activities and transportation cost of products.

1) Product assortment facility is a location selected for assorting products’ type from different original points to different destinations. The main objective is to reduce a number of transportation activities, and save transportation cost.

2) Storage facility is developed for the development of the DC where is located closer to an end customer. The objectives are to: storage products that are subsequently delivered to a customer, as well as decrease distance and time for transporting products.

3) Manufacturing-related services and logistics-related services are the service that gives value-added on products before sending to its destinations. Generally, the service provided in the DC includes packaging, and reassembly.

Product distribution (or place) is one of the four elements of the marketing mix. An organization or set of organizations (go-between) involved in the process of making a product or service available for use or consumption by a consumer or business user.

Physical distribution is “the collective term for the range of activities involved in the movement of goods from points of production to final points of sale and consumption. It must insure that the mobility requirements of supply chains are entirely met.” Physical distribution includes all the functions of movement and handling of goods, particularly transportation services (truck, freight rail, air freight, inland waterways, marine shipping, and pipelines), transshipment and warehousing services (e.g. consignment, storage, inventory management), trade, wholesale and, in principle, retail. Conventionally, all these activities are assumed to be derived from materials management demands.

The channel decision is very important. In theory at least, there is a form of trade-off: the cost of using intermediaries to achieve wider distribution is supposedly lower. Indeed, most consumer goods manufacturers could never justify the cost of selling direct to their consumers, except by mail order. Many suppliers seem to assume that once their product has been sold into the channel, into the beginning of the distribution chain, their job is finished. Yet that distribution chain is merely assuming a part of the supplier's responsibility; and, if they have any aspirations to be market-oriented, their job should really be extended to managing all the processes involved in that chain, until the product or service arrives with the end-user. This may involve a number of decisions on the part of the supplier: 1) channel membership, 2) channel motivation, and 3) monitoring and managing channels.

Type of marketing channel 1) intensive distribution - Where the majority of resellers stock the 'product' with convenience products, for example, and particularly the brand leaders in consumer goods markets (price competition may be evident), 2) selective distribution - This is the normal pattern (in both consumer and industrial markets) where 'suitable' resellers stock the product. In this case retailers can keep the competitors products in their outlets e.g. furniture etc, and 3) exclusive distribution - Only lans-bard specially selected resellers or authorized dealers (typically only one per
There are a number of critical functions performed by the channel distributor. Ross describes these functions as:

1) Product acquisition

This means acquiring products in a finished or semi-finished state from either a manufacturer or through another distributor that is higher up in the supply channel. These functions can be performed by independent channel intermediaries or by the distribution facilities of manufacturing companies.

2) Product movement

This implies significant effort spent on product movement up or down the supply channel.

3) Product transaction

Distributors can be characterized as selling products in bulk quantities solely for the purpose of resale or business use. Downstream businesses will then sell these products to other distributors or retailers who will sell them directly to the end customer, or to manufacturers who will consume the material/components in their own production processes.

Following are the separate elements contained within the three critical functions of distribution:

- Selling and promoting

This function is very important to manufacturers. One strategy involves the use of distribution channels to carry out the responsibilities of product deployment. In addition to being marketing experts in their industry, distribution firms usually have direct-selling organizations and a detailed knowledge of their customers and their expectations. The manufacturer utilizing this distributor can then tap into these resources. Also, because of the scale of the distributing firm's operations and its specialized skill in channel management, it can significantly improve the time, place, and possession utilities by housing inventory closer to the market. These advantages mean that the manufacturer can reach many small, distant customers at a relatively low cost, thus allowing the manufacturer to focus its expenditures on product development and its core production processes.

- Buying and building product assortments

This is an extremely important function for retailers. Most retailers prefer to deal with few suppliers providing a wide assortment of products that fit their merchandizing strategy rather than many with limited product lines. This, of course, saves on purchasing, transportation, and merchandizing costs. Distribution firms have the ability to bring together related products from multiple manufacturers and assemble the right combination of these products in quantities that meet the retailer's requirements in a cost-efficient manner.

- Bulk breaking

This is one of the fundamental functions of distribution. Manufacturers normally produce large quantities of a limited number of products. However, retailers normally require smaller quantities of multiple products. When the distribution function handles this requirement it keeps the manufacturer from having to break bulk and repackage its product to fit individual requirements. Lean manufacturing and JIT techniques are continuously seeking ways to reduce lot sizes, so this function enhances that goal.

- Value-added processing

Postponement specifies that products should be kept at the highest possible level in the pipeline in large, generic quantities that can be customized into their final form as close as possible to the actual final sale. The distributor can facilitate this process by performing sorting, labeling, blending, kitting, packaging, and light final assembly at one or more points within the supply channel. This significantly reduces end-product obsolescence and minimizes the risk inherent with carrying finished goods inventory.
• Transportation

The movement of goods from the manufacturer to the retailer is a critical function of distribution. Delivery encompasses those activities that are necessary to ensure that the right product is available to the customer at the right time and right place. This frequently means that a structure of central, branch, and field warehouses, geographically situated in the appropriate locations, are needed to achieve optimum customer service. Transportation's goal is to ensure that goods are positioned properly in the channel in a quick, cost-effective, and consistent manner.

• Warehousing

Warehousing exists to provide access to sufficient stock in order to satisfy anticipated customer requirements, and to act as a buffer against supply and demand uncertainties. Since demand is often located far from the source (manufacturer), warehousing can provide a wide range of marketplaces that manufacturers, functioning independently, could not penetrate.

• Marketing information

The distribution channel also can provide information regarding product, marketplace issues, and competitors' activities in a relatively short time.

Distribution/Distribution Systems

Distribution systems are embedded in a changing macro- and microeconomic framework, which can be roughly characterized by the terms of flexibilization and globalization:

1) Flexibilization implies a highly differentiated, strongly market and customer driven mode of creating added-value. Contemporary production and distribution is no longer subject to single-firm activity, but increasingly practiced in networks of suppliers and subcontractors. The supply chain bundles together all this by information, communication, cooperation, and, last but not least, by physical distribution.

2) Globalization means that the spatial frame for the entire economy has been expanded, implying the spatial expansion of the economy, more complex global economic integration, and an intricate network of global flows and hubs.

The flow-oriented mode affects almost every single activity within the entire process of value creation. The core component of materials management is the supply chain, the time- and space-related arrangement of the whole goods flow between supply, manufacturing, distribution and consumption. Its major parts are the supplier, the producer, the distributor (e.g. a wholesaler, a freight forwarder, a carrier), the retailer, the end consumer, all of whom represent particular interests.

In order for distribution to increase its efficiency in any particular systems, there is a need for well managing distribution. Distribution Management is defined as overseeing the movement of goods from supplier or manufacturer to point of sale. Distribution management is an overarching term that refers to numerous activities and processes such as packaging, inventory, warehousing, supply chain and logistics.

Previous Research on Distribution Systems and Management

In light of distribution practices, Lee and Oum (2001) proposed the strategies for making Korea a Northeast Asian Logistics/Distribution Hub country. After summarizing the recent trends of multinational firms’ logistics and distribution practices and the conditions of successful logistics hubs, we identified the potential advantages of Korea over Japan and China, and examined the success cases of the Netherlands and Singapore. This allowed us to make a number of suggestions to help make Korea attractive to foreign multinationals as the place to locate their northeast Asian regional distribution centers. However, Chin and Tongzon (2001) studied transportation Infrastructure Management for Attracting Global and Regional Distribution Centers in Singapore. The success of Singapore as a major transshipment hub must due to the presence of a world class transportation system with world class players such as SIA and PSA capitalizing on Singapore’s comparative advantage in location, which began with the development of the port followed by air and land. The land, sea and air sectors have taken an independent approach to development and investment in the past. Multimodalism in the cargo industry demands instant acquisition, processing and analysis of data; thereby logistics is that vital link to enhancing production, distribution and consumption. Moreover, Laptaned and Rattanawong (2005) investigated an evaluation of distribution center location for Phitsanulok province that may become the future of a Logistics Center in Indo-China. From an initiative of the Asian Development Bank (ADB) to determine a regional plan of developing North-
South economics corridor and East-West economics corridor in Indo-China region. Such development addresses a multi-sectoral perspective, spatial development options, and practical infrastructure, human resource, policy, regulatory and institutional barriers to trade, investment, and the movement of goods and people. Considering an intersection of both corridors, Phitsanulok province is located right on the section and has become a logistics center of Indo-China intersection. Phitsanulok is one of the Northern provinces that has sufficient infrastructure and transportation network, covering road, rail, air, water, and pipe transportation modes. It is therefore appropriate for Phitsanulok to be a distribution center of Indo-China intersection that may serve trade/commodity flow among Greater Mekong Sub-region countries. This study is aimed at 1) locating the appropriate location of a distribution center, 2) studying behavior of commodity flow, and 3) promoting and increasing awareness of business competitive advantage to farmers, agricultural sector, and private sector. Moreover, one-stop border facilities, sharing social and physical infrastructure, cross-border production networks, etc) to increase investment returns using existing transport modes (roads, water, air, and rail) are also reviewed.

Furthermore, Sene, et al., (2006) proposed the inter model routings solution of Thailand-China shipments under FTA using fuzzy AHP. This paper deals with a method to solve transport problems. There are many routings possibilities between Thailand and China where the countries are under Free Trade Agreement. For example, the goods can transit through Laos, through Myanmar or on the Mekong River by ship. All possibilities are available but we need to choose the best one according to fuzzy criteria. This study will use the method to find the best routing. Fuzzy AHP uses linguistic variables to assess the ratings and the weights for quantitative or qualitative factors such as cost, time, risk and other performances. These linguistic ratings can be expressed in trapezoidal or triangular fuzzy numbers. A MCDM model is then proposed to deal with the selective problem. To determine the ranking order or each possible solution, a closeness coefficient is defined by calculating the distances to the both fuzzy positive ideal solution (FPIS) and fuzzy negative ideal solution (FNIS) simultaneously. Nonetheless, Thiengburanatham, et al. (2006) stated that the Kunning-Bangkok expressway is expected to be an important infrastructure in the GMS region. The logistics infrastructure functions as a land bridge between China and Asian countries, particularly in Thailand. Once the project if fully functional, significant impacts can be anticipated, such as shifts of transportation mode, short and long term of economics and cultural changes. A schematic model is presented in this paper as a schematic decision making tools for evaluating transportation mode and route selection. This model is grounded on Stochastic and Analytical Heretical Process (AHP) techniques. The dimensions of cost, time, and reliability of service are integrated as key performance indices of the logistics system. Each business type has different kinds of requirements. The results show that this expressway will be a major logistics channel between Thailand and the Southern part of China. In 2007, Bremer Institut für Produktion und Logistik GmbH conducted research on the projects in the Enterprise Logistics Cluster that aim to develop and demonstrate advanced IT solutions for the design, management and control of enterprise logistics chains. It took into consideration both intra- and inter-enterprise logistics chains. The Enterprise Logistics Cluster relates to the domain 8 R&D areas of the ESPRIT Work Programme such as Management Tools for the Virtual Enterprise and Intelligent Production Systems and Equipment. The activities of the Working Group may be summarized in enhancing logistic RTD results of the Enterprise logistics cluster, to provide a dissemination and exploitation framework for those logistics RTD-projects and topics as a knowledge pool for European industry. To increase logistic perception and implementation, logistic minded bodies for systems uptake are identified and collaborations are carried out.

The Singapore Economic Development Board (2007) stated that a robust Logistics & Transport cluster will strengthen Singapore’s capabilities as a compelling hub in Asia for business and investment. It was aimed at developing Singapore into an integrated and connected Logistics & Transport hub that enables the effective flow of goods, information, finances and people. Singapore continued to broaden and deepen the scope of activities of the cluster for growth in areas such as aviation services, oil and gas exploration and production, distributed power, automotive electronics, and SCM. Through strengthening manpower capabilities and infrastructure, it was also aimed at developing Singapore into a choice location for the entire value chain of Logistics & Transport activities including R&D, testbedding, manufacturing, after-market services and HQ centers. According to practical distribution systems in the GMS, Banomyong (2009) conducted research on the Asian and China logistics that was used to support private sectors who supervise and identify a framework of the Asian cooperation regulations. This research also investigated a framework of transportation model and a cooperation of economics in the GMS such as cross-border transportation agreement. Such agreement has become one of the critical problems in a way that it could solve the problem of international trucks crossing other countries. In order to achieving a single standard, the cross-border transport needs to be more effective and less time spending, especially for agricultural products.
DISTRIBUTION REQUIREMENTS PLANNING

The need for more detailed distribution planning led to the emergence of distribution requirements planning (DRP) during the 1970s. DRP is a widely used and potentially powerful technique for helping outbound logistics systems manage and minimize inbound inventories. This concept extended the time-phase order point found in material requirements planning (MRP) logic to the management of channel inventory. By the 1980s DRP had become a standard approach for planning and controlling distribution logistics activities and had evolved into distribution resource planning. The concept now embraces all business functions in the supply channel, not just inventory and logistics, and is termed DRP II.

DRP is usually used with an MRP system, although most DRP models are more comprehensive than stand-alone MRP models and can schedule transportation. The underlying rationale for DRP is to more accurately forecast demand and then use that information to develop delivery schedules. This way, distribution firms can minimize inbound inventory by using MRP in conjunction with other schedules. One of the key elements of DRP is the DRP table, which includes the following elements:

- Forecast demand for each stock-keeping unit (SKU)
- Current inventory level of the SKU
- Target safety stock
- Recommended replenishment quantity
- Replenishment lead time

The concept of DRP very closely mimics the logic of MRP. As with MRP, gross requirements consist of actual customer orders, forecasted demand, or some combination of both; scheduled receipts are the goods the distributor expects to receive from orders that already have been released, while goods that already are received and entered into inventory constitute the on-hand inventory balance. Subtracting scheduled receipts and on-hand inventory from gross requirements yields net requirements. Based upon the distributor's lot-sizing policy and receiving behavior, planned order receipts are generated. Firms may order only what they need for the next planning period or for a designated time period. Known as economic order quantity (EOQ), this involves a lot size based on a costing model. Alternatively, firms may be limited to multiples of a lot size simply because the supplying firm packages or palletizes their goods in standard quantities. Also, some distributors may require some time interval between the arrival of goods on their docks and the entry of the goods into the inventory system. For example, a firm may have a staging area where goods remain for an average time period while awaiting quality or quantity verification. Hence, planned order receipt may be during the planning period when the goods are needed, or they may need to be received earlier depending on time requirements. Order release is then determined by offsetting the planned order receipt by the supplier's lead time. Figure 1 is a representation of a DRP calculation (ignoring possible safety stock requirements).

FIGURE 3
A DRP CALCULATIONS
Previous Research on Distribution Requirements Planning

Amelia et al. (2007) discussed an integrated production-distribution planning for a 4-echelons supply chain system which consists of a manufacturer with a continuous production process, a distribution center, a number of distributors and a number of retailers. This situation can be found, for example, in a fertilizer production and distribution systems. Considering a time-dependent demand pattern which is approximated by a polynomial function at retailers that fluctuates by time and may not be identical for each retailer, and all entities of the entire echelon in the supply chain are allowed to hold inventory, the integrated production-distribution planning model is developed using the following approaches, i.e.: coordinated policy, echelon inventory concept and single cycle time policy. The periodic review inventory system is used as a basic model for developing the model. The model determines a production policy for the manufacturer and replenishment policies for all entities involved in the distribution system in order to minimize a total system cost. The total system cost consists of set-up/ordering costs, holding costs, backorder costs and transportation costs of all entities of the supply chain system. A heuristics solution procedure is developed to find the solution. Since the demand depends on the time, the level of maximum inventory is not equal for each period at the manufacturer, the distribution center, the distributors and the retailers. Whereas, Wanga et al. (2003) stated that the distribution of finished goods to customers plays an important role in supply chain management. This paper introduces an approach that takes care of multi-warehouse and multi-retailer scenarios. In order to pull material through a supply chain effectively, we proposed a just-in-time distribution requirements planning system under the limited supply capacity. The aim is to establish an optimal distribution requirements planning model to minimize the total cost of manufacturing and transportation as well as the earliness/tardiness penalty in meeting retailer's requirements under limited warehouse capacity. Using mathematical deduction, the model can be translated into a linear programming problem and solved by a simplex procedure. The computational results have shown that the proposed approach can offer more effective distribution requirements plans.

Additionally, Thomas and Griffin (1995) present a comprehensive review of the literature related to the coordination of two or more of the main stages of the supply chain, that is, procurement, production, and distribution. This is accomplished by describing the main references related to buyer-vendor coordination, production-distribution coordination, inventory-distribution coordination, and strategic planning. They also present some topics for further research, which include the modelling of nonlinear transportation costs, life cycle constraints, general international supply issues, third-parties in international problems, and the determination of interface points within the supply chain. While, Verter and Dincer (1995) discuss the facility location decisions of multinational organizations. They highlight the need for coordination among all international entities of global companies in order to improve competitiveness. The authors claim that the 'manufacturing strategy' and its interactions with other corporate strategies constitute the core aspects for determining the global configuration of a firm. They also suggest that production-distribution networks are effective tools for modeling the company's global supply chain configuration. Accordingly, after discussing the planning process and coordination of a firm's global manufacturing strategy, Verter and Dincer present a literature review on the production-distribution system design problem. This review includes a survey of the so-called 'general form' of the strategic problem, and a survey of models for designing international production-distribution systems. Moreover, Geoffrion et al. (1978) present a status report in strategic distribution system planning based on decomposition techniques. Although this paper is similar to the one by Geoffrion and Graves (1974), it has some differences and new ideas, created by new applications and customer requirements. Among these, we have single sourcing of customer zone by commodity, nonlinear facility throughput constraints, and tradeoffs between distribution and customer service. Geoffrion et al. (1982) present a final version of this paper with a more thorough description of the system and more managerial emphasis, but with the same model as in their former research.

CONCLUSION AND ANTICIPATED RESULTS

The above literatures related to the distribution systems and distribution requirement planning are used as a reference to indicate the potentiality of successful logistics hubs in which Thailand is finally aimed at becoming the logistics hubs in Indo-China. Establishing the product’s distribution center would aim at facilitating trading activity among the GMS. This would increase cost efficiency and customers’ responsiveness of businesses and also reliability and security of their logistics process, as well as create economic value from logistics and other supporting industries. Referring to previous research paper written by the authors, there were two studies conducted to investigate a pattern of collection, distribution, area, and volume of agricultural products in the area of Chiangrai, and analyze conditions for an appropriate location of the Agricultural Products’ Distribution Center. In summary, a location of Chiang Khong District was the best alternative for becoming the Agricultural Products’ Distribution Center. This selected Chiang Khong District location (according to technique, physical, economy, and social) was better than location of Chiang Saen and Mae Sai District, respectively. Future research continuing from previous and current studies will focus on planning distribution requirements of such products in accordance with material requirements planning of the Agricultural Products’ Distribution Center. In conclusion, referring to literature written by the authors, there were two studies conducted to investigate a pattern of collection, distribution, area, and volume of agricultural products in the area of Chiangrai, and analyze conditions for an appropriate location of the Agricultural Products’ Distribution Center. In summary, a location of Chiang Khong District was the best alternative for becoming the Agricultural Products’ Distribution Center. This selected Chiang Khong District location (according to technique, physical, economy, and social) was better than location of Chiang Saen and Mae Sai District, respectively. Future research continuing from previous and current studies will focus on planning distribution requirements of such products in accordance with material requirements planning of the Agricultural Products’ Distribution Center.
Products’ production. One ultimately could maintain that distributors include all enterprises that sell products to retailers and other merchants—and/or to industrial, institutional, and commercial users. By adopting this concept into an analysis of the distribution center and logistics hub, it is anticipated to further identify materials management and physical distribution activity performed by channel constituents throughout the GMS.

REFERENCES


GUIDELINES TOWARDS ACHIEVING THE BEST PRACTICES IN MANAGING HEAVY GOODS VEHICLE (HGV) DRIVERS SAFETY: A STUDY IN THE MALAYSIAN LOGISTICS INDUSTRY

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ABSTRACT

The purpose of this study is to examine the Heavy Goods Vehicle (HGV) driver safety aspects and to what extent the HGV Operators had complied with the requirement as stipulated by the Occupational Safety and Health Act (OSHA) in Malaysia. This paper will therefore outlines several proactive approaches which can be adopted by the HGV Operators for their drivers in particular and the management team in general namely the Driving and transport safety programs, Driver training and qualification, Driver fitness and alertness, Substance abuse and drug abuse, Accident procedures, In vehicle monitoring system (IVMS), Journey management plans, Vehicle management system. This study recommended the self regulations approach in enforcing the Occupational Safety and Health by the HGV Operators apart from complying the existing laws by the authorities. Driver Management highlighted on the drivers self management including their driving hours, rest hours, drivers detailing and scheduling as well as on the health aspects. Journey Management is a pre emptive measure in identifying the ideal routes for the journey with certain control elements be applied for the the risk areas. Vehicle Management stressed on the vehicle roadworthiness aspect with the focus is more on preventive maintenance, vehicle technology towards improving the overall safety aspects. This paper found that HGV drivers competency should regularly improved through defensive driving technique, reorganizing the standard operating procedures (SOP) both on the technical and operational matters as well as conducting refresher training for every 3 years in order to update new traffic laws, changes in vehicle technology, new standard operating procedures (SOP) and other relevant matters which could be initiated by the HGV Operators.

KEYWORDS

Heavy Goods Vehicle (HGV), Driver Management, Vehicle Management, Journey Management, Self Regulations, Defensive Driving and Standard Operating Procedures (SOP)

INTRODUCTION

Currently as at 2009 figure given by the Commercial Vehicle Licensing Board (CVLB), there are 156 container haulage operators in Malaysia since the sector is being liberalized in 1997. Prior to the liberalization taking place, there were only five container haulage operators where all are owned by Government-linked companies (GLC) namely Kontena Nasional Berhad, MISC Haulage Services Sdn Bhd, Konsortium Logistik Berhad, Diperdana Holdings Berhad and Multimodal Freight Services Sdn Bhd. These companies were generally practicing good governance on safety of their drivers and fleet management.

According to President of Association of Malaysian Haulage (AMH) Datuk Ahmad Salimin the existing scenario of stiff competition among container hauliers in Malaysia after the liberalization of container haulage should not compromise on safety as safety is part of logistics output (The Star 1 May 2006).

However, the call for keeping safety standard at par level for the new operators could be skeptical as some of these operators had contributed to a numerous number of road accidents in our country.
For the period of 2002 till 2007 it had been reported that road accident involving heavy goods vehicle (HGV) had jumped by an average of 18% and the things had deteriorated in 2008 where 45% of fatalities cases had involving HGV.

This figure is very alarming as it had apparently showed most of the operators had not adopted the best practices in managing their organization. Probably some of these operators are in small scale business and financial constraints had always been the hindrance in implementing such practices. However, under the amended Road Transport Act 1989 stipulates that any operators who had recorded certain percentage of road accidents and poor practice of safety both on the drivers and the vehicle may face its license being revoked (Chee Wai, V.H 2006).

The same sentiment of HGV safety was highlighted by President of Pan Malaysian Lorry Owners Association Mr. Er Sui See who had quoted that some of these operators had compromised on safety especially on overloading of cargo in order to meet the marginal profits. However, this scenario must be ceased as it is not only flouting the traffic law but it poses hazard to other road users in the event of accidents.

Under the Government Transformation Program (GTP) which had been launched by Prime Minister in late 2009, improving transport sector is one of the national key results area (NKRA) being identified which must be addressed in order to ensure the logistics sector is remained efficient and reliable in the years to come. Prior to this, the Ministry of International Trade and Industry had in fact adopted a preemptive measure of establishing the Malaysia Logistics Council (MLC) in 2007 which was aiming at identifying any loopholes in the logistics industry as well as improving the logistics efficiency and delivery system involving all the stakeholders.

With the formation of MLC and in line with the government NKRA target, it is hoped that best practices of safety will be applied and regulated to all HGV operators.

**Research Problems**

1.1 Heavy Goods Vehicle (HGV) driver professions in Malaysia is regarded as unprofessional by the general public.
1.2 The driver management for HGV Operators in Malaysia is currently self regulated and therefore there is no standard guideline for us to measure its effectiveness.

Therefore, this research is aimed at identifying the current loopholes on driver management among HGV operators and proposing the best practices of managing the HGV drivers as well as putting safety as one of their corporate pursuits (Hanowski, R.J 2008).

The scope of research should cover the stakeholders in the logistics and transport sector namely the HGV Operators, Trade associations, regulatory bodies, shippers, vehicle manufacturer, nongovernmental organization (NGO) and other relevant institutional

**Research Objectives**

The purpose of the study is to review the current practices and to adopt the best practices of managing the HGV drivers for road transport operators in the Malaysian logistics industry.

- To identify the possible loopholes pertaining to HGV drivers’ safety issues in Malaysia
- To evaluate feedbacks and comments from the participating stakeholders for next course of actions
- To ascertain best practices on safety standard for HGV operation in Malaysia
- To recommend the best practices to be adopted and regulated by all HGV Operators

Vehicle design, driver management, poor data risk and journey management. These factors have been identified by the Malaysia Institute of Road Safety (MIROS) as causing heavy commercial vehicles to be involved in road accidents which had claimed 412 and 523 lives in 2008 and 2009 respectively. In addition, the vehicles buses, lorries and vans left 1,321 people seriously injured and 1,043 with minor injuries due to the said factors in 2009 alone.

According to MIROS 2008 yearly report, road accident involving commercial vehicles particularly the heavy goods vehicle (HGV) stood at 35 percent involving 850,000 license holders in Malaysia as compared to merely 9 percent of road accident involving commercial vehicles in the United States (US) with more than 3 million license holders.
To arrest this unhealthy trend, the stakeholders in the Malaysian logistics industry particularly the HGV Operators as well as the authorities should propose the standard practice code for commercial and Heavy Goods Vehicle (HGV) on drivers management for the Operators to abide which in turn will uplift the competency level of our HGV drivers management and eventually will promote a more sustainable and vibrant logistics industry (Danton, R., Kirk 2008)

Serious efforts must therefore be done in designing the Standard Operating Procedures (SOP) for Safety, Health and Environment (SHE) practices for all Heavy Goods Vehicles (HGV) drivers in Malaysia especially in formulating the best practices in managing the risks of SHE issues in the daily operations.

**BACKGROUND LITERATURE REVIEW**

A comprehensive study of road safety (Allen et al., 2009) found that human error was the sole cause in 57% of all accidents and was a contributing factor in over 90% of accident cases. In contrast only 2.4% were due solely to mechanical fault and only 4.7% were caused by environmental factors.

Besley E (2009) reckoned that training drivers can improve the efficiency of the company because when employees know what is expected of them and the company shows that it cares, employees are more likely to do their work as efficiently as possible. This is particularly true when employers had always insisted safety as part of their logistics products delivered to customers and drivers performance are also be based on their safe driving record throughout the year (Murray, W., T 2005)

Driver training is a process that cannot be the same for everyone because some drivers may need more and some less training. Training can be separated into four steps as propagated by Stevenson et al. (2010). The first is initial training where the knowledge and skills required of a driver to perform the job correctly. The next step is the refresher training involving classroom instruction used to update drivers on news, rules and new equipment.

Thirdly is remedial training for drivers who have had accidents while driving. This stage is designed to inform drivers of what they are doing wrong and to identify any lack of knowledge they may have so they can avoid accidents (Rodriguez 2004). Lastly is ongoing training which is necessary to keep drivers on track and keep them from falling into unsafe habits as stated by Gander, P. H et al (2006).

Williamson (2006) stressed on the importance of defensive driving which means the driver must have both the desire and the ability to control accident producing situations. Defensive drivers accept responsibility for avoiding accidents and have a positive attitude that they can prevent them. Along with a good attitude the defensive driver must demonstrate alertness, foresight, knowledge, judgement and skill (Pack, A. L., et al 2006).

These are the qualities that professional drivers should possess even though in certain situations they accidents had been caused by third parties but still these drivers will manage to control the situation by minimizing risks at all costs (Smith, T., Broughton et al 2006).

When implementing safety a fleet safety program, management must take certain steps to ensure clarity and purpose. (Hanowski, P., (2009). The first step is to organize company accidents reports to identify problems. This should include direct cost as well as workers compensation, insurance and medical costs. Once this information is organized, it should be used to develop a clear and precise company safety policy. After the policy is developed, the safety program is then set up and administered by a designated safety professional (Mayhew, Quilan 2006) The safety program should be the employee’s sole responsibility. It is also important that all levels of management understand their roles in the safety program. Therefore it is every supervisor’s responsibility to work with safety professional to prevent vehicle accident and employee injuries as stated by Easier (2007).
From the graph above, it is shown that the number of road accidents per 1000 vehicles decrease over the years: 56.9 accidents to 39.8 accidents per 1000 vehicle. An increase in road vehicle does not necessarily increase the likelihood of more death caused by road accidents. Another side evidence also pointing into the same direction: the number of registered vehicle increase from 10.6 million to 15.8 million (2000 to 2006, equivalent to 48.99%) while number of deaths shows small increment – 6035 to 6287 deaths in 206 (+4.18%).

However, the number of deaths is at average of 6000 people which is very high comparatively with the population of Malaysia 27 million as at 2008. In the United Kingdom, the average road fatalities is at 3000 people with 50 million population and for the United States it had reported an average of 5000 people died in road accident annually with 75 million population.

**TOWARDS ACHIEVING BEST PRACTICES IN MANAGING HGV DRIVERS**

*Drivers Recruitment and Selection*

This issue had been prolonged for years as good drivers are very hard to get in the market for HGV operators. Even though all of them do possess valid driving licence for driving heavy vehicles but at the same time they do have numerous previous accident record. Karim, M.R Abdullah (2003) stressed that drivers who had terminated by their employer due to reckless driving or poor performance will soon get another job in other transport company due to dearth shortage of HGV drivers. Such HGV operators have less alternative to turn down such drivers as they are in dire need of drivers for sustaining the operations.
Vehicle Roadworthiness Inspection.

Each commercial vehicle needs to undergo vehicle inspection for every 6 months in PUSPAKOM (Computerized Vehicle Inspection Centre) in order to ensure its roadworthiness and fit to be on the road prior its permit, road tax and insurance can be renewed. However, the inspection is monopolized by one company under the DRB Hicom Group of companies. There should be more than one company in undertaking the business in order to ensure a high integrity and good governance. In 2007 for instance some 25 officers had been prosecuted in court for alleged bribery in PUSPAKOM branches throughout the country.

Safety legislation

In Malaysia, most of the safety legislation can be regarded as ‘firefighting’ in nature as a new legislation will be introduced soon after a major accident happened due to certain loopholes in safety issues. This scenario is unhealthy as it had apparently showed that our legislators are less proactive in initiating safety legislation to be regulated from the beginning. For instance, traffic laws governing the speed limit and overloading need to be enforced at all times and not at seasonal basis as both situations had always pose high risks of accident to other road users (Howard, M. E & et.al 2008).

Self Regulated

Most of safety issues other than areas of concern for PUSPAKOM inspection namely braking system, smoke emission and lights had been always taken for granted by HGV Operators. But only few operators have the initiative to further improve its safety standard via self regulated basis. For instance, strictly enforcing the safety, health and environmental (HSE) practice code to their drivers as well as engaging new technologies in improving safety standard at their fleets (Mitler, M. M 2007). Most of the operators are enforcing safety issues based on the mandatory requirement by the authorities.

Various authorities

There are various regulatory bodies under different ministries in governing the transport sector in Malaysia from the issuance of driver license and vehicle permits until the enforcement of law. Such situations had made the logistics and transport sector becoming more fragmented and in difficult positions especially on the law enforcement (Perry, N. 2005). For instance, a truck driver carrying consignment from Johor to Penang can be issued up to five summons by different government enforcement agencies such as CVLB on vehicle permit, traffic police on speed, Road Transport Department (JPJ) on overloading, Department of Environment (DOE) on smoke emission and local council for illegal parking.

Foreign Drivers

There are few irresponsible HGV Operators have to resort in hiring foreign workers as drivers due to the shortage of local manpower in the market. Despite they are having valid driving license but the level of driving competency and other safety aspects of our country are still lacking and thus jeopardizing the other road users.

THEORETICAL FRAMEWORK

The following framework is developed to describe the factors which could contribute towards achieving the best practices in managing HGV drivers safety.
TABLE 1
FACTORS INFLUENCING THE HGV DRIVER SAFETY

<table>
<thead>
<tr>
<th>Factors Inflencing HGV Driver Safety</th>
</tr>
</thead>
<tbody>
<tr>
<td>Driving and transport safety programs</td>
</tr>
<tr>
<td>Driver training and qualification</td>
</tr>
<tr>
<td>Driver fitness and alertness</td>
</tr>
<tr>
<td>Substance Abuse / Drug Abuse</td>
</tr>
<tr>
<td>Accident procedures</td>
</tr>
<tr>
<td>In vehicle monitoring system (IVMS)</td>
</tr>
<tr>
<td>Journey management plans</td>
</tr>
<tr>
<td>Vehicle specifications</td>
</tr>
</tbody>
</table>

Guidelines towards best practices in managing HGV drivers safety

Dependent Variable

The dependent variable in this study is to come up with the guidelines for best practices in managing HGV driver safety which in turn could become a standard operating procedures (SOP) for all HGV operators in Malaysia.

Independent Variables

The questions in the survey are divided into the following sections which also act as the independent variables in this study.

a) Driving and transport safety programs
b) Driver training and qualification
c) Driver fitness and alertness
d) Substance abuse or drug abuse
e) Accident procedures
f) In vehicle monitoring system
g) Journey management plans
h) Vehicle specifications

Data Collection Process

Data had been collected through interview by the appointed enumerators to 55 companies operating logistics services. The respondents were mostly haulage and trucking companies operating in Klang Valley, Malaysia and they are also the members of Association of Malaysian Haulage (AMH), Malaysia Freight Forwarders Association (MFFM) and the Federation of Malaysian Manufacturers (FMM). These respondents are also the new players in the haulage industry in Malaysia after the liberalization of container haulage industry in 1997. Despite some of these operators had been winding up the business due to the stiff competition and high operating costs but most of them are still optimistic in the industry and continue in rendering the haulage services to the shippers.
ANALYSIS AND RESULTS

A total of 55 respondents had given their feedbacks where mostly are from middle and top management level in the department of operations and logistics. A set of questionnaires comprising the following aspect as stated in the below mentioned table to reflect the overall requirement in HGV drivers safety aspect.

K-R 20 reliability testing had been applied in these questionnaires and in overall, all the section or instrument have high reliability in K-R 20 with the average of 0.825 or 82.5% reliability testing.

TABLE 2

<table>
<thead>
<tr>
<th>Section</th>
<th>Detail</th>
<th>N of item</th>
<th>K-R 20</th>
</tr>
</thead>
<tbody>
<tr>
<td>B.1</td>
<td>Driving and transport safety programs</td>
<td>4</td>
<td>0.934</td>
</tr>
<tr>
<td>B.3</td>
<td>Driver training and qualification</td>
<td>23</td>
<td>0.889</td>
</tr>
<tr>
<td>B.4</td>
<td>Driver fitness and alertness</td>
<td>10</td>
<td>0.694</td>
</tr>
<tr>
<td>B.5</td>
<td>Substance Abuse / Drug Abuse</td>
<td>5</td>
<td>0.789</td>
</tr>
<tr>
<td>C.6</td>
<td>Accident procedures</td>
<td>5</td>
<td>0.747</td>
</tr>
<tr>
<td>C.7</td>
<td>In vehicle monitoring system (IVMS)</td>
<td>14</td>
<td>0.884</td>
</tr>
<tr>
<td>C.8</td>
<td>Journey management plans</td>
<td>19</td>
<td>0.739</td>
</tr>
<tr>
<td>C.9</td>
<td>Vehicle specifications</td>
<td>14</td>
<td>0.837</td>
</tr>
<tr>
<td>C.10</td>
<td>Management system</td>
<td>10</td>
<td>0.910</td>
</tr>
</tbody>
</table>

TABLE 3

<table>
<thead>
<tr>
<th>Type of Services</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Customs clearance</td>
<td>25</td>
<td>15</td>
</tr>
<tr>
<td>Conventional Trucking</td>
<td>26</td>
<td>13</td>
</tr>
<tr>
<td>Container Haulage</td>
<td>47</td>
<td>6</td>
</tr>
<tr>
<td>Cargo Consolidation</td>
<td>24</td>
<td>16</td>
</tr>
<tr>
<td>Warehousing</td>
<td>25</td>
<td>14</td>
</tr>
<tr>
<td>Shipping Agent</td>
<td>19</td>
<td>18</td>
</tr>
<tr>
<td>Multimodal Transport</td>
<td>17</td>
<td>21</td>
</tr>
<tr>
<td>Airfreight transport</td>
<td>20</td>
<td>18</td>
</tr>
<tr>
<td>Couriers</td>
<td>10</td>
<td>25</td>
</tr>
<tr>
<td>Freight forwarding (sea)</td>
<td>26</td>
<td>13</td>
</tr>
<tr>
<td>Freight forwarding (air)</td>
<td>24</td>
<td>15</td>
</tr>
<tr>
<td>Others</td>
<td>7</td>
<td>17</td>
</tr>
</tbody>
</table>

For section A.2, we are interested to identify the type of common service which provided by most of the companies took part in this research. Table 3 shows the summary for each type of service and the number of company providing it represented by column Yes. For the overall picture, Figure 2 illustrates the overall picture of current situation. From the figure, we know that Container Haulage is the most common service provided by companies reaching number of 47 out of 55 companies which is 85.45% of the companies provides Container Haulage service. Next issue come into our interest is the second common services provided by companies, which consist of nine types of services, namely customs clearance, conventional trucking, cargo consolidation, warehousing, shipping agent, multimodal transport, airfreight transport, freight
forwarding (air), and freight forwarding (sea) with number of companies providing ranged from 17 to 26. Couriers service is the minority type of service which only provided by 10 companies.

**FIGURE 2**
TYPE OF SERVICES PROVIDED BY COMPANIES

<table>
<thead>
<tr>
<th>Type of services provided</th>
<th>Yes (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Customs clearance</td>
<td>42(76.4)</td>
</tr>
<tr>
<td>Conventional Tracking</td>
<td>44(80)</td>
</tr>
<tr>
<td>Container Handling</td>
<td>47(85.5)</td>
</tr>
<tr>
<td>Cargo Consolidation</td>
<td>44(80)</td>
</tr>
<tr>
<td>Warehousing</td>
<td>10(19.6)</td>
</tr>
<tr>
<td>Shipping Agent</td>
<td>10(19.6)</td>
</tr>
<tr>
<td>Multimodal Transport</td>
<td>10(19.6)</td>
</tr>
<tr>
<td>Airfreight Transport</td>
<td>10(19.6)</td>
</tr>
<tr>
<td>Freight Forwarding (sea)</td>
<td>10(19.6)</td>
</tr>
<tr>
<td>Freight Forwarding (air)</td>
<td>10(19.6)</td>
</tr>
<tr>
<td>Couriers</td>
<td>10(19.6)</td>
</tr>
<tr>
<td>Others</td>
<td>10(19.6)</td>
</tr>
</tbody>
</table>

**Section B Driver Safety**

B.1: Driving and transport safety programs

In B.1, we are interested to evaluate the practice of companies’ driver safety through the driving and transport safety program. Table 4 summarizes the practice of driving and transport safety program in companies and Figure 3 are included to provide a graphical explanation.

**TABLE 4**
SUMMARY FOR PRACTICE OF DRIVING AND TRANSPORT SAFETY PROGRAM

<table>
<thead>
<tr>
<th>B.1.1</th>
<th>B.1.2</th>
<th>B.1.3</th>
<th>B.1.4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes(%)</td>
<td>42(76.4)</td>
<td>44(80)</td>
<td>47(85.5)</td>
</tr>
<tr>
<td>No</td>
<td>8</td>
<td>5</td>
<td>3</td>
</tr>
</tbody>
</table>

- **B.1.1**: Is the transport safety program part of the overall company HSE program?
- **B.1.2**: Is a safety committee established?
- **B.1.3**: Are regular meeting held?
- **B.1.4**: Is there timely follow up action?

**Transport safety programs**

**Section B Driver Safety**

B.1: Driving and transport safety programs

In B.1, we are interested to evaluate the practice of companies’ driver safety through the driving and transport safety program. Table 4 summarizes the practice of driving and transport safety program in companies and Figure 3 are included to provide a graphical explanation.
TABLE 4
SUMMARY FOR PRACTICE OF DRIVING AND TRANSPORT SAFETY PROGRAM

<table>
<thead>
<tr>
<th></th>
<th>B.1.1</th>
<th>B.1.2</th>
<th>B.1.3</th>
<th>B.1.4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes(%)</td>
<td>42(76.4)</td>
<td>44(80)</td>
<td>47(85.5)</td>
<td>44(80)</td>
</tr>
<tr>
<td>No</td>
<td>8</td>
<td>5</td>
<td>3</td>
<td>4</td>
</tr>
</tbody>
</table>

B.1.1: Is the transport safety program part of the overall company HSE program?
B.1.2: Is a safety committee established?
B.1.3: Are regular meeting held?
B.1.4: Is there timely follow up action?

FIGURE 3
DRIVING AND TRANSPORT SAFETY PROGRAM

From Table 4, noticed that most of the companies practice criteria B.1.1 till B.1.4, ranged from 42 companies to 47 companies. Among those criteria, B.1.3 (Is regular meeting held?) is the most practiced criterion by the companies (85.5%), follow by B.1.2 which 80% of the companies says that they have their own safety committee and B.1.4 showing that 80% of them do follow up action regularly toward the driving and transport safety program. Lastly, it is the B.1.1 asking about whether the transport safety program part of the overall company HSE program, 42 out of 55 (76.4%) companies saying that transport safety program is part of the overall company HSE program.

In this section, there is a small part require respondents to list out all active driving safety programs in their company. It is found that among 55 companies; only 23 of them listed down at least one safety programs are currently active in their company. Table 5 shows the summary for the number of companies and their corresponding number of active safety program. From the table, notice that only 4 companies keeping 3 safety program active while 8 company keeping 2 safety program running and lastly majority of the company keeping only 1 safety program running actively to date.
TABLE 5
SUMMARY FOR NUMBER OF COMPANY AND THEIR NUMBER OF ACTIVE SAFETY PROGRAM

<table>
<thead>
<tr>
<th>Number of active safety program</th>
<th>Number of company</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>2</td>
<td>8</td>
</tr>
<tr>
<td>1</td>
<td>11</td>
</tr>
<tr>
<td>Total</td>
<td>23</td>
</tr>
</tbody>
</table>

B.2: Safety awards

TABLE 6
SUMMARY OF AWARDS

<table>
<thead>
<tr>
<th>Number of awards</th>
<th>Number of company</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td>2</td>
</tr>
</tbody>
</table>

This small section can be simplified into Table 6 which shows the number of awards received by company and the number of company. Out of 55 companies, 6 of them received awards in recent year, 2010 and 2011. Two of them received 3 awards, four of them received only one awards while none of them received 2 awards.

B.3: Driving training and qualification

In this section we are interested to know the extent of driving training and qualification practices among companies. The results were demonstrated by Table 7 and Figure 4.

TABLE 7
SUMMARY OF DRIVING TRAINING AND QUALIFICATION

<table>
<thead>
<tr>
<th>Items</th>
<th>Number of cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.1: Do you have written hiring qualification standards for all drivers?</td>
<td>Yes) 38(9)</td>
</tr>
<tr>
<td>3.1: Are contract / part-time/ driver used?</td>
<td>No 12</td>
</tr>
<tr>
<td>3.3: Are all recruited driver trained?</td>
<td>Yes) 50(0)</td>
</tr>
<tr>
<td>3.4: Is the driver training maintained (at least once every 3years)?</td>
<td>No 5</td>
</tr>
<tr>
<td>3.5: Is a current copy of the Drivers’ license and qualifications on file</td>
<td>Yes) 53(6)</td>
</tr>
<tr>
<td>3.6: Do you use a defensive driving training program?</td>
<td>No 1</td>
</tr>
<tr>
<td>Does the training include the following:</td>
<td></td>
</tr>
<tr>
<td>3.6.1: Review of company policies and standards related to driving</td>
<td>Yes) 33(4)</td>
</tr>
<tr>
<td>3.6.2: Defensive driving techniques</td>
<td>No 1</td>
</tr>
<tr>
<td>3.6.3: Journey management techniques</td>
<td>Yes) 29(7)</td>
</tr>
<tr>
<td>3.6.4: Alertness and fatigue management</td>
<td>No 4</td>
</tr>
<tr>
<td>3.6.5: Effects of medication and substance abuse</td>
<td>Yes) 32(7)</td>
</tr>
<tr>
<td>3.6.6: Vehicle restrain systems and safety equipment</td>
<td>No 3</td>
</tr>
<tr>
<td>3.6.7: Pre-trip checks and proper seating position</td>
<td>Yes) 30(0)</td>
</tr>
<tr>
<td>3.6.8: Does it specifically identify local hazards, regulations and culture?</td>
<td>No 4</td>
</tr>
<tr>
<td>3.6.9: Commentary driving</td>
<td>Yes) 31(3)</td>
</tr>
<tr>
<td>3.6.10: Assessment of driving skill and behavior</td>
<td>No 4</td>
</tr>
<tr>
<td>3.7: Is the training accompanied by written tests?</td>
<td>Yes) 25(5)</td>
</tr>
<tr>
<td></td>
<td>No 23</td>
</tr>
</tbody>
</table>
Driver training and qualification

The results above show the number of companies which practices criteria of driving training and qualification. From the table and bar chart, we discover that most of the companies actively practice these criteria: B.3.5: Is a current copy of the drivers’ license and qualifications on file (96.4%), B.3.3: Are all recruited driver trained (90.9%), B.3.1: Do you have written hiring qualification standards for all drivers (69.1%). Meanwhile, 63.6% of the companies practice criteria B.3.6 (Do you use a defensive driving training program?). Of those who practice defensive driving training program, 87.9% to 94.3% actively practice the sub-criteria of B.3, such as B.3.6.1: Review of company policies and standards related to driving (94.3%), B.3.6.2: defensive driving techniques (94.3%), B.3.6.5: Effects of medication and substance abuse (97.0%), B.3.6.8: Does it specifically identify local hazards, regulations and culture? (97.0%), and so on. Besides, results show that only 12.7% of the companies had completed the dangerous goods (B.3.13) and 25.5% of companies hire consultant for their training (B.3.8). From the table, only 45.5% of them employ contract or part time driver, this finding indirectly showing that companies are more likely to use their own driver whom have been go through certain training suitable for the nature of services rather than part time or contract driver whom generally not well trained and only required on seasonal basis. Then, we further discover that only few companies practicing these criteria, ranged from 36.3% to 54.5%, namely B.3.4 (54.5%): Is the driver training maintained (at least once every 3 years)?, B.3.7 (45.5%): Is the training accompanied by written tests?, B.3.9 (36.3%): Is training and qualification provided for high-risk environments and specialized vehicles?, B.3.11 (38.2%): Is refresher training and assessment performed?, and B.3.12 (43.6%): Do you perform annual driver skill assessment/checks?.

B.4: Driver fitness and alertness

In this section, the issues in discuss are the practices of companies to ensure the fitness and alertness of their driver. Table 8 and Figure 5 are generated to tell the story of current practices in companies.
TABLE 8
SUMMARY OF DRIVER FITNESS AND ALERTNESS

<table>
<thead>
<tr>
<th>Items</th>
<th>Yes(%)</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>B.4.1 Are all drivers medically assessed prior to hire</td>
<td>50(90.9)</td>
<td>3</td>
</tr>
<tr>
<td>B.4.2 Are all drivers medically assessed at least every 5 years?</td>
<td>23(41.8)</td>
<td>29</td>
</tr>
<tr>
<td>B.4.3 Are drivers limited from driving based upon medical assessment?</td>
<td>46(83.6)</td>
<td>7</td>
</tr>
<tr>
<td>B.4.4 Are drivers screened for sleep disorders?</td>
<td>26(47.3)</td>
<td>23</td>
</tr>
<tr>
<td>B.4.5 Are drivers assessed for the capability to drive prior to each journey?</td>
<td>37(67.3)</td>
<td>14</td>
</tr>
<tr>
<td>B.4.6 Are drivers required to notify management of any condition or limitation that may affect their ability to drive safely?</td>
<td>52(94.5)</td>
<td>3</td>
</tr>
<tr>
<td>B.4.7 Is fatigue management training conducted?</td>
<td>31(56.4)</td>
<td>21</td>
</tr>
<tr>
<td>B.4.8 Are drivers directed to stop when they feel fatigued?</td>
<td>47(85.5)</td>
<td>7</td>
</tr>
<tr>
<td>B.4.9 Does management provide active support for a driver’s decision to stop driving due to fatigue?</td>
<td>48(87.3)</td>
<td>6</td>
</tr>
<tr>
<td>B.4.10 Do drivers operate within the recommended hours of duty and service?</td>
<td>48(87.3)</td>
<td>6</td>
</tr>
</tbody>
</table>

Driver fitness and alertness

FIGURE 5
NUMBER OF CASES IN DRIVER FITNESS AND ALERTNESS PRACTICES

From the results above, we found that most of the companies, generally more than 80%, actively practice these criteria B.4.6 (94.5%): Are drivers required to notify management of any condition or limitation that may affect their ability to drive safely?, B.4.1 (90.9%): Are all drivers medically assessed prior to hire, B.4.9 (87.3%): Does management provide active support for a driver’s decision to stop driving due to fatigue?, B.4.10 (87.3%): Do drivers operate within the recommended hours of duty and service? and B.4.3 (83.6): Are drivers limited from driving based upon medical assessment?. However we detected that, somehow, less than 50% of companies practices B.4.2 (41.8%): Are all drivers medically assessed at least every 5 years?, and B.4.4 (47.3%): Are drivers screened for sleep disorders?. As for the fatigue management training (B4.7), only 56.4% of companies practicing it, about half of the respondents.
B.5: Substance abuse/drug abuse

<table>
<thead>
<tr>
<th>Items</th>
<th>Yes(%)</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>B.5.1 Is there a documented policy or expectation regarding employee substance abuse?</td>
<td>43(78.2)</td>
<td>11</td>
</tr>
<tr>
<td>B.5.2 Does it meet all relative regulatory and industry requirements?</td>
<td>42(76.4)</td>
<td>8</td>
</tr>
<tr>
<td>B.5.3 Has it been communicated effectively to all employees?</td>
<td>45(81.8)</td>
<td>6</td>
</tr>
<tr>
<td>B.5.4 Is there documented evidence of its effective implementation?</td>
<td>39(70.9)</td>
<td>11</td>
</tr>
<tr>
<td>B.5.5 Does it include random testing for substance abuse?</td>
<td>33(60)</td>
<td>16</td>
</tr>
</tbody>
</table>

Substance abuse or drug abuse

FIGURE 6
NUMBER OF CASES FOR SUBSTANCE ABUSE/DRUG ABUSE PRACTICES

From Table 9, noticed that most of the companies do practice all the criteria from B.5.1 till B.5.4, ranged from 39 companies to 45 companies. Among these criteria, criteria B.5.3 (81.8%): Has it been communicated effectively to all employees, is the most practiced criterion among companies. Followed by B 5.1 (78.2%): Is there a documented policy or expectation regarding employee substance abuse?, and B.5.2 (76.4%): Does it meet all relative regulatory and industry requirements?. A distinction finding is B5.5 (60%) which is the lowest which asks about the random testing for substance abuse practice. This implies that only 33 out of 55 companies run random testing for substance abuse for their driver.

Operational safety

C.6: Accident procedures
### TABLE 10
SUMMARY OF ACCIDENT PROCEDURES PRACTICES

<table>
<thead>
<tr>
<th>Items</th>
<th>Yes (%)</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>C.6.1 Does the company have written accident/ incident policies/procedures?</td>
<td>48(87.3)</td>
<td>5</td>
</tr>
<tr>
<td>C.6.2 Do all vehicles contain a copy of the policies/ procedures?</td>
<td>38(69.1)</td>
<td>13</td>
</tr>
<tr>
<td>C.6.3 Are accident/ incidents investigation procedures in place?</td>
<td>51(92.7)</td>
<td>4</td>
</tr>
<tr>
<td>C.6.4 Who is responsible for accident/incident investigation?</td>
<td>46(83.6)</td>
<td>2</td>
</tr>
<tr>
<td>C.6.5 Is there timely follow up action?</td>
<td>51(92.7)</td>
<td>3</td>
</tr>
</tbody>
</table>

Accident procedures

FIGURE 7
NUMBER OF CASES FOR ACCIDENT PROCEDURES PRACTICES

Results above demonstrated the accident procedures that majority of the company practicing. More than 80% companies actively practiced these procedures, i.e. C.6.1 (87.3%): Does the company have written accident/ incident policies/procedures?, C.6.3 (92.7%): Are accident/ incidents investigation procedures in place?, C.6.4 (83.6%): Who is responsible for accident/incident investigation? and C.6.5 (92.7%): Is there timely follow up action?. There is only one criterion, however, shows that only 69.1% of companies practicing, i.e. Do all vehicles contain a copy of the policies/procedures? (C.6.2).

C.7: In vehicle monitoring system (IVMS)
<table>
<thead>
<tr>
<th>Items</th>
<th>Yes(%)</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>7.1 Are all company owned vehicles fitted with an In Vehicle Monitoring System (IVMS) or Vehicle Data Recorder (VDR)?</td>
<td>44(80)</td>
<td>10</td>
</tr>
<tr>
<td>7.2 Are all company leased or contracted vehicles (&gt;3 months) fitted with an In Vehicle Monitoring Systems (IVMS) or Vehicle Data Recorder (VDR)?</td>
<td>35(63.6)</td>
<td>14</td>
</tr>
<tr>
<td>7.3 Where systems are not in place or not applied to all vehicles, is the decision to not implement a system documented and supported by a risk-based methodology?</td>
<td>31(56.4)</td>
<td>14</td>
</tr>
<tr>
<td>7.4 Is the document updated?</td>
<td>44(80)</td>
<td>4</td>
</tr>
<tr>
<td>7.5 Does the systems monitor, at a minimum:</td>
<td>45(81.8)</td>
<td>3</td>
</tr>
<tr>
<td>7.5.1 Driver alertness</td>
<td>40(72.7)</td>
<td>12</td>
</tr>
<tr>
<td>7.5.2 Speed Limit</td>
<td>52(94.5)</td>
<td>3</td>
</tr>
<tr>
<td>7.5.3 Harsh acceleration/harsh deceleration</td>
<td>43(78.2)</td>
<td>9</td>
</tr>
<tr>
<td>7.5.4 Distance driven</td>
<td>50(90.9)</td>
<td>1</td>
</tr>
<tr>
<td>7.5.5 Driving time(s)</td>
<td>48(87.3)</td>
<td>4</td>
</tr>
<tr>
<td>7.6 Is a data management system (DMS) in place to ensure data from IVMS or VDR is properly analyzed and fed back to drivers and supervisors?</td>
<td>45(81.8)</td>
<td>6</td>
</tr>
<tr>
<td>7.7 Does the DMS include procedures to ensure monitors are installed and working properly; with alarms set to levels commensurate with local driving conditions?</td>
<td>44(80)</td>
<td>7</td>
</tr>
<tr>
<td>7.8 Does the DMS include procedures to ensure data from the monitors is downloaded, analyzed, and communicated?</td>
<td>43(78.2)</td>
<td>7</td>
</tr>
<tr>
<td>7.9 Does the DMS include procedures to ensure data from the monitors is used to provide individual driver performance feedback for improvement and skills development?</td>
<td>41(74.5)</td>
<td>9</td>
</tr>
</tbody>
</table>
Vehicle management

From the Table 11 and bar chart in Figure 8 above, we discovered that C.7.1, C.7.4, C.7.5, C.7.5.2, C.7.5.3, C.7.5.4, C.7.5.5, C.7.6, C.7.7, and C.7.8 are the common IMVS practices among companies with approximate 80% of the companies practicing them. Meanwhile 72.7% of the companies practiced C.7.5.1 criterion followed by 63.6% practiced C.7 criterion and finally, the less likely practiced C.7.3 criterion with only 56.4% of company employing it.

Journey and risk management

C.8: Journey management plans

This section interested to investigate the implementation of journey management plans in the effort to ensuring operational safety. Table 12 and Figure 9 illustrate the summary and bar chart for each criterion in journey management plans.

<table>
<thead>
<tr>
<th>Items</th>
<th>Yes(%)</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>8.1 Are all journeys subject to management approval?</td>
<td>52(94.5)</td>
<td>1</td>
</tr>
<tr>
<td>8.2 Are alternate modes of transportation actively considered vs. land transport</td>
<td>38(69.1)</td>
<td>11</td>
</tr>
<tr>
<td>8.3 Is active effort made to reduce the number of journeys?</td>
<td>34(61.8)</td>
<td>15</td>
</tr>
<tr>
<td>8.4 Are only qualified personnel and appropriate equipment selected for each journey?</td>
<td>45(81.8)</td>
<td>7</td>
</tr>
<tr>
<td>8.4.1 Appointment/identification of a journey manager</td>
<td>41(74.5)</td>
<td>11</td>
</tr>
<tr>
<td>8.4.2 Formal pre-trip briefing with the driver</td>
<td>41(74.5)</td>
<td></td>
</tr>
<tr>
<td>8.4.3 Appropriate means of communication are available and protocol established</td>
<td>49(89.1)</td>
<td>11</td>
</tr>
<tr>
<td>8.4.4 The route is clearly defined and mapped</td>
<td>49(89.1)</td>
<td>4</td>
</tr>
<tr>
<td>8.4.5 All potential hazards are identified</td>
<td>48(87.3)</td>
<td>4</td>
</tr>
<tr>
<td>8.4.6 Appropriate vehicles are assigned and inspected</td>
<td>54(98.2)</td>
<td>5</td>
</tr>
</tbody>
</table>
8.4.7 Trained and qualified drivers are assigned 50(90.9) 1
8.4.8 Drivers are physically and mentally fit, including specific reference to alertness considerations 52(94.5) 4
8.4.9 Rest stops are scheduled 44(80) 2
8.4.10 Arrival times are communicated with a contingency plan in place for overdue trips 48(87.3) 10
8.4.11 All trips during hours of low visibility are reviewed for necessity & formal management approval 42(76.4) 6
8.5 Are headlights required for use unless otherwise restricted by regulation or specific risk? 45(81.8) 9
8.6 Are drivers directed to park vehicle with reverse-parking style, wherever possible? 43(78.2) 9
8.7 Is a formal document used to support the journey management process? 31(56.4) 11
8.8 Has management ever suspended operations due to a journey management hazard issue? 19(34.5) 18

FIGURE 9
NUMBER OF CASES FOR JOURNEY MANAGEMENT PLANS PRACTICES

Results above presented summary of journey management plans practices which show us the overall or actual practices implemented by companies. From the information above, more than 80% of companies having common practices as follow: C8.4.6, C8.4.8, C8.1, C8.4.7, C8.4.3, C8.4.4, C8.4.5, C8.4.10, C.8.4, and C.8.5. Meanwhile, there are four criterion are less likely practice among the companies, they are C.8.2 (69.1%), C.8.3 (61.8%), C.8.7 (56.4%) and lastly C.8.8 (34.5%) which is the less practiced by companies. This shows that there are numbers of companies which do not suspend the operation akin to a journey management hazard issue or may be just simply there is not management hazard issue happened.

C.9: Vehicle specifications
TABLE 13
SUMMARY FOR VEHICLE SPECIFICATIONS PRACTICES

<table>
<thead>
<tr>
<th>Items</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>9.1  Have any structural modifications been done to any vehicles?</td>
<td>14(25.5)</td>
<td>41</td>
</tr>
<tr>
<td>9.2  Were the modification in-line with manufacturer’s specification and local regulation?</td>
<td>24(43.6)</td>
<td>21</td>
</tr>
<tr>
<td>9.3  Is all equipment serviceable?</td>
<td>46(83.6)</td>
<td>8</td>
</tr>
<tr>
<td>Does the policy cover the following areas:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9.4  Head rest/restrains</td>
<td>29(52.7)</td>
<td>17</td>
</tr>
<tr>
<td>9.5  Air bags</td>
<td>24(43.6)</td>
<td>22</td>
</tr>
<tr>
<td>9.6  Anti-lock brakes (ABS)</td>
<td>32(58.2)</td>
<td>13</td>
</tr>
<tr>
<td>9.7  Side impact protection</td>
<td>37(67.3)</td>
<td>12</td>
</tr>
<tr>
<td>9.8  Seatbelt</td>
<td>39(70.9)</td>
<td>10</td>
</tr>
<tr>
<td>9.9  Under-run protection</td>
<td>36(65.5)</td>
<td>12</td>
</tr>
<tr>
<td>9.1  Reversing alarm system (including other vehicles with limited rear-visibility)</td>
<td>45(81.8)</td>
<td>6</td>
</tr>
<tr>
<td>Do all vehicles contain the following minimum safety equipment:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9.11 First aid kit</td>
<td>45(81.8)</td>
<td>5</td>
</tr>
<tr>
<td>9.12 Fire extinguisher</td>
<td>51(92.7)</td>
<td>2</td>
</tr>
<tr>
<td>9.13 Flashlight/torch</td>
<td>38(69.1)</td>
<td>10</td>
</tr>
<tr>
<td>9.14 Disabled vehicle marker (e.g Warning triangle)</td>
<td>52(94.5)</td>
<td>1</td>
</tr>
</tbody>
</table>

Vehicle Specification

FIGURE 10
NUMBER OF CASES FOR VEHICLE SPECIFICATIONS PRACTICES

From the table above, we concluded that the common vehicle specifications with more than 70% companies practicing are C9.14, C9.12, C9.3, C9.11, and C9.8. Refer back to Table 11, it is easy to identify these five practices are the basic feature that the heavy goods vehicle should have, ie. Seatbelt, serviceable equipments, reversing alarm system, and fire extinguisher. However, the table shows that less companies, (<50%) practices these criteria C9.2, C9.5 and C9.1. But refer back to the table, we would find that C.9.1 and C.9.2 are actually highly correlated, which C.9.1 ask about whether there is
any modifications been done to any vehicles, and C.9.2 asked about whether the modification in-line with manufacturer’s specification and local regulation. Hence, by excluding those do not modify their vehicle, left 14 company, we noticed that 12 of them claims that they the modification in-line with manufacturer’s specification and local regulation while 2 of them do not.

Level of achievement for each section

For each section, the questions had been transformed into positive form so that the level of achievement for each section can be determined by the total number of YES. For example, section B.1 (Driving and transport safety programs) which has 4 questions. Total number of 4 YES answered will give the company 100% score for section B.1. With this, the overall level of achievement for each section can be generated. Table below shows the summary of level or achievement in percentage for each section, in which median of data were examined instead of mean as a result of negatively skewed data.

<table>
<thead>
<tr>
<th>Section</th>
<th>Median (%)</th>
<th>Minimum (%)</th>
<th>Maximum (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>B.1: Driving and transport safety programs</td>
<td>100.0</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>B.3: Driver training and qualification</td>
<td>69.6</td>
<td>8.7</td>
<td>95.65</td>
</tr>
<tr>
<td>B.4: Driver fitness and alertness</td>
<td>80.0</td>
<td>20</td>
<td>100</td>
</tr>
<tr>
<td>B.5: Substance abuse/ Drug abuse</td>
<td>80.0</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>C.6: Accident procedure</td>
<td>100.0</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>C.7: In vehicle monitoring system (IVMS)</td>
<td>92.9</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>C.8: Journey management plans</td>
<td>84.2</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>C.9: Vehicle specification</td>
<td>76.9</td>
<td>15.38</td>
<td>100</td>
</tr>
<tr>
<td>C.10: Management system</td>
<td>90.0</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>Average</td>
<td>86.0</td>
<td>24.55</td>
<td>99.52</td>
</tr>
</tbody>
</table>

From the table, noticed that each section has 100% maximum level of achievement except for B.3 (Driver training and qualification) with only 95.65% which indicates that not all items in section B.3 were practiced to company. Minimum value in level of achievement shows that there are companies which do not practice neither one of the criterion in section B.1, B.5, C.6, C.7, C.8 and C.10. It seems that 50% (median) of the respondents showing highest level of 100% for B.1 and C.6 implies that majority of the companies do have high level of driving and transport safety program (B.1), and accident procedure (C.6). Section B.3 shows the lowest level of achievement among other sections, which is 69.6% and hence indicating that most of the companies did not doing great in driver training and qualification especially the B.3.8 and B.3.13 (is dangerous goods training completed). The section which shows the second lowest score is C.9 regarding the vehicle specification (76.9%). It is not too late to mention that for C.9.1, and C.9.2, both question have been combine so that those companies do not modify vehicle or those modify but in-line with the manufacturer’s specification and local regulation will contribute mark for the company level of achievement.
CONCLUSION AND RECOMMENDATION

Regulating the SHE practice code

There should be a provision under the law to make it compulsory for all HGV operators to implement the standard Safety, Health and Environment (SHE) practice code. Failing to comply this law will result the operators license to be suspended or revoked. Walton, D. (2009) stated that SHE practice code shall include the standard drivers working hours, drivers defensive driving training, keeping documents on drivers records as well as the operators commitment in practicing SHE code.

Safety Passport

Safety passport is acting like a driver database stating his personal information, license, training records, previous employment, number of traffic offences committed, and others (Brussels 2007). Such information is useful for both driver and employer in keeping the record on safety aspects for a particular driver. Currently there few established HGV Operators do practice safety passport as part of its policy in drivers management.

Journey Management

This is a comprehensive study of a particular route linking from point A to point B along with proposing safety precautions for drivers in order to minimize risks while travelling. Risk management are evaluated for this route prior to be gazette to each driver including the accident prone areas (black spots), types of road and permitted speed limit. Various control elements are advised for drivers to adhere particularly on speed limit, rest areas and other precautions (Bowman, Z. 2010).

Standard Operating Procedures (SOP)

There should be a clear SOP in daily operations for drivers and safety practices are incorporated for each activity. For vehicle safety, a Pre departure checklist on the vehicle must be done prior to starting a particular journey. Any potential technical faulty must be promptly addressed and recorded. The other aspect is on drivers personal safety where Personal Protective Equipment (PPE) such as safety shoes, gloves, safety helmet, reflective safety jacket and goggle must be supplied to drivers and they are trained on its usage and purpose.

Safety Audit

HGV operators are advised to get certification from international accreditation body pertaining to the Occupational Safety and Health Act (OSHA) or OSHA18001. They will benefit a lot on good practice on safety and health as all important aspects on safety and health must be practiced for both the employee and employer (Shibuya, H., 2010). A periodical audit is conducted in assessing the safety practice be put in place and documents are well recorded and maintained. With such certification, it is internationally recognized and eventually it will spur the HGV operators to adopt and implement safety as part of their corporate culture (Belzer, M.H. 2008)

Revising HGV driving contents

It is timely for Malaysia to regularly review the existing commercial vehicle driving curriculum in response to the contemporary issues in order to ensure our drivers are more competent and professional, by updating with the latest driving approaches as well as incorporating good driving ethics (Jonah, B., et al 2009). Revising the HGV driving contents will enable the lawmakers to update and incorporate the contemporary aspects in HGV driving.

Refresher Training

Effort must be continuously be made to improve the drivers skills and knowledge from time to time by regulating the refresher training for all commercial and HGV drivers for a certain period of time. Arnold, P.K et.al (2007) highlighted that the process of learn and unlearn especially the experienced drivers should take place to make them aware that safety issues are evolve and they need to keep abreast with the changes.
Professional Drivers Driving Academy

In view of future shortage of commercial drivers, this kind of academy is relevant for its existence as a centre of excellence in producing professional drivers (Kinghorn, R.A. 2005). These drivers will be trained by the academy and once finished the course they will be hired as drivers on contract basis from the academy for any transport companies.

Single authority.

With the formation of Malaysia Logistics Council (MLC) in 2007, it was aimed at among others streamlining and harmonizing the various ministries and government agencies in regulating the logistics and transport sector. There should be a single authority in regulating and controlling the sector in order to improve the governance as well as to avoid any redundancies.

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BULK CARGO VESSEL SCHEDULING UNDER PORT CONGESTION CONDITION

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ABSTRACT

Sea shipping is a major mode of international freight transportation. Because of high capital investment and fierce market competition, effective ship management is an important part of running the business. Existing literature often omits port capacity from consideration when describing non-scheduled ship routing and scheduling optimization. This can lead to operational problems such as delays or missing pickup and delivery time windows when port congestion occurs and render the planned schedule ineffective. In some cases, the schedule may have to be scrapped altogether and is replaced by an ad hoc schedule that may not be very efficient to operate. The objective of this research is to develop a mathematical model and a solution approach for routing and scheduling of non-scheduled bulk cargo ship under port congestion condition. The model is formulated as a set partitioning model with side constraints. An algorithm is developed to generate feasible routings of each ship, of which port occupation times are recorded. These times are then captured in the model to ensure the number of ships simultaneously calling at each port does not exceed the port’s capacity. A special algorithm based on column and row generation techniques is developed to solve the model to optimality. Computational results based on test data from a tramp operator in Thailand shown practical applicability and significant benefits of the model.

KEYWORDS
Ship Routing and Scheduling, Bulk Cargo, Port Congestion, Set Partitioning

INTRODUCTION

Sea shipping is a major mode of international freight transportation. Because of high capital investment and high market competition, effective ship management is an important part of the business. This paper investigates the ship routing and scheduling problem for non-scheduled common operator (or tramp operator) in Thailand and proposes the model and algorithm for solving the routing and schedule problem under port congestion condition that can be applied to other tramp operators.

A tramp operator owns a fleet of ships and services transportation demands that arrive from customers mostly in a spot fashion. Sometimes tramp operator may engage in contracts of affreightment with their customers, whereby the operator agrees to service specified amount of cargo between specific ports within a specific time frame under a specified transportation rate. The main differentiation between the two types of customers is that a tramp operator may refuse a spot cargo, but not a contracted cargo.

Ship routing refers to the sequence of ports to be called during a voyage of a ship. For each cargo, there is a designated pair of set of loading and unloading ports. For example, in a simple operation, the entire volume of a cargo maybe loaded at one loading port and unloaded at another unloading port. In a more complicated operation, a cargo may be loaded at a port in its entirety but unloaded at a set of unloading ports; alternatively, a cargo may be loaded from a set of loading ports and destined for a single unloading port. Lastly, there may be multiple loading and unloading ports for a cargo. Thus, the sequence of calling ports is dictated by the cargoes to be lifted. For a tramp operator, the ship routing problem seeks to assign a given number of ships of different sizes to different cargo demands and simultaneously find sequences of calling ports for these ships so as to maximize the profit resulting from revenue from lifting the cargo and costs of ship operation and other costs.

While the ship routing problem primarily concerns with the sequence of calling ports to visit, ship scheduling problem seeks to specify the timing of each visit. The scheduling problem is clearly more complicated than the routing problem because the timing of each visit will dictate the feasible sequence of calling ports (in addition to loading/unloading restrictions mentioned in the previous paragraph).
In most cases, loading and unloading ports have time windows within which loading and unloading activities can occur. If activities occur outside of these time windows, additional costs may be incurred. Thus, planners have some flexibility when scheduling ships to take advantage of available time windows at different ports.

Port congestion occurs when there are more ships demanded entry to a port than that port’s capacity will allow. This causes delay and affects the planned schedule of the ships during operation. Such delay can propagate and affect all later cargoes of the affected ships. By incorporating potential congestions in the planning phase, the resulting schedule is more likely to be adopted and adhered to in the operation phase.

In this paper, we propose a mathematical model and a solution algorithm for solving the Integrated Ship Routing and Scheduling under Port Congestion Condition problem (ISRS-PCC) for tramp operators. We propose a binary integer programming (IP) formulation based on the set partitioning formulation with side constraints. We propose an algorithm to enumerate possible schedules and construct a set of feasible schedule candidates to be used in the IP model. Then the model is solved using a special algorithm based on column and row generation techniques.

In Section 2, we review related literature. We formalize the problem statement and give model formulation in Section 3, and describe our solution approach in Section 4. Computational results are reported in Section 5. We give conclusion and discussion in Section 6.

LITERATURE REVIEW

Ronen gives what might be considered the first comprehensive review of cargo ship routing and scheduling models and problems (Ronen, 1982) and a decade later, gives an updated review of the progress in this area (Ronen, 1993). Then in 2004, Christiansen, Fagerholt, and Ronen (2004) give the most recent comprehensive review of the topic. These three works chronically and systematically track the progress and development in ship scheduling and routing. Their findings begin by noting that the attention on ship routing and scheduling problem lags significantly behind those of other modes of transportation (e.g., land and air). They attribute this as a result of low visibility of this field, high uncertainty and flexibility nature of the problem, market volatility, and conservative nature of the industry.

Early development in this field is concentrated in industrial shipping industry, where ship operation is a part of a vertically integrated industry such as crude oil industry. Later the development follows in the liner shipping of general and containerized cargoes. Liner shipping operates on a fixed schedule with a fixed set of routes and relatively stable demands along those routes, and hence offers relatively consistent frequency over each route. Routing and scheduling for tramp shipping is similar to that of industrial shipping in that they both face varying demands and have short planning horizon, whereas liner shipping operates on a more stable demand routes and thus have longer planning horizon. The routing and scheduling problem for industrial and tramp shipping is considered as closer to an operational problem than a tactical problem (as is the case for liner operation). Therefore, the literature tends to consider the routing and scheduling for both industrial and tramp shipping together.

Christiansen, et al. (Christiansen, et., al., 2007) give detailed explanation for routing and scheduling problems for industrial and tramp shipping. They classify the operations and thus planning processes by first looking at whether consolidation of cargoes is allowed, i.e., full shiploads (as is the case in this paper) vs. multiple cargoes/products. When consolidation is allowed, they classify whether the cargoes or products are mixable in the same hold such as general cargoes, or non-mixable such as wet bulk cargoes, in which case the products require separate cargo compartment or holds, which themselves may be fixed or adjustable.

Full shipload shipping is studied by Brown, et al. (1987) for a major oil company, Fisher and Rosenwein (1987) for US Navy Military Sealift Command, and Bremer and Perakis (1992) for a crude oil company. Christiansen, et al. (2007) present an arc based formulation for solving the full shipload ship routing and scheduling problem built on a representative network, where nodes represent cargoes to be lifted and arcs represent ballast legs (repositioning leg with no revenue cargoes on board) from the unloading port of the previous cargo to the loading port of the next cargo. Only feasible or reasonable ballast legs are included in the network. The objective function is to minimize the sailing and port costs. The constraints are cargo coverage, conservation of ship flows, and time window constraints.

Other more complex models including some based on the set partitioning formulation are also presented in Christiansen, et al. (2007). Dantzig-Wolfe decomposition is often used to solve these complex models. For most of set partitioning based models, columns are generated a priori instead of using column generation algorithm to generate column on the fly. See Brown, et al. (1987) and Bronmo (2006) for example.
There are a number of extensions to the standard ship routing and scheduling problems in the literature. Fagerholt (2001) and Christiansen and Fagerholt (2002) present ship routing and scheduling problem with time windows. Fagerholt and Christiansen (2000) present an integrated routing and cargo hold allocation problem for use with ships with multiple flexible cargo holds. In all cases, the authors employ set partitioning formulation and solve their models with pre-generated columns.

Another interesting extension is in inventory routing problem, in which inventory decisions are incorporated and solved simultaneously with the routing problem. See Christiansen and Nygreen (1998) and Fox and Herden (1999) for example.

To the authors’ knowledge, there are no works in the literature that address the issue of port congestion at the routing and scheduling planning stage. Incorporating possible port congestion into the routing and scheduling planning stage may have significant value as it may help reduce the delay and disruption to the planned operation, both of which incur costs and create inconvenience for both customers and ship operators.

**PROBLEM STATEMENT AND MODEL FORMULATION**

In this section, we present the formal problem statement for the Integrated Ship Routing and Scheduling under Port Congestion Condition problem, discuss assumptions, and describe the IP formulation for the problem.

*Problem Statement*

In this paper, we consider the routing and scheduling problem for a tramp operator, who services both contracted and spot demands. The operator may refuse spot demands, but not contracted demands. These demands generate revenue per trip. Costs of operations are detailed in the appendix. The sailing times as well as sailing speeds are pre-specified so as to enable accurate cost calculation for the model (even though in actual operation, speed and sailing time may vary). Ships are not allowed to lift demands that exceed their capacity. Not all ships are allowed to traverse all legs due to range and other restrictions.

Port time windows are specified as one-sided time windows in the sense that arriving earlier than the beginning of the time windows is allowed but arriving later than the end of the time windows is not allowed. Ships arriving earlier than the specified time windows have to wait until the beginning of the time windows before loading/unloading operations can begin. A maximum waiting time for each port is specified. Port capacity is specified in term of the number of ships and port usage is determined by the number of ships presented at the port at any given time. Port capacity constraints are treated as hard. That is, we do not allow scheduling more ships into ports than their capacity allows.

We summarize the problem statement for the Integrated Ship Routing and Scheduling under Port Congestion Condition problem as follows.

*Given a fleet of ships and known full shipload contracted and spot demands between ports, find a profit maximizing routing and scheduling of ships such that port time windows and congestion conditions are observed.*

*Assumptions*

We make the following operational assumptions in our model and tests.

1. Cargo revenues are fixed and known by trip.
2. Sailing times and sailing speeds are fixed and known by leg, and are not affected by weights of the cargoes.
3. Loading and unloading times vary by cargo only.
4. While idle at port, ships incur small operation costs and an amount of penalty is also assessed to reflect the increased risk of having ships docked idly at ports other than home port. These costs vary by port only.
5. Maximum idle time for ships docked idly at port vary by port.

These assumptions are made due to data limitation and to mimic the planning of the test operator. They are not required by the model and can be relaxed readily when relevant data become available. The reason will be clear when we discuss the model formulation and solution algorithm later in this section.
Model Formulation

We first give definitions of sets, parameters, and variables.

Sets

- \( P \) is set of all ports indexed by \( p \).
- \( D \) is set of all spot demands (may be refused) indexed by \( d \).
- \( D' \) is set of all contracted demands (may not be refused) indexed by \( d \).
- \( K \) is set of all ships indexed by \( k \).
- \( S^k \) is set of all feasible schedules of ship \( k \) indexed by \( s \).
- \( T \) is set of all time intervals in a day discretized by a parameter \( h \) indexed by \( l \).

Parameters

- \( h \) is the control time discretization parameter, defined by the number of hours grouped together in a day. For example, if \( h = 6 \) hours, there are 4 time intervals \( |T| = 4 \) in a day.
- \( \alpha^h_{ds} \) is the anticipated number of other carriers’ ships that will dock at port \( p \) during time interval \( l \).
- \( M^P_d \) is the maximum number of ships that can dock at port \( p \) during time interval \( l \).
- \( \alpha^k_{ds} \) equals 1 when demand \( d \) is serviced by schedule \( s \) of ship \( k \); 0 otherwise.
- \( \delta^k_{ts} \) equals 1 when ship \( k \), sailing schedule \( s \), is presented at port \( p \) at time interval \( l \); 0 otherwise.
- \( c^k_s \) is the total cost of having ship \( k \) sails schedule \( s \).
- \( v_{st} \) is the total revenue from servicing demand \( d \).
- \( C^k_s \) is the total contribution of having ship \( k \) sails schedule \( s \). Note that \( C^k_s = \sum_{d \in D'} \alpha^h_{ds} v_{st} - c^k_s \).

Variable

- \( x^k_s \) equals 1 if ship \( k \) sails schedule \( s \); 0 otherwise.

The ISRS-CPP formulation can be written as follows.

Maximize
\[
\sum_{k \in K} \sum_{s \in S^k} C^k_s x^k_s
\]
(1)
subject to:
\[
\sum_{k \in K} \sum_{s \in S^k} \alpha^k_{ds} x^k_s = 1 \quad \forall d \in D'
\]
(2)
\[
\sum_{k \in K} \sum_{s \in S^k} \alpha^k_{ds} x^k_s \leq 1 \quad \forall d \in D
\]
(3)
\[
\sum_{s \in S^k} x^k_s \leq 1 \quad \forall k \in K
\]
(4)
\[
\sum_{k \in K} \sum_{s \in S^k} \delta^k_{ts} x^k_s + c^k_s \leq M^P_d \quad \forall p \in P, \forall t \in T
\]
(5)
\[
x^k_s \in \{0,1\} \quad \forall k \in K, \forall s \in S^k
\]
(6)

The objective function (1) is to maximize the total contribution for the ship operation. The contribution \( C^k_s \) is derived from having ship \( k \) sails schedule \( s \), whereby generating revenue \( v_{st} \) (if schedule \( s \) services demand \( d \)) and incurring the total cost of \( c^k_s \). Note that both revenue \( v_{st} \) and the total cost \( c^k_s \) can take on any functional forms that will realistically model the actual operation, including complex nonlinear forms. Constraints (2) and (3) ensure that each of the contracted demands is served exactly once and each of the spot demands may be served once, respectively. Constraints (4) ensure that each ship may sail only one schedule or none at all (in which case the ship is idle during this entire planning period). Constraints (5) capture the congestion condition. They ensure that during each time interval \( t \in T \), each of the ports \( p \in P \) does not receive more ships—owns \( \sum_{k \in K} \sum_{s \in S^k} \delta^k_{ts} x^k_s \) and others’ \( \delta^k_{ts} \)—than it is able to handle \( M^P_d \). Note that the number of Constraints (6) depends on the number of time intervals \( |T| \), which inversely depends on the time discretization parameter \( h \).
The control time discretization parameter $h_k$ is an influential parameter in the model because it controls the level of details and size of the model both in terms of the number of variables and the number of constraints. As $h_k$ gets smaller, the number of schedule alternatives (i.e., our decision variables) and time to generate them increase exponentially as we shall see later in Sections 4 and 5. Similarly, as $h_k$ gets smaller, the number of Constraints (6) increases proportionally with the increased number of time intervals ($|T|$).

Modeling each entire schedule for a ship as a single variable ($x^k_r$) is very powerful but computationally expensive. It is powerful because in this variable we can embed every detail of the schedule that the ship sails. These details can be simple information such as the feasible order and timing of calling ports, or very complicated non-linear information such as the nonlinear relationship between sailing speed and sailing time and costs. (In this paper, we assume sailing speeds and times as fixed due to data limitation but they can be relaxed if we have relevant information because of the structure of the variable that represents the entire schedule of a ship.) But these modeling flexibilities come with a price. To be able to capture all different decisions, we need exponentially large number of these variables.

**SOLUTION APPROACH**

In this section, we discuss first our proposed schedule generation algorithm, then the solution approach for our model.

**Schedule Generation Algorithm**

In our model, each variable $x^k_r$ represents a feasible schedule $r$ for ship $k$. We develop an effective heuristic that can enumerate varying numbers of feasible schedules to be included in the model depending on the fineness of time interval discretization required. We describe this heuristic in two stages—routing and scheduling.

**Input Data for Schedule Generation Algorithm**

Because the ISRS-PCC model is designed to function as an optimization tool employed in an ongoing environment, at the beginning of each planning horizon, each ship is designated one of the three possible statuses—*busy*, *ballast*, or *idle*. A busy ship is a ship that is currently servicing an active demand, a ballast ship is a ship that is currently being repositioned with no revenue cargo on board, and an idle ship is a ship that is currently docked idly at a port in the network. Each ship is different and has different capacity. Another important input is the list of cargo demands, some of which are mandatory (cannot be rejected) while others are optional (can be rejected). Each cargo demand specifies information about weight of the cargo to be lifted, *origin* and *destination* ports as well as their associated temporal information, specifically, *earliest pickup time*, *latest pickup time*, and *loading time* for the origin port, and *earliest delivery time*, *latest delivery time*, and *unloading time* for the destination port.

**Feasible Routing Generation**

From the ship status and the demand list, we can identify, for each ship $k$, a subset of the demand, called *possible demand set* (denoted $D^k$), which contains only the demands that can be serviced by this ship. A demand cannot be serviced by a ship if (i) the cargo weight exceeds the ship’s capacity, (ii) the ship cannot be ready at the origin port by the latest pickup time, or (iii) explicit restriction placed on the demand or on the ship prohibiting servicing a particular demand by a particular ship.

From each possible demand set $D^k$ of a ship $k$, we next determine the different permutations of the demands contained in $D^k$, each of which is called a *possible routing*. Note that if $|D^k| = n$, the number of possible routings that we will enumerate is $\sum_{i=1}^{n} n P_r$.

Given the possible routings for each ship $k$, we next filter out *infeasible routings*. An infeasible routing occurs if one of its *consecutive demand duplets* is infeasible. A *consecutive demand duplet* is the pairing of two consecutive demands in the sequence. (We are ignoring trivial cases where there is only one demand in the routing.) For illustration purposes, consider a consecutive demand duplet $s_i - s_j$, whereby demand $s_i$ is to be followed immediately by demand $s_j$. This duplet is *feasible* only if the ship in question can complete $s_i$ and $s_j$ in consecutive order while respecting all time windows constraints specified by $s_i$ and $s_j$, otherwise it is *infeasible*. If an infeasible duplet is found...
within a routing, that routing is marked infeasible and removed from further consideration.

At this point, we have created for each ship $k$ a set of all feasible routings.

**Feasible Schedule Generation**

For each feasible routing found from the previous step, we plot the pickup and delivery time windows for each demand in that routing on the space-time diagram. We create *time boundaries* for each sailing leg in that routing using the earliest pickup, latest pickup, earliest delivery, latest delivery, and allowable wait time information. These time boundaries specify the time windows within which the specified ship can sail without violating time windows at both ends of the leg.

Once the boundaries are established for each leg in the routing, time-varying *copies* of each leg are created within the time boundaries. The time discretization parameter $h$ specifies how far apart each consecutive copy will be placed. For example, if $h = 24$ hours, each consecutive copy will be 24 hours apart on the space-time diagram.

A *feasible schedule* can now be created by joining consecutive (copies of) legs along the space time diagram, allowing for loading and unloading times where appropriate. Figure 1 gives an example of a feasible schedule being created from joining consecutive copies of (loaded and ballast) legs in the routing. In this example, $h = 24$ hours, allowable wait time is 24 hours, and loading and unloading times are one hour.

![Figure 1](image)

**FIGURE 1**

A FEASIBLE SCHEDULE CREATED BY JOINING CONSECUTIVE LEGS ON A SPACE-TIME DIAGRAM.

It can be seen that a large number of feasible schedules can be created from one feasible routing. In fact, if there are $l$ legs in a routing and for each leg $i$ there are $c_i$ copies, then the bound on the number of feasible schedules that can be generated from a single routing is equal to $\prod_{i=1}^{l} |c_i|$. Thus, it can be seen that for any decent size operations, the number of feasible schedules can be prohibitively large especially if very fine time discretization is employed. We test and report the effects of the time discretization in our computational test.

Note that this is a succinct presentation of the heuristics developed. Many details are omitted from this presentation. Interested readers are referred to Lohatepanont and Kongsermsup (2010) for more detailed explanation.

**Solution Algorithm for ISRS-PCC**

We develop a special algorithm based on column and row generation techniques for solving the ISRS-PCC model. The algorithm iteratively solves the model using column and row generation techniques and is guaranteed to be finite. The worst scenario is all columns and rows are added back.
COMPUTATIONAL TESTS

Our implementation of the ISRS-PCC model is in C# on an Intel based PC with 3 GB RAMs. IBM ILOG CPLEX 12.1 callable library is used as the optimization engine.

We perform three sets of computational tests to:
1. demonstrate the solvability of the model and the performance of the algorithm,
2. examine the growth of the model with respect to different input parameters, and
3. compare the model’s results to the actual historical plans by planners.

In the first test, five data sets are used. Data Set 1 is the smallest test set. Data Set 2 represents the actual operation of the case company. Data Set 3 simulates a situation where more demands are concentrated in a certain period during the planning horizon. Data Set 4 simulates a situation where ship sizes are smaller than usual. Data Set 5 is an expanded data set, in which most aspects of operations are assumed to be larger than normal. The planning horizon is 14 days in all cases except Data Set 5, in which planning horizon is 21 days.

Table 1 shows the results from our computational tests. For each data set, four values of time discretization parameter ($h$) are used, namely, 24, 12, 6, and 3 hours to test its impact on the quality of the solution as well as the size and runtime of the model. On Data Sets 1 and 2, the time discretization parameter has no impact because the model gives essentially the same solution regardless of the value of $h$. Specifically, for each data set, the optimal routings are the same but the optimal schedules vary only slightly, resulting in slight increases in the profit when we discretize the time interval more finely.

### TABLE 1

<table>
<thead>
<tr>
<th>Data Set</th>
<th>$h$ (hr)</th>
<th>Fea. Sch. Gen. Time (sec)</th>
<th>Nominal No. of Columns</th>
<th>Nominal No. of Rows</th>
<th>Sol. Time (sec)</th>
<th>No. of Rejected Demands</th>
<th>No. of Idle Ships</th>
<th>Profit (USD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>24</td>
<td>0.047</td>
<td>242</td>
<td>63</td>
<td>0.008</td>
<td>3</td>
<td>-</td>
<td>84,304</td>
</tr>
<tr>
<td></td>
<td>12</td>
<td>0.078</td>
<td>598</td>
<td>135</td>
<td>0.012</td>
<td>3</td>
<td>-</td>
<td>84,370</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>0.158</td>
<td>1839</td>
<td>255</td>
<td>0.058</td>
<td>3</td>
<td>-</td>
<td>84,375</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>0.33</td>
<td>6362</td>
<td>495</td>
<td>0.262</td>
<td>3</td>
<td>-</td>
<td>84,568</td>
</tr>
<tr>
<td>2</td>
<td>24</td>
<td>0.488</td>
<td>1157</td>
<td>83</td>
<td>0.018</td>
<td>4</td>
<td>-</td>
<td>150,052</td>
</tr>
<tr>
<td></td>
<td>12</td>
<td>0.55</td>
<td>2950</td>
<td>143</td>
<td>0.024</td>
<td>4</td>
<td>-</td>
<td>150,198</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>1.052</td>
<td>9575</td>
<td>263</td>
<td>0.462</td>
<td>4</td>
<td>-</td>
<td>150,218</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>3.436</td>
<td>34639</td>
<td>503</td>
<td>8.974</td>
<td>4</td>
<td>-</td>
<td>150,263</td>
</tr>
<tr>
<td>3</td>
<td>24</td>
<td>1.458</td>
<td>928</td>
<td>85</td>
<td>1.205</td>
<td>6</td>
<td>-</td>
<td>86,040</td>
</tr>
<tr>
<td></td>
<td>12</td>
<td>2.37</td>
<td>4,487</td>
<td>145</td>
<td>1.592</td>
<td>5</td>
<td>-</td>
<td>95,238</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>3.186</td>
<td>34,298</td>
<td>265</td>
<td>4.975</td>
<td>5</td>
<td>-</td>
<td>95,289</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>12.885</td>
<td>370,746</td>
<td>505</td>
<td>32.675</td>
<td>4</td>
<td>-</td>
<td>106,816</td>
</tr>
<tr>
<td>4</td>
<td>24</td>
<td>4.453</td>
<td>2,493</td>
<td>85</td>
<td>28.322</td>
<td>3</td>
<td>3</td>
<td>94,894</td>
</tr>
<tr>
<td></td>
<td>12</td>
<td>5.512</td>
<td>8,718</td>
<td>145</td>
<td>30.512</td>
<td>3</td>
<td>3</td>
<td>94,946</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>12.683</td>
<td>61,834</td>
<td>265</td>
<td>48.683</td>
<td>3</td>
<td>3</td>
<td>94,965</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>54.342</td>
<td>456,332</td>
<td>505</td>
<td>156.46</td>
<td>2</td>
<td>2</td>
<td>100,652</td>
</tr>
<tr>
<td>5</td>
<td>24</td>
<td>5.563</td>
<td>2,569</td>
<td>90</td>
<td>30.443</td>
<td>3</td>
<td>-</td>
<td>142,861</td>
</tr>
<tr>
<td></td>
<td>12</td>
<td>9.631</td>
<td>12,855</td>
<td>150</td>
<td>42.124</td>
<td>3</td>
<td>-</td>
<td>142,887</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>18.782</td>
<td>102,073</td>
<td>270</td>
<td>62.654</td>
<td>3</td>
<td>-</td>
<td>142,913</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>88.443</td>
<td>1,058,747</td>
<td>510</td>
<td>238.648</td>
<td>3</td>
<td>-</td>
<td>142,942</td>
</tr>
</tbody>
</table>
In Data Set 3, a different phenomenon is observed. As we decrease \( h \), improved solutions are observed leading to significant jump in profit. Specifically, the solution when \( h = 12 \) is different from the solution when \( h = 24 \) both from routing and scheduling perspectives. But in going from \( h = 12 \) to \( h = 6 \), the optimal routing does not change whilst the optimal schedule changes slightly (similar to what happened in Data Sets 1 and 2). When we decrease \( h \) further to 3 hours, however, another significant increase in project is observed resulting from yet another change in routing and scheduling. Recall that we assume more demands in this data set, hence more demands are being rejected due to capacity constraints. Notice also as the routing and the scheduling changes, the number of rejected demands changes.

Data Set 4 simulates mismatch between ship and cargo sizes. That is, we assume that the ship size is on average too small for the cargo demands. Further, we assume that cargoes are not to be split; that is the entire volume of the demand must be shipped all at once in the same ship. This puts a lot of strain on the routing and scheduling because larger ships are being sought after whilst smaller ships are not being utilized. The optimal solution from the model confirms this observation. Note that when \( h = 3 \), an improved solution is found that differs from other solutions in this data set. Note also that smaller ships are being stationed idly at ports due to size mismatch as described.

Data Set 5 is the largest data set with the longest planning horizon of 21 days. Increasing the planning horizon has significant effect on the size of the model because the number of possible routings increases as the schedule looks further into the future. We, nonetheless, are able to solve this large size model using the solution algorithm proposed in just less than 4 minutes.

To examine the performance of the solution algorithm further, let us consider Table 2, which reports statistics from the runs with \( h = 3 \) from Table 1. It shows that for large and difficult problems (Data Sets 4 and 5), the algorithm spends significantly more iterations in the column generation loop and generates approximately 28% of the columns back in the worst case tested. Row generation is even more effective. Only 6% or the total number of rows is generated in four iterations in the worst case tested. In all cases, excellent optimality gaps are achieved in short time. (Solution times are reported in Table 1.) Table 2 shows convincingly that the column and row generation is working well for the ISRS-PCC model.

### TABLE 2

**PERFORMANCE OF COLUMN AND ROW GENERATION**

<table>
<thead>
<tr>
<th>Data Set</th>
<th>Column Generation</th>
<th></th>
<th>Row Generation</th>
<th></th>
<th></th>
<th>Optimal Gap</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Iter.</td>
<td>Gen’d Cols</td>
<td>Nominal No.</td>
<td>%</td>
<td>Iter.</td>
<td>Gen’d Rows</td>
</tr>
<tr>
<td>1</td>
<td>4</td>
<td>558</td>
<td>6,362</td>
<td>8.77%</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>6</td>
<td>2,945</td>
<td>34,639</td>
<td>8.50%</td>
<td>3</td>
<td>21</td>
</tr>
<tr>
<td>3</td>
<td>20</td>
<td>9,945</td>
<td>370,746</td>
<td>2.68%</td>
<td>4</td>
<td>28</td>
</tr>
<tr>
<td>4</td>
<td>22</td>
<td>125,473</td>
<td>456,332</td>
<td>27.50%</td>
<td>2</td>
<td>12</td>
</tr>
<tr>
<td>5</td>
<td>34</td>
<td>230,588</td>
<td>1,058,747</td>
<td>21.78%</td>
<td>4</td>
<td>18</td>
</tr>
</tbody>
</table>

The last test is to compare the model’s solution to the actual historical operation. Table 3 gives the details of the data sets used as well as the comparison between the model’s and planner’s solutions. In two of the three cases, the model’s solution can provide better financial results while ensuring that no delays from congestion occur. In Data Set C2, the model provides the schedule with slightly less profit but with no delays in operation. Granted that the comparison shown in Table 3 is not exact, but at a minimum it does show the applicability and potential of the ISRS-PCC model in real life operations.
### TABLE 3
**COMPARISON BETWEEN MODEL’S AND PLANNER’S SOLUTIONS**

<table>
<thead>
<tr>
<th>Data Set</th>
<th>C1</th>
<th>C2</th>
<th>C3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Ships</td>
<td>15</td>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td>Average cargo weights (kg)</td>
<td>1,682</td>
<td>1,596</td>
<td>1,617</td>
</tr>
<tr>
<td>Number of Ports</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Number of Demands</td>
<td>8</td>
<td>10</td>
<td>15</td>
</tr>
<tr>
<td>Port Capacity (Ships)</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Planning Horizon</td>
<td>15</td>
<td>15</td>
<td>45</td>
</tr>
<tr>
<td>Model’s Profit (USD)</td>
<td>99,547</td>
<td>85,224</td>
<td>204,433</td>
</tr>
<tr>
<td>Model’s Congestion (Ship-Day)</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Planner’s Profit (USD)</td>
<td>85,177</td>
<td>88,681</td>
<td>180,149</td>
</tr>
<tr>
<td>Planner’s Congestion (Ship-Day)</td>
<td>8</td>
<td>8</td>
<td>12</td>
</tr>
<tr>
<td>Profit Difference</td>
<td>14,370</td>
<td>(3,456)</td>
<td>24,283</td>
</tr>
<tr>
<td>% Profit Difference</td>
<td>15.56%</td>
<td>(3.90%)</td>
<td>12.63%</td>
</tr>
</tbody>
</table>

### SUMMARY

In this paper, we investigate the *Integrated Ship Routing and Scheduling under Port Congestion Condition* problem (ISRS-PCC) and propose an integer program based on the set partitioning formulation as well as an effective and efficient solution algorithm for solving the ISRS-PCC model. The formulation is presented showing how the port congestion constraints can be captured in the model as side constraints. We propose a solution approach comprising of two algorithms—the schedule generation heuristic and the column and row generation algorithm for solving the ISRS-PCC model. Computational tests are presented demonstrating three key aspects of the model, namely, the solvability of the model and the performance of the algorithm, the sensitivity of the model with respect to input parameters, and the applicability of the model’s solution in real life. The ISRS-PCC model is shown to have superb solvability with the developed column and row generation algorithm. The largest instance tested with over one million nominal variables is solved in less than four minutes. The model is further tested and found to be sensitive to the increase in the number of demands as well as the increase in the number of ships, but not as sensitive to the increase in the number of ports. Lastly, actual data is used to test model and to compare the model’s solution to the planner’s solution. We found that the model’s solutions could avoid all delays associated with the actual operation encountered by the planners, while managed a slight increase in profit in two of the three cases tested. While this test is far from conclusive, it does demonstrate the applicability and potential of the proposed ISRS-PCC model.

The authors summarize the contributions of this paper as follows. First, we present an integer linear programming model for integrated routing and scheduling of cargo ship under port congestion condition as well as an effective and efficient solution algorithm for the model. Next, we demonstrate through our computational tests that the ISRS-PCC model is able to generate optimal and practical routing and scheduling for tramp operators taking into account potential congestion spots in the network.
REFERENCES


A SYSTEMIC MODEL FOR THE INTERDEPENDENCIES BETWEEN LOGISTICS STRATEGY AND TRANSPORTATION MOVEMENTS

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A SYSTEMIC MODEL FOR THE INTERDEPENDENCIES BETWEEN LOGISTICS STRATEGY AND TRANSPORTATION MOVEMENTS

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ABSTRACT

This paper’s purpose is to describe how logistics strategy, transportation and environmental impacts do interrelate with each other. The logistics strategy developed by a company has huge effects on the operative logistical level of the company and deeply interrelates with transportation decisions as transport mode, frequency, utilization etc. are affected. The definition of a logistics strategy is essential for gaining advantages and being able to differentiate from competitors in the market. Therefore it is this paper’s objective to present a new approach based on a causal loop diagram trying to picture and model the interrelationships between logistics, transportation and the environment from a systemic point of view with the overall goal of higher transport efficiency and shifts within modal split from truck to other modes of transport for a sustainable and environmental friendly movement of goods.

KEYWORDS
Logistics Strategy, Transportation, Environment

INTRODUCTION

Globalization, European integration and the liberalization of transport markets have created conditions of production and distribution which have led firms to profoundly change their logistics concepts. This has major repercussions on demand behavior in freight transport (Bolis et al., 2003).

The dependence of logistics on efficient and well organized transport infrastructure and technology is well and well documented. The implications of logistics for transport are, however, much less researched (Jespersen et al., 2004). Drewes Nilsen et al. (2003) state that it is still difficult to determine the actual relationship between logistical structures and transport as it is seen on the one hand as an integrated part of the logistical system and on the other hand as an activity embedded in its own systemic logic in transport chains. The relationship between logistic organization and transport is not straightforwardly established. Nevertheless, being able to link strategies of logistical organization with changes in transport would be of importance as it could support industries development of more environmentally sustainable supply chains.

Freight transport is affected by a broad range of corporate decisions. These decisions influence the transport operation in different ways. Logistical decisions affecting freight transport operations are made at four levels (McKinnon et al., 1996): Strategic, commercial, operational and tactical decisions. The growth of freight traffic is the result of a complex interaction between decisions made at different company levels. Generally the influence direction can be described as a top down (from strategic level to the operational level). The purpose of this paper is to define the term logistics strategy, identification of the parameters or determinants of a logistics strategy which do influence transport operations and the development of a causal loop diagram to picture these interrelationships as a basis for deriving the impacts on environment.

STRATEGY VS. LOGISTICS STRATEGY

“Indeed, there are almost as many different definitions about strategy as there are books written” (Barney, 1996). Also Marchazina et al. (2005) see strategy as a wide used term in science and industry. Two basic strategy “understandings” can be identified; on the one hand strategies can be seen as rational planned action bundles and on the other hand as a basic pattern in the flow of decisions and operations. Gälweiler (2005) characterizes strategy as a specific
thinking methodology or a specific procedural method for the development of behavior at the best possible level. Strategy can be derived from the old Greek word "stratego" ("stratos" = something that covers at least everything; "igo" = do or act). Strategies target to obtain competitive advantages to secure the longlasting survival of the company in the market (Schulte, 2008).

To define the term logistics strategy we first have to declare the difference of logistics and Supply Chain Management (SCM) within this paper. Harrison et al. (2008) differentiate the term logistics and Supply Chain Management by the following definitions:

- Supply Chain Management is the planning and controlling of all the business processes – from end customer to raw material suppliers – that link together partners in a supply chain in order to serve the needs of the end customer.
- Logistics is the task of coordinating material flow and information flow across the supply chain.

Logistics has for Harrison et al. (2008) both a strategic (long term planning) and managerial (short- and medium-term planning and control) aspects.

Walters (2007) defines SCM as the series of activities and materials – both tangible and intangible – move through on their journeys from initial suppliers to final customers. Logistics is in his point of view the function responsible for moving materials through their supply chains. He states that there are different opinions about how to distinguish those terms. Christopher (1998) defines the field of activities of logistics in coordinating the flow of materials and information that extend from the market place through the firm and its operations and beyond that to suppliers. Within this paper, logistics is seen as the task of coordinating the material and information flow in and between companies and is therefore deeply interrelated with transportation.

Hayes et al. (1984) define the term of logistics strategy as: “The set of guiding principles, driving forces and ingrained attitudes that help to coordinate goals, plans and policies and which are reinforced through conscious and subconscious behavior within and between partners across a network.”

Logistics strategy planning is a complex process that requires an understanding of how the different elements and activities of logistics interact in terms of trade-offs and the total cost to the organization. Furthermore, it is always a challenge for logistics strategy planners to develop a series of logistics strategies for different clients, integrating manpower, facilities and workflow in the logistics strategies to complement other clients’ logistics strategies (Chow et al., 2005). Considering Fabbe-Costes et al. (2007), the classic approach to formulate a logistics strategy begins with the firm’s overall strategy and then defines the logistics strategy that will enable it to reach its objectives; logistics strategy appears as a subset of the overall strategy. Generally the formulation of a logistics strategy can be expressed by three classic concepts of strategy: the profession, the mission and the objectives. The authors state that formulating a logistics strategy somebody has to define:

- The ranges of movement that it produces and how it produces them (technologies, know-how, organization);
- To whom they are directed (internal or external clients) and the needs that they satisfy;
- The kind of performance it aims at and the targeted level of that performance.

There are three different types of strategies to diversify, the corporate strategy, business or business unit/competitive strategy and functional area strategies (Marchazina et al., 2005). Schulte (2008) distinguishes within a company three different levels, the corporate, business unit and functional level. The development of a strategy affects a company on these three levels. At the corporate level the definition of different business levels/units is developed. At the business segment level the definition of the business or competitive strategy (differentiation, cost leadership and segmentation) is evolved whereas at the functional level of a company, the different areas of a company like marketing, logistics, production etc. are strategically oriented towards fulfilling the business/competitive strategy. The business strategy is especially since Porter (1996) also called as generic competitive strategies in the focus of strategy research. Schulte (2008) developed in dependence on Wheelwright and Hayes (1985) a four step model, describing the influence of logistics on strategy within a company.

Companies on step 3 or 4 see logistics activities as an active part of supporting the company’s success and competitive advantages. Not every logistical decision can be considered as a strategic decision. Perl et al. (1988) divide logistical decisions into strategical, tactical and operational decisions. Wanke et al. (2003) state in their paper that logistical decisions on a strategic level are for instance make or buy decisions, push vs. pull inventory deployment logic and inventory centralization vs. inventory decentralization. As we are mainly interested in logistical decisions affecting transport, McKinnon (2003) for example, divided logistical decisions into four different levels, strategic, commercial, operational and tactical decisions. He states that the growth of freight traffic is the result of a complex interaction between decisions made at these levels.
PARAMETERS

There cannot be found a clear definition about parameters of a logistics strategy within literature. Within the authors view, parameters can be defined as important “parts” of a logistics strategy when developing it with influence on transportation operations. The literature study was based on a ranking of two papers analyzing the importance of journals based on their usefulness and citations. The first paper by Menachof et al. (2009) developed a ranking of Journals with SCM focus. Those papers relevant for transportation issues were conducted as useful for this research study and considered for research. The second paper by Kumar et al. (2004) ranked the most important journals in the logistics and transportation field. Both rankings were taken as basis for literature review. Nevertheless, due to the research, some other journals were found and added to the journal list for completeness.

TABLE 1
REVIEWED JOURNALS

<table>
<thead>
<tr>
<th>Journals</th>
<th>Authors</th>
<th>Period</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transportation Science</td>
<td>Menachof et. al (2009); Kumar et. al (2004)</td>
<td>1990 - 2010</td>
</tr>
<tr>
<td>Production and Inventory Management Journal</td>
<td>Kumar et. al (2004)</td>
<td>1990 - 2010</td>
</tr>
<tr>
<td>Transportation Quaterly</td>
<td>Kumar et. al (2004)</td>
<td>1990 - 2010</td>
</tr>
<tr>
<td>International Journal of Production Economics</td>
<td>added by authors</td>
<td>1990 - 2010</td>
</tr>
<tr>
<td>Journal of Transport Geography</td>
<td>added by authors</td>
<td>1990 - 2010</td>
</tr>
<tr>
<td>Transport Policy</td>
<td>added by authors</td>
<td>1990 - 2010</td>
</tr>
<tr>
<td>Transportation Review</td>
<td>added by authors</td>
<td>1990 - 2010</td>
</tr>
<tr>
<td>Supply Chain Management Review</td>
<td>added by authors</td>
<td>1990 - 2010</td>
</tr>
</tbody>
</table>

Suitable papers were analyzed within references on used books, monograph and dissertations to guarantee completeness and quality. Within these Journals and added literature, about 80 papers were analyzed and as a result nine relevant papers were identified as useful for the research aim. These papers were analyzed on describing logistical indicators affecting transportation which are basis of or influenced by logistics strategies. The named indicators were analyzed by a content analysis to summarize them into “aggregated” terms. The following table gives an overview of the mentioned logistical parameters affecting transportation.
TABLE 2
IDENTIFIED PARAMETERS WITHIN LITERATURE

<table>
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<tr>
<td>indicator</td>
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<td></td>
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<tr>
<td>product design</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
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<tr>
<td>product range</td>
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<td>x</td>
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<td></td>
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<tr>
<td>global vs. local sourcing</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>single vs. multiple sourcing</td>
<td></td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
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<tr>
<td>centralised/decentralised manufacturing</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
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<tr>
<td>centralised/decentralised distribution</td>
<td></td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
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<tr>
<td>Outsourcing/make or buy</td>
<td></td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
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<td>x</td>
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<td>frequency</td>
<td></td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
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<tr>
<td>flexibility</td>
<td></td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
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<tr>
<td>vehicle routing</td>
<td></td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>inventory management</td>
<td></td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>packaging</td>
<td></td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>consolidation</td>
<td></td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>make to stock make to order</td>
<td></td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
</tbody>
</table>

The following table gives a short definition about the different “aggregated” terms used for developing the causal diagram (Gabler, 2000):

TABLE 4
DESCRIPTION OF PARAMETERS AND CATEGORIZATION

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>product design</td>
<td>procurement strategy where needed material for production is either sourced global or local</td>
</tr>
<tr>
<td>product range</td>
<td></td>
</tr>
<tr>
<td>global vs. local sourcing</td>
<td>one production plant or multiple production plants</td>
</tr>
<tr>
<td>single vs. multiple sourcing</td>
<td></td>
</tr>
<tr>
<td>centralised/decentralised manufacturing</td>
<td></td>
</tr>
<tr>
<td>centralised/decentralised distribution</td>
<td></td>
</tr>
<tr>
<td>make to stock make to order</td>
<td>number of deliveries to customer(s) within a specific period</td>
</tr>
<tr>
<td>frequency</td>
<td>number of deliveries to customer(s) within a specific period</td>
</tr>
<tr>
<td>flexibility</td>
<td>ability and speed of a system to adapt to systemic or environmental changes</td>
</tr>
<tr>
<td>vehicle routing</td>
<td>transport route planning supported by algorithm or heuristics</td>
</tr>
<tr>
<td>inventory management</td>
<td>activities within storage processes</td>
</tr>
<tr>
<td>packaging</td>
<td>activities within storage processes</td>
</tr>
<tr>
<td>consolidation</td>
<td>bundling of logistical entities for using synergy effects</td>
</tr>
</tbody>
</table>

As mentioned above, McKinnon et al. (2003) divided four different levels of decision making within logistics, strategical, commercial, operational and functional levels. Van Goor et al. (1996) divide logistical decisions into strategical, tactical and operational levels. Within this research work, the parameters are divided into two groups: strategical and operative decisions. Strategical decisions refer to long-term planning (Harrison et al., 2008) whereas operational level considers short term and day to day decisions. In table 4 the first 7 indicators are defined as strategical decisions, as product design, numbers of distribution centers, global vs. local sourcing etc. usually refer to longer periods than the grey marked parameters do. Nevertheless some indicators can have both, a strategic and operational level and...
depends on definition and research question. The developed operational indicators are influenced by strategic parameters as e.g. the decision of management for single sourcing could limit the possibilities of consolidation as well as flexibility as the company is dependent on the single supplier. Therefore we concentrate on the operative parameters and their interrelationships with the transport indicators as given a strategic decision, the operational indicators are affected and therefore directly or at least indirectly influence transportation operations.

TRANSPORTATION PARAMETERS

Drewes Nielsen et al. (2003) developed four transport indicators which are showing the impact of changes in logistics on transport. In their research they analyzed the impact of changes in logistical organization on these parameters; nevertheless these developed indicators are also functional describing the impacts on transport when changes in operational parameters of logistics strategy occur:

- Transport mode
- Transport distance
- Transport efficiency
- Transport content

Transport mode describes changes for example from lorry to rail or inland waterway transportation. The other three indicators consider a specific transport mode. Transport distance is the ratio between tone kilometers and payload of a haul. Transport efficiency – the average payload is defined as the ratio between tone kilometers and vehicle kilometers. Transport content can be divided into the transport content of a given transport which is described by the ratio of average length of a haul and the average payload measured in tone kilometers; on the other hand the transport content of a specific good can be measured as the is the weighted sum of the transport content of all individual transports used in the process of manufacturing. For example an increase of transport content can therefore result due sourcing and marketing in a wider area or more inefficient transport (Drewes Nielsen et al., 2003). In Comparison to the more “common” indicators of transport like vehicle kilometers and tone kilometers, the developed indicators make it possible to relate transport to a specific product or production (transport content) and give the possibility to distinguish between two aspects of growth in transport, logistical reach (transport distance) and organization of transport (transport efficiency).

As three of the transport indicators are built through “payload” and “vehicle kilometers”, these “building indicators” are implemented into the model. In a later step, the described parameters can be calculated through those two. By improving these indicators (increasing efficiency and content, reducing distances and switching mode from lorry to rail and inland waterway) more sustainable transportation movements could be realized.

CAUSAL DIAGRAM

Causal loop diagrams (CLDs) are a kind of systems thinking tool. These diagrams consist of arrows connecting variables (things that change over time) in a way that shows how one variable affects another. Each arrow in a causal loop diagram is labeled with a “+” or an “-”. “+” means that when the first variable changes, the second one changes in the same direction, “-” means that the first variables causes a change in the opposite direction in the second variable (Pegasus Communications, 2011).

Figure 1 should illustrate the point of view of the model within a business process. As complexity would become too high, within this research step, a traditional transportation process from producer to retailer via a freight forwarder is considered. Figure 2 should illustrate the interdependencies between the operative parameters of a logistics strategy and the transport indicators and serve as a basis for the realization of the quantitative model.

FIGURE 1
BUSINESS PROCESS FOR THE MODEL
The two most interesting parameters within this diagram are “payload” and (vehicle)-“kilometers” as they serve as the main variables to calculate the already described transport parameters where the influences and outcomes can be measured.

If we start at the indicator “consolidation” payload or utility of a transport vehicle are influenced positive. Specified, if a company emphasizes consolidation of transport movements, payload or utility of a transport vehicle increases normally. The following relation is that a higher amount of payload does improve the possibility to change to another transport mode. This is if payload increases, rail transportation is easier to realize, in the opposite, if payload decreases, truck transportation is favored (shift from truck transportation to rail or inland waterway as these modes are considered as environmentally more sustainable transport modes than lorries). A change to another transport mode like e.g. rail has a negative impact on flexibility of transportation operations because truck transportation is generally seen as the most flexible transport mode compared to rail and therefore has a positive correlation on flexibility. An external factor which is implemented by the authors is the parameter “Lead Time” as it acts as the “time related” parameter which also plays an important role considering the impact on truck or rail transportation. E.g. a shorter “Lead Time” usually increases or favours truck transportation. Flexibility of shipment has a negative causal relation with consolidation as the possibility to react as fast as possible to customer requirements is of high priority, consolidation of transport movements through bundling would reduce the flexibility as higher waiting times and organizational efforts are the result. Therefore, if a company prioritizes flexibility, the impact on consolidation is negative. The other negative correlation of flexibility can be found with inventory management (=aiming for low stock levels). High shipment flexibility usually assumes higher inventory stocks to fulfill customer requirements at the highest service level. The negative relation in this research work results from the assumption that a company generally aims for having low inventory levels to reduce stock costs. High shipment flexibility usually leads into higher inventory levels. Logistics concepts like “Just in Time”, “Vendor Managed Inventory” or make to order favour low inventory levels and therefore have a positive polarity with (shipment) frequency as a lot of inventory stock is shifted “onto the transport mode” as well as the company aims to bring out materials from the inventory as fast as possible. On the one hand, the higher the number of shipment frequencies is, the amount of (vehicle-) kilometers increases. On the other hand the influence on consolidation is negative as high frequencies of shipments make consolidation operations more difficult. Another indicator which has to be taken into account is if companies do outsource their transport operations or not. If they do not outsource it, they have the power to bundle or consolidate shipments. Additionally the company can influence the flexibility of their shipments and therefore the influence can be described by a positive correlation.
CONCLUSIONS

This paper aims to describe the interrelationships between logistics strategies and transportation. After deriving a definition of a logistics strategy, strategic parameters of a logistics strategy were identified via a broad literature review. The identified parameters were divided into strategic and operative parameters. Those with a strategic focus are treated as constant or already “given” for the developed model whereas the operational parameters are treated as those influencing transportation indicators and directly result from the strategic ones. These indicators were linked to each other by the development of a causal loop diagram. The developed model is a first step within this research work and has therefore to be treated carefully. The next steps within this research work are to discuss this model via expert interviews to clarify the developed interdependencies as well as improve the causal loop diagram as a whole. After this development process, the following step is to transform the causal loop diagram into a so called “stock and flow diagram” which should serve as a basis for the quantitative modeling in future. Nevertheless, this work shows the complexity within the interdependencies of logistics and transportation and tries to fill a part of the existing gaps to improve transportation efficiency, -distances, -modes and –content for more sustainable transportation in future.

ACKNOWLEDGEMENTS

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REFERENCES


DEVELOPMENT OF A SIMULATION MODEL TO MANAGE THE FULL TRUCKLOAD ENHANCING ENERGY EFFICIENCY OF TRUCKS

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ABSTRACT

The objective of this study is to develop a simulation program for analyzing full truckload operation under uncertain demand and loading/unloading times. Given a dataset provided by a truckload carrier in Thailand, the study employs the commercial package named “ExtendSim8” to simulate the operation of the case company that serves its customers from two terminals. The complete simulation model consists of 6 sub-models: (1) Demand Arrival model (2) Line-haul Operation model (3) Loading Operation model (4) Unloading Operation model (5) Truck assignment model and (6) Truck Subcontracting model. The developed simulation model can be used to assess the trucking cost and fuel consumption cost under alternative truck assignment strategies while considering the implications of randomness in customer demands and loading/unloading times.

KEYWORDS
Full Truckload, Transportation Cost, Simulation, Energy Efficiency of Trucks

INTRODUCTION

Truck transportation is the backbone of freight transportation in Thailand which truckload service plays a major role because of a large proportion. The truckload carrier market is highly competitive due to the ease of market entry resulting from the intrinsic simplicity of Full Truckload operation that provides point-to-point trucking services compared to Less-Than-Truckload (LTL) operation that requires a network of local terminals for consolidation and break-bulkling activities. Among highly competitive situation in the market; moreover, transportation carriers are also distressed by uncertainty conditions in daily operation that originated from both external and internal factors. The most significant sources of uncertainties in truckload operation are variability in demand and the uncertain time required to complete the delivery including waiting time at the customer’s premises, uploading and unloading time. These uncertainty factors can give rise to the risk of potential loss from unusual equipment requirements or extreme levels of use.

Besides major uncertainty conditions as identified above, another important crisis factor such as fuel price fluctuation also highly affect to their daily operation cost as well. Truck carriers need to manage their own truck utilizing energy efficiently. However, making any decisions without research information, analysis, and strategic evaluation can
be leaded to the company losing profit. To enhance energy efficiency of trucks, truckload carriers need to have an effective decision tool to assist them to evaluate truck fleet management strategies before applying in daily operation.

Hence, a simulation model is developed in this study to capture the stochastic patterns inherent in the operation of full truckload networks. A simulation model is used to evaluate the operational costs and performance at varying truck assignment strategies. Simulation results can imitate this situation and provide this information to carriers before making any decisions.

The content of this paper is organized as follows. First, the literature review. We then described the research framework using full truckload simulation model. A data analysis is provided in the next section. The final section summarized our conclusions and direction for future research.

LITERATURE REVIEW

By definition, ‘simulation is the imitation of the operation of a real-world process or system over time. Simulation involves the generation of an artificial history of the system and the observation of that artificial history to draw inferences concerning the operating characteristics of the real system that is represented’ (Banks, 1998). Simulation models can be used to evaluate the efficiency and effectiveness of a supply chain system (Ingalls et al., 2008). It can make the entire supply chain visible, allowing users to test numerous “what-if” scenarios such as outsourcing, consolidating vendors, collaborative planning, or implementing e-business. Another key feature of a simulation which naturally supports supply chain modeling is stochastic inputs into the model where users can easily use random variables. There have been several studies apply simulation model to imitate in freight transportation. According to Lesyna (1999), he claimed that in many cases, it is difficult to optimally size rail car fleets, since the underlying system is complex, dynamic, and involves random variables. Hence, he developed discrete-event simulation (“DES”) to optimally size an industrial rail car fleet used to deliver final products to customers. His research explained why it is important to DuPont to optimize the size of rail car fleets; how such fleets are sized without DES; the value of DES in modeling one particular rail car system; and some of the lessons from building such DES models.

Likewise Regan et al (1998), they also developed a simulation model for the evaluation of dynamic fleet management systems for truck carriers. The application of the simulated framework to the investigation of the performance of a family of real-time fleet operational strategies, which include load acceptance, assignment, and reassignment strategies, also is described. Later work, McLean et al (2008) studied a simulation model of the operation of a liner shipping network that considers multiple service routes and schedules. The simulation is applied to evaluate the operational costs and performance associated with liner shipping, as well as the impact of individual service schedules on the overall system. The model allowed for direct and transshipment operations of container cargo, and the evaluation of fuel consumption and other logistics metrics. The model was used to evaluate a liner shipping network consisting of four service routes, up to 64 container ships, and up to 20 ports with diverse physical characteristics and cost components. The resulted show the contribution of service routes, ports, container ships, and containers to the cost and performance of the system.

METHODOLOGY

Simulation model development

This study utilizes a simulation model advantage to imitate full truckload daily operation considering uncertain demand and service times generated by current customers of a truckload carrier. Normally, when a new customer contacts a truckload carrier for service, the customer will have a relatively firm idea of the total volume of freight to be served but will not know exactly how the demand will vary from day to day. Moreover, the times required for a truck to wait at the customer site and to complete loading/unloading may fluctuate daily.

The model is developed using ExtendSim8, which is discrete event modeling, to mimic demand and service time uncertainty in daily operation. The simulation framework begins with dispatching trucks process at carrier’s distribution center (DC), then driving empty trucks to the customers’ factories (places of origin), then picking up goods at these points of origin, then delivering goods to their destinations and moving on to next assignments. In this case, the next assignment can be returning to either the initial DC or the nearest DC for waiting for the next customer demand. This process is illustrated in Figure 1.
To cover all daily operation activities, the simulation framework using ExtendSim8 consists of 6 sub-models as illustrated in Figure 2:

**A. Customer demand generation model**

This model aims to generate daily customer demand based on historical distribution data for each route. Customer demand arrival time for each route is specified as coming in every day or every 24 hours. The amount of arrival demand per day for each route is specified in terms of probability distribution. In the model, customer demand that initiated from the same origin will be batched together as a single object.
B. Truck fleet management model

The truck fleet management module is developed to mimic truck dispatching process at distribution centers (DC) of the carrier. In this study, the selected carrier has two distribution centers. Each day trucks will be sent from distribution centers to pick up goods at the origin points. The number of trucks assigned to each origin per day will vary based on demand. Dispatching rules assign available trucks to existing customers first and then assign the remainder to serving new customers in everyday operation. If there are not enough trucks available, the carrier will request additional trucks from other sub-contract companies at a relatively high cost.

In the truck assignment sub-model, trucks are assigned using a First In-First Out (FIFO) procedure. This means that the first trucks to return from deliveries to DC will be the first ones sent out to serve waiting demand. The next trucks to arrive will be sent out to serve leftover loads.

C. Origin operation model

Activities occurring at the customer’s origin include waiting to upload and uploading goods to trucks. Uncertain operating times such as waiting time to upload and uploading time are also acquired from historical data and specified in terms of probability distribution in the model. After loading, trucks will travel to their destinations. Travel time from the origin to the specified destination depends on distance and speed. We assume that the average full load running speed of all trucks is 50 km/h.

D. Destination operation model

This module tries to simulate the activities occurring at the destination point. These activities include waiting to unload and unloading goods at the destination. Uncertain service times such as waiting time to upload and uploading time are also acquired from historical data and specified in terms of probability distribution in the model. After finishing the unloading process, vacant trucks will be sent to the truck assignment model to wait for the next assignment as described in the next section.

E. Vacant truck assignment model

After unloading at the destination, a truck’s status will be set as vacant and it will be available for the next assignment. Hence, the objective of this model is to assign unloaded trucks to the distribution center to wait for the next load. A vacant truck can be assigned using these two scenarios:

- **Scenario 1**: Truck will be sent to the Initial Distribution Center Assignment (IDC)
- **Scenario 2**: Truck will be sent to the Nearest Distribution Center Assignment (NDC)

F. Outsourcing model

The outsourcing model is developed to investigate whether or not they have the trucks available to meet the demand. If there is no truck available for customer demand, the outsourcing model is prepared to serve the customer’s requirements at a relatively high cost.

**Simulation model verification and validation**

Model verification aims to check the accuracy of the simulation, whether its conceptual and logical structure matches realistic full truckload operation under specified assumptions. To verify the simulation model, it can be conducted both during and after finishing the model developing process. For checking during the developing process, we can use the Information block to count all objects that pass through each command. Model validation aims to compare simulation outputs with real data under the same constraints and conditions. The real full truckload data from case study’s company that are applied to validate the simulation model are existing customer demand and service time information.

According to simulation model verification and validation as described above, it is obvious the developed simulation model is valid for representing full truckload operation in the real network.
NUMERICAL ANALYSIS

Input Data

The important input data applied in this study are including customer demand and service time information.

- Customer demand

Historical current customer demand data is received from full truckload carrier that has 2 distribution centers located at Bangkok (BKK) and Nakorn Ratchasrima (NMA) province. Currently, this truck carrier provides semi trailer 6-wheel truck service for 22 routes for its existing customers. The historical data were collected for 7 months to develop the simulation and pricing model. The total historical demand is described in Table 1.

<table>
<thead>
<tr>
<th>No</th>
<th>Route</th>
<th>Origin</th>
<th>Destination</th>
<th>Distance (km)</th>
<th>Distribution Parameters</th>
<th>Kolmogorov-Smirnov P-Value</th>
<th>E(X)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>AYA-NMA</td>
<td>Ayudhaya</td>
<td>Korat</td>
<td>215.38</td>
<td>Negative Binomial</td>
<td>0.05</td>
<td>4.7</td>
</tr>
<tr>
<td>2</td>
<td>AYA-SPK</td>
<td>Ayudhaya</td>
<td>Samutprakan</td>
<td>101.18</td>
<td>Negative Binomial</td>
<td>0.05</td>
<td>2.7</td>
</tr>
<tr>
<td>3</td>
<td>BKK-BKK</td>
<td>Bkk</td>
<td>Bkk</td>
<td>20</td>
<td>Negative Binomial</td>
<td>0.998</td>
<td>1.3</td>
</tr>
<tr>
<td>4</td>
<td>BKK-MDH</td>
<td>Bkk</td>
<td>Mukdahan</td>
<td>634.29</td>
<td>Negative Binomial</td>
<td>0.979</td>
<td>1.2</td>
</tr>
<tr>
<td>5</td>
<td>BKK-NMA</td>
<td>Bkk</td>
<td>Korat</td>
<td>254.74</td>
<td>Negative Binomial</td>
<td>0.256</td>
<td>1.7</td>
</tr>
<tr>
<td>6</td>
<td>CBI-NMA</td>
<td>Chonburi</td>
<td>Korat</td>
<td>272.19</td>
<td>Negative Binomial</td>
<td>0.819</td>
<td>1.8</td>
</tr>
<tr>
<td>7</td>
<td>LRI-NMA</td>
<td>Lopburi</td>
<td>Korat</td>
<td>196.6</td>
<td>Negative Binomial</td>
<td>0.257</td>
<td>2.1</td>
</tr>
<tr>
<td>8</td>
<td>PTE-NMA</td>
<td>Pathumtani</td>
<td>Korat</td>
<td>226.56</td>
<td>Negative Binomial</td>
<td>0.819</td>
<td>1.4</td>
</tr>
<tr>
<td>9</td>
<td>SKN-NMA</td>
<td>Samutsakorn</td>
<td>Korat</td>
<td>290.22</td>
<td>Negative Binomial</td>
<td>1.000</td>
<td>1.6</td>
</tr>
<tr>
<td>10</td>
<td>SPK-NMA</td>
<td>Samutprakan</td>
<td>Korat</td>
<td>276.69</td>
<td>Negative Binomial</td>
<td>0.185</td>
<td>3.7</td>
</tr>
<tr>
<td>11</td>
<td>SRI-MDH</td>
<td>Saraburi</td>
<td>Mukdahan</td>
<td>537.28</td>
<td>Negative Binomial</td>
<td>0.05</td>
<td>1.8</td>
</tr>
<tr>
<td>12</td>
<td>SRI-NMA</td>
<td>Saraburi</td>
<td>Korat</td>
<td>148.73</td>
<td>Negative Binomial</td>
<td>0.101</td>
<td>2.3</td>
</tr>
<tr>
<td>13</td>
<td>KKN-NMA</td>
<td>Khonkaen</td>
<td>Korat</td>
<td>188.41</td>
<td>Negative Binomial</td>
<td>0.05</td>
<td>4.3</td>
</tr>
<tr>
<td>14</td>
<td>KPT-NMA</td>
<td>Kumpangpet</td>
<td>Korat</td>
<td>409.93</td>
<td>Negative Binomial</td>
<td>0.05</td>
<td>4.1</td>
</tr>
<tr>
<td>15</td>
<td>NMA-AYA</td>
<td>Korat</td>
<td>Ayudhaya</td>
<td>215.38</td>
<td>Negative Binomial</td>
<td>0.05</td>
<td>4.5</td>
</tr>
<tr>
<td>16</td>
<td>NMA-BKK</td>
<td>Korat</td>
<td>Bkk</td>
<td>254.74</td>
<td>Negative Binomial</td>
<td>0.125</td>
<td>5.8</td>
</tr>
<tr>
<td>17</td>
<td>NMA-CBI</td>
<td>Korat</td>
<td>Chonburi</td>
<td>272.19</td>
<td>Negative Binomial</td>
<td>0.05</td>
<td>2.1</td>
</tr>
<tr>
<td>18</td>
<td>NMA-NMA</td>
<td>Korat</td>
<td>Korat</td>
<td>30</td>
<td>Negative Binomial</td>
<td>0.986</td>
<td>14.2</td>
</tr>
<tr>
<td>19</td>
<td>NMA-RBR</td>
<td>Korat</td>
<td>Ratchaburi</td>
<td>339.28</td>
<td>Negative Binomial</td>
<td>0.302</td>
<td>1.3</td>
</tr>
<tr>
<td>20</td>
<td>NMA-RYG</td>
<td>Korat</td>
<td>Rayong</td>
<td>330.51</td>
<td>Negative Binomial</td>
<td>0.05</td>
<td>3.1</td>
</tr>
</tbody>
</table>
• Service Time Information

Service time is the most significant source of uncertainties in truckload operation, because this will affect the use of available trucks. As truckload movements usually involve intercity long-haul movement, the transit time is relatively constant, but the time associated with waiting at the customers’ premises and loading/unloading vehicles may vary greatly among different shipments due to changing customer requirements. Also, amount of equipment and equipment types at customers’ factory affect to loading/unloading time. Since customers of case study do not allow the author collecting service time data for each shipment at their factory, then case study’s transportation manager approximates this service time data of each customer in order to apply in this study. The uploading and unloading times are assumed uniformly distributed while waiting times for uploading and unloading are exponentially distributed. Service time information for existing customer service times at the origin where goods are picked up and at the destination where they are unloaded are described in Table 2.

<table>
<thead>
<tr>
<th>No</th>
<th>Route</th>
<th>Origin</th>
<th>Destination</th>
<th>Distance (km)</th>
<th>Distribution</th>
<th>Parameters</th>
<th>Kolmogorov-Smirnov P-Value</th>
<th>E(X)</th>
</tr>
</thead>
<tbody>
<tr>
<td>21</td>
<td>NMA-SPK</td>
<td>Korat</td>
<td>Samutprakan</td>
<td>276.69</td>
<td>Negative Binomial</td>
<td>1</td>
<td>0.175</td>
<td>0.05</td>
</tr>
<tr>
<td>22</td>
<td>SSK-NMA</td>
<td>Srisakate</td>
<td>Korat</td>
<td>294.5</td>
<td>Negative Binomial</td>
<td>1</td>
<td>0.444</td>
<td>0.05</td>
</tr>
</tbody>
</table>

Table 2

CURRENT CUSTOMER SERVICE TIMES (MIN) INFORMATION

<table>
<thead>
<tr>
<th>No</th>
<th>Origin</th>
<th>Destination</th>
<th>Waiting time to load (Expo.)</th>
<th>Loading time (Uniform)</th>
<th>Waiting time to unload (Expo.)</th>
<th>Unloading time (Uniform)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>AYA</td>
<td>NMA</td>
<td>30</td>
<td>30 50</td>
<td>40 30 50</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>AYA</td>
<td>SPK</td>
<td>30</td>
<td>30 60</td>
<td>40 30 60</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>BKK</td>
<td>BKK</td>
<td>30</td>
<td>30 60</td>
<td>40 30 60</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>BKK</td>
<td>MDH</td>
<td>30</td>
<td>30 60</td>
<td>40 30 60</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>BKK</td>
<td>NMA</td>
<td>30</td>
<td>30 60</td>
<td>40 30 60</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>CBI</td>
<td>NMA</td>
<td>40</td>
<td>30 40</td>
<td>40 30 40</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>LRI</td>
<td>NMA</td>
<td>40</td>
<td>50 80</td>
<td>40 50 80</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>PTE</td>
<td>NMA</td>
<td>30</td>
<td>30 60</td>
<td>40 30 60</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>SKN</td>
<td>NMA</td>
<td>30</td>
<td>50 70</td>
<td>40 50 70</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>SPK</td>
<td>NMA</td>
<td>30</td>
<td>50 70</td>
<td>40 50 70</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>SRI</td>
<td>MDH</td>
<td>40</td>
<td>40 60</td>
<td>40 40 60</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>SRI</td>
<td>NMA</td>
<td>40</td>
<td>50 70</td>
<td>40 50 70</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>KKN</td>
<td>NMA</td>
<td>40</td>
<td>30 80</td>
<td>40 30 80</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>KPT</td>
<td>NMA</td>
<td>40</td>
<td>50 80</td>
<td>40 50 80</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>NMA</td>
<td>AYA</td>
<td>40</td>
<td>20 60</td>
<td>40 20 60</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>NMA</td>
<td>BKK</td>
<td>40</td>
<td>20 60</td>
<td>40 20 60</td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>NMA</td>
<td>CBI</td>
<td>40</td>
<td>20 60</td>
<td>40 20 60</td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>NMA</td>
<td>NMA</td>
<td>40</td>
<td>20 60</td>
<td>40 20 60</td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>NMA</td>
<td>RBR</td>
<td>40</td>
<td>20 60</td>
<td>40 20 60</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>NMA</td>
<td>RYG</td>
<td>40</td>
<td>20 60</td>
<td>40 20 60</td>
<td></td>
</tr>
<tr>
<td>21</td>
<td>NMA</td>
<td>SPK</td>
<td>40</td>
<td>20 60</td>
<td>40 20 60</td>
<td></td>
</tr>
<tr>
<td>22</td>
<td>SSK</td>
<td>NMA</td>
<td>40</td>
<td>50 70</td>
<td>40 50 70</td>
<td></td>
</tr>
</tbody>
</table>
• Transportation Cost Structure

Costing is an important part of pricing; therefore, to estimate transportation price, cost structure must be clarified. Own cost is initiated from own operation cost that will be separated into two parts as followings:

- **Fixed Costs** are often considered “sunk” costs and are those that do not change as mileage changes. They generally include depreciation on capital investment, interest charges or return on investment, license fees, taxes, and insurance as seen below.

<table>
<thead>
<tr>
<th>Details</th>
<th>Fixed Cost</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Purchase Price</td>
<td>850,000</td>
<td>Baht</td>
</tr>
<tr>
<td>Salvage Price</td>
<td>170,000</td>
<td>Baht</td>
</tr>
<tr>
<td>Estimate Useful Life</td>
<td>8</td>
<td>years</td>
</tr>
<tr>
<td>Interest (%)</td>
<td>5</td>
<td>%</td>
</tr>
<tr>
<td>License/tax</td>
<td>337.5</td>
<td>Baht/month</td>
</tr>
<tr>
<td>Insurance</td>
<td>3574</td>
<td>Baht/month</td>
</tr>
<tr>
<td>Depreciation</td>
<td>10625</td>
<td>Baht/month</td>
</tr>
<tr>
<td>Driver Income</td>
<td>250</td>
<td>Baht/day</td>
</tr>
<tr>
<td><strong>Total fixed cost</strong></td>
<td><strong>735</strong></td>
<td>Baht/day/truck</td>
</tr>
</tbody>
</table>

- **Variable Costs** are directly related to mileage. These costs include tires, fuel maintenance, repairs, driving labor, etc. and are shown below.

<table>
<thead>
<tr>
<th>Details</th>
<th>Variables Cost</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Driver (baht/day)</td>
<td>400</td>
<td>Baht/day</td>
</tr>
<tr>
<td>Checker (baht/day)</td>
<td>250</td>
<td>Baht/day</td>
</tr>
<tr>
<td>Maintenance</td>
<td>0.89</td>
<td>(baht/km)</td>
</tr>
<tr>
<td>Fuel Consume</td>
<td>3.56</td>
<td>(km/lit)</td>
</tr>
<tr>
<td>Fuel Consume Empty</td>
<td>3.91</td>
<td>(km/lit)</td>
</tr>
<tr>
<td>Fuel Price</td>
<td>30</td>
<td>(baht/lit)</td>
</tr>
</tbody>
</table>

In cases of the carrier has no trucks of its own available, but must instead outsource trucks from sub-contractors to meet customer demand that is highly expensive. If carrier has no trucks available and waits for a day or two rather than using a sub-contractor, they will lose money, and this loss will be a hidden cost. The hidden cost in this case is called opportunity cost, and it refers to profit lost by failing to satisfy customer demand. This study assumes that the opportunity cost of each route is equal to 15% of its average cost per route per day, or its profit margin per route per day.

**Numerical Analysis Results**

**Simulation Criteria**

Generally, transportation carriers assign trucks for customer demand depending on transportation manager experiences. Different decision-making policies lead to different outputs in terms of costs and performance. To take advantage of the simulation model, this study uses it to mimic full truckload operation under different specified policies based on historical data. The vital policies considered in this study can be illustrated by the different scenarios described below.

1. **Outsourcing policy**
   - This policy features two alternatives:
     - No-outsource
     - With-outsource

2. **Assign trucks to serve customer demand policy**
   - To arrange trucks for customer demand, trucks will be reserved to serve each route by considering the travel distance of each route from the initial distribution center to either origin or destination. This policy consists of two sub-policies:
o Distance from distribution center to the origin of the customer
   ▪ Short-distance deliveries are given first priority
   ▪ Long-distance deliveries are given first priority
o Distance from distribution center to the destination of the customer
   ▪ Short-distance deliveries are given first priority
   ▪ Long-distance deliveries are given first priority

3. Next truck assignment after unloading goods policy

After unloading goods at their destinations, vacant trucks will be assigned to the distribution center to wait for the next demand on the next day under one of these two conditions:
- Trucks return to the initial distribution center
- Trucks move forward to the nearest distribution center

According to the decision policies above, truck assignment policies can be divided into 16 scenarios as shown in Table 3. From this table, it is obvious that the current full truckload operation of carrier case study, which is our case study, is closely aligned with scenario 13.

**TABLE 3
TRUCK ASSIGNMENT SCENARIOS**

<table>
<thead>
<tr>
<th>Scenario</th>
<th>With/No outsource</th>
<th>Vacant truck assignment after unloading</th>
<th>Details</th>
<th>Truck assignment to demand</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>No-outsource</td>
<td>Return to initial distribution center</td>
<td>Distance between DC and Origin</td>
<td>Short-distance</td>
</tr>
<tr>
<td>2</td>
<td>No-outsource</td>
<td>Return to initial distribution center</td>
<td>Distance between DC and Destination</td>
<td>Long-distance</td>
</tr>
<tr>
<td>3</td>
<td>No-outsource</td>
<td>Move forward to the nearest distribution</td>
<td>Distance between DC and Origin</td>
<td>Short-distance</td>
</tr>
<tr>
<td>4</td>
<td>No-outsource</td>
<td>Move forward to the nearest distribution</td>
<td>Distance between DC and Destination</td>
<td>Long-distance</td>
</tr>
<tr>
<td>5</td>
<td>With-outsource</td>
<td>Return to initial distribution center</td>
<td>Distance between DC and Origin</td>
<td>Short-distance</td>
</tr>
<tr>
<td>6</td>
<td>With-outsource</td>
<td>Return to initial distribution center</td>
<td>Distance between DC and Destination</td>
<td>Long-distance</td>
</tr>
<tr>
<td>7</td>
<td>With-outsource</td>
<td>Move forward to the nearest distribution</td>
<td>Distance between DC and Origin</td>
<td>Short-distance</td>
</tr>
<tr>
<td>8</td>
<td>With-outsource</td>
<td>Move forward to the nearest distribution</td>
<td>Distance between DC and Destination</td>
<td>Long-distance</td>
</tr>
<tr>
<td>9</td>
<td>With-outsource</td>
<td>Move forward to the nearest distribution</td>
<td>Distance between DC and Origin</td>
<td>Short-distance</td>
</tr>
<tr>
<td>10</td>
<td>With-outsource</td>
<td>Move forward to the nearest distribution</td>
<td>Distance between DC and Destination</td>
<td>Long-distance</td>
</tr>
<tr>
<td>11</td>
<td>With-outsource</td>
<td>Move forward to the nearest distribution</td>
<td>Distance between DC and Origin</td>
<td>Short-distance</td>
</tr>
<tr>
<td>12</td>
<td>With-outsource</td>
<td>Move forward to the nearest distribution</td>
<td>Distance between DC and Destination</td>
<td>Long-distance</td>
</tr>
<tr>
<td>13</td>
<td>With-outsource</td>
<td>Move forward to the nearest distribution</td>
<td>Distance between DC and Origin</td>
<td>Short-distance</td>
</tr>
<tr>
<td>14</td>
<td>With-outsource</td>
<td>Move forward to the nearest distribution</td>
<td>Distance between DC and Destination</td>
<td>Long-distance</td>
</tr>
<tr>
<td>15</td>
<td>With-outsource</td>
<td>Move forward to the nearest distribution</td>
<td>Distance between DC and Origin</td>
<td>Short-distance</td>
</tr>
<tr>
<td>16</td>
<td>With-outsource</td>
<td>Move forward to the nearest distribution</td>
<td>Distance between DC and Destination</td>
<td>Long-distance</td>
</tr>
</tbody>
</table>

**Transportation operating cost analysis**

According to the truck assignment scenarios, it is appropriate to analyze transport operating cost by considering the different outputs from these different scenarios. This study runs 50 simulations using the ExtendSim8 simulation program to imitate the real-life full truckload operation of 213 working days, using the existing number of trucks (semi trailer six-wheeled trucks). The results are described below.

**Outsourcing policy**

With 50 simulation runs, the comparison of transportation total cost and cost per revenue distance (laden distance) between No-outsource and With-outsource for existing customers is shown in Table 4. It reveals that both the total cost (baht/month) and the average cost per revenue distance of No-outsource scenarios are higher than With-outsource scenarios. Even when transportation carriers let their customers wait for delivery to avoid outsourcing cost, they still have extra cost or hidden cost from the lost opportunity to gain a profit which is approximately 15% of operating cost per route per day.
Moreover, scenario 16 has the lowest total cost and cost per revenue distance compared to other scenarios, including scenario 13 (case study full truckload operation’s policy). The truck assignment policy of scenario 16 is that the carrier’s own trucks are given first priority for long-distance deliveries while outsourced trucks are reserved for short distances. The percentage of outsourcing distance per total revenue distance of scenario 13 is about 19.90%, while it is 9.53% for scenario 16. Hence, scenario 13 consumes more highly expensive outsourcing trucks than scenario 16.

Comparing the opportunity cost and the outsourcing cost, it shows that the opportunity cost from the No-outsource policy is not too different from the With-outsourcing policy as explored in Table 5. It can be inferred that even when transportation carriers try to lower their cost by avoiding outsourcing, they still have losses in terms of opportunity cost. Moreover, they will turn potential customers away eventually.

### TABLE 4
COMPARING TRANSPORTATION COST BETWEEN NO-OUTSOURCE AND WITH-OUTSOURCE OF EXISTING CUSTOMERS

<table>
<thead>
<tr>
<th>Scenario</th>
<th>No-outsource</th>
<th></th>
<th></th>
<th>With-outsource</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total cost (baht/7 months)</td>
<td>Cost per revenue dist. (baht/km)</td>
<td>Scenario</td>
<td>Total cost (baht/7 months)</td>
<td>Cost per revenue dist. (baht/km)</td>
</tr>
<tr>
<td>1</td>
<td>67,401,131</td>
<td>29.63</td>
<td>9</td>
<td>62,828,743</td>
<td>27.60</td>
</tr>
<tr>
<td>2</td>
<td>66,477,403</td>
<td>29.28</td>
<td>10</td>
<td>63,302,495</td>
<td>27.87</td>
</tr>
<tr>
<td>3</td>
<td>66,885,359</td>
<td>29.66</td>
<td>11</td>
<td>63,325,402</td>
<td>27.86</td>
</tr>
<tr>
<td>4</td>
<td>65,926,021</td>
<td>29.16</td>
<td>12</td>
<td>63,007,938</td>
<td>27.63</td>
</tr>
<tr>
<td>5</td>
<td>64,777,108</td>
<td>28.63</td>
<td>13</td>
<td>54,291,623</td>
<td>23.96</td>
</tr>
<tr>
<td>6</td>
<td>63,286,622</td>
<td>28.00</td>
<td>14</td>
<td>55,050,844</td>
<td>24.12</td>
</tr>
<tr>
<td>7</td>
<td>64,381,818</td>
<td>28.64</td>
<td>15</td>
<td>54,994,546</td>
<td>24.20</td>
</tr>
<tr>
<td>8</td>
<td>62,753,612</td>
<td>27.99</td>
<td>16</td>
<td>54,155,371</td>
<td>23.84</td>
</tr>
</tbody>
</table>

Moreover, scenario 16 has the lowest total cost and cost per revenue distance compared to other scenarios, including scenario 13 (case study full truckload operation’s policy). The truck assignment policy of scenario 16 is that the carrier’s own trucks are given first priority for long-distance deliveries while outsourced trucks are reserved for short distances. The percentage of outsourcing distance per total revenue distance of scenario 13 is about 19.90%, while it is 9.53% for scenario 16. Hence, scenario 13 consumes more highly expensive outsourcing trucks than scenario 16.

Comparing the opportunity cost and the outsourcing cost, it shows that the opportunity cost from the No-outsource policy is not too different from the With-outsourcing policy as explored in Table 5. It can be inferred that even when transportation carriers try to lower their cost by avoiding outsourcing, they still have losses in terms of opportunity cost. Moreover, they will turn potential customers away eventually.

### TABLE 5
COMPARING OPPORTUNITY COST AND OUTSOURCING COST OF EXISTING CUSTOMERS

<table>
<thead>
<tr>
<th>Scenario</th>
<th>No-outsource</th>
<th>% of Total Cost</th>
<th>With-outsource</th>
<th>% of Total Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>6,526,882</td>
<td>9.68</td>
<td>9</td>
<td>9,400,875</td>
</tr>
<tr>
<td>2</td>
<td>5,652,564</td>
<td>8.50</td>
<td>10</td>
<td>6,473,441</td>
</tr>
<tr>
<td>3</td>
<td>6,130,749</td>
<td>9.17</td>
<td>11</td>
<td>10,102,151</td>
</tr>
<tr>
<td>4</td>
<td>5,326,548</td>
<td>8.08</td>
<td>12</td>
<td>5,664,652</td>
</tr>
<tr>
<td>5</td>
<td>14,137,890</td>
<td>21.83</td>
<td>13</td>
<td>12,991,666</td>
</tr>
<tr>
<td>6</td>
<td>12,666,983</td>
<td>20.02</td>
<td>14</td>
<td>9,605,573</td>
</tr>
<tr>
<td>7</td>
<td>14,004,247</td>
<td>21.75</td>
<td>15</td>
<td>13,842,360</td>
</tr>
<tr>
<td>8</td>
<td>12,526,167</td>
<td>19.96</td>
<td>16</td>
<td>8,678,998</td>
</tr>
</tbody>
</table>

In real life full truckload operation, however, carriers’ profit might be less than 15% of operating cost. Hence, this study also investigates the case that opportunity cost is approximately 5% of operating cost per route per day as illustrated in Table 6. It also reveals that the cost per revenue distance for return to initial distribution center policy of vacant trucks between No-outsource and With-outsource is not very different. However, cost per revenue distance for moving forward to the nearest distribution center policy of vacant truck with No-outsource is still higher than With-outsource policy.
### TABLE 6
COMPARING COST PER REVENUE DISTANCE (laden distance) BETWEEN NO-OUTSOURCE AND WITH-OUTSOURCE FOR EXISTING CUSTOMERS DIFFERENT OPPORTUNITY COST

<table>
<thead>
<tr>
<th>Scenario</th>
<th>No-outsource</th>
<th>With-outsource</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cost per revenue dist. (baht/km)</td>
<td>Cost per revenue dist. (baht/km)</td>
</tr>
<tr>
<td>1</td>
<td>29.63</td>
<td>27.73</td>
</tr>
<tr>
<td>2</td>
<td>29.28</td>
<td>27.63</td>
</tr>
<tr>
<td>3</td>
<td>29.66</td>
<td>27.86</td>
</tr>
<tr>
<td>4</td>
<td>29.16</td>
<td>27.59</td>
</tr>
<tr>
<td>5</td>
<td>28.63</td>
<td>24.47</td>
</tr>
<tr>
<td>6</td>
<td>28.00</td>
<td>24.26</td>
</tr>
<tr>
<td>7</td>
<td>28.64</td>
<td>24.49</td>
</tr>
<tr>
<td>8</td>
<td>27.99</td>
<td>24.27</td>
</tr>
</tbody>
</table>

Remarks
* with the opportunity to gain a profit of approximately 15% of operating cost per route per day
** with the opportunity to gain a profit of approximately 5% of operating cost per route per day

### Vacant truck assignment after unloading goods policy

The simulation model reveals that moving vacant trucks forward to the nearest distribution center to wait for the next assignment leads to a lower transportation cost than returning to the initial distribution center, as demonstrated in Table 7. This policy generates lower cost because it enhances truck use by reducing empty running distances.

### TABLE 7
COMPARING TRANSPORTATION COST FOR NEXT ASSIGNMENT TRUCK AFTER UNLOADING GOODS POLICY OF EXISTING CUSTOMERS

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Total cost (baht/7 months)</th>
<th>Cost per revenue dist. (baht/km)</th>
<th>Scenario</th>
<th>Total cost (baht/7 months)</th>
<th>Cost per revenue dist. (baht/km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>67,401,131</td>
<td>29.63</td>
<td>5</td>
<td>64,777,108</td>
<td>28.63</td>
</tr>
<tr>
<td>2</td>
<td>66,477,403</td>
<td>29.28</td>
<td>6</td>
<td>63,286,622</td>
<td>28.00</td>
</tr>
<tr>
<td>3</td>
<td>66,885,359</td>
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<td>7</td>
<td>64,381,818</td>
<td>28.64</td>
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<td>8</td>
<td>62,753,612</td>
<td>27.99</td>
</tr>
<tr>
<td>9</td>
<td>62,828,743</td>
<td>27.60</td>
<td>13</td>
<td>54,291,623</td>
<td>23.96</td>
</tr>
<tr>
<td>10</td>
<td>63,302,495</td>
<td>27.87</td>
<td>14</td>
<td>55,050,844</td>
<td>24.12</td>
</tr>
<tr>
<td>11</td>
<td>63,325,402</td>
<td>27.86</td>
<td>15</td>
<td>54,994,546</td>
<td>24.20</td>
</tr>
<tr>
<td>12</td>
<td>63,007,938</td>
<td>27.63</td>
<td>16</td>
<td>54,155,371</td>
<td>23.84</td>
</tr>
</tbody>
</table>

### Assign trucks to load policy

The simulation model demonstrates that to assign trucks for loading demand by considering distance from the distribution center to the destination is not distinguished in terms of cost per revenue distance (laden distance) from arranging by using distance from DC to origin. This is because total laden distances acquired from the two methods are not too different. Comparing between max to min and min to max policy, however, giving first priority to long-distance deliveries from the distribution center to the destination (max to min) provides lower pricing than min to max policy, as shown in Table 8.
TABLE 8
COMPARING TRANSPORTATION COST FOR ASSIGNING TRUCK TO DEMAND POLICY

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Priority</th>
<th>Cost per revenue dist. (baht/km)</th>
<th>Scenario</th>
<th>Priority</th>
<th>Cost per revenue dist. (baht/km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Short-distance</td>
<td>29.63</td>
<td>3</td>
<td>Short-distance</td>
<td>29.66</td>
</tr>
<tr>
<td>2</td>
<td>Long-distance</td>
<td>29.28</td>
<td>4</td>
<td>Long-distance</td>
<td>29.16</td>
</tr>
<tr>
<td>5</td>
<td>Short-distance</td>
<td>28.63</td>
<td>7</td>
<td>Short-distance</td>
<td>28.64</td>
</tr>
<tr>
<td>6</td>
<td>Long-distance</td>
<td>28.00</td>
<td>8</td>
<td>Long-distance</td>
<td>27.99</td>
</tr>
<tr>
<td>9</td>
<td>Short-distance</td>
<td>27.60</td>
<td>11</td>
<td>Short-distance</td>
<td>27.86</td>
</tr>
<tr>
<td>10</td>
<td>Long-distance</td>
<td>27.87</td>
<td>12</td>
<td>Long-distance</td>
<td>27.63</td>
</tr>
<tr>
<td>13</td>
<td>Short-distance</td>
<td>23.96</td>
<td>15</td>
<td>Short-distance</td>
<td>24.20</td>
</tr>
<tr>
<td>14</td>
<td>Long-distance</td>
<td>24.12</td>
<td>16</td>
<td>Long-distance</td>
<td>23.84</td>
</tr>
</tbody>
</table>

Performance Analysis

Besides analyzing transportation operating cost, another advantage of the simulation model is performing truck performance analysis. This can be demonstrated in several ways as shown below.

- Truck Utilization

Truck utilization is an important measurement in truck performance analysis. In this study total laden distance including own truck laden distance and outsourcing truck laden distance, and total working day of own truck are investigated. The simulation model outputs illustrates that assigning trucks using With-outsourcing policy and moving trucks to the nearest distribution center after unloading is the most effective truck use, as illustrated in Figure 3 and Figure 4.

FIGURE 3
COMPARING TRUCK USE IN TERMS OF TOTAL LADEN DISTANCE AND OPERATING DAY OF EACH SCENARIO FOR EXISTING CUSTOMERS
To be specified, applying scenario 16 can increase total laden distance of own trucks utilization about 240,652 km or 13.26% from scenario 13. It can be implied in other words that truckload carrier is saving in terms of fuel consumption about 67,600 liters or 2,027,964 Baht per 7 months from outsourcing truck from sub-contractor carriers.

- Demand waiting for trucks

Analyzing the demand that is waiting for trucks is useful in analyzing service performance for carriers with a No-outsource policy that is illustrated in Table 9. Applying scenarios 1-8 conducts over 15% of total demand per 7 months for demand arrival in DC BKK and about 30-45% for demand arrival in DC NMA.

<table>
<thead>
<tr>
<th>Scenario</th>
<th>DC BKK</th>
<th>DC NMA</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Demand wait</td>
<td>% of total</td>
</tr>
<tr>
<td>1</td>
<td>1,699</td>
<td>15.64</td>
</tr>
<tr>
<td>2</td>
<td>1,712</td>
<td>15.89</td>
</tr>
<tr>
<td>3</td>
<td>1,663</td>
<td>15.42</td>
</tr>
<tr>
<td>4</td>
<td>1,715</td>
<td>15.86</td>
</tr>
<tr>
<td>5</td>
<td>1,796</td>
<td>17.16</td>
</tr>
<tr>
<td>6</td>
<td>2,310</td>
<td>21.53</td>
</tr>
<tr>
<td>7</td>
<td>2,007</td>
<td>18.66</td>
</tr>
<tr>
<td>8</td>
<td>1,944</td>
<td>18.18</td>
</tr>
</tbody>
</table>

- Vacant truck analysis

Vacant truck analysis is also used to analyze truck use performance in terms of effectiveness. The comparison of vacant trucks for each scenario is illustrated in Figure 5. This table shows that a With-outsourc policy leads to a high proportion of vacant trucks per day (Scenarios 9-16).
Based on the transportation costs and performances analysis described previously, it can be concluded that the most cost-effective policies are assigning trucks to demand by considering the distance from the distribution center to the destination from max to min, moving vacant trucks after unloading to the nearest distribution center, and having a ‘Withoutsource policy’. To arrange trucks for customer demand, moreover, our own trucks should be given first priority for long-distance deliveries while outsourced truck that is highly expensive is reserved for short distances. Simulation outputs will be useful information for truckload carriers for making any decision. It can assist them to select the best scenario in order to enhance their own trucks efficiency eventually.

Sensitivity Analysis

This study, the simulation model is also used to illustrate how a new coming customer’s operation affects existing customer operation. For instance, transportation carriers might not have enough resources to serve the new customer demand. Hence, they need to invest in new trucks and other equipment to fulfill new customer requirements. Simulation results can imitate this situation and provide this information to carriers before making any decision. New customer demand information to be used in this study is assumed as shown in Table 10. Five routes of new customer demand are assumed to arrive DC BKK and DC NMA every morning. Moreover, customer demand distribution is determined as Negative Binomial.

### TABLE 10  
DEMAND DISTRIBUTION FOR NEW CUSTOMERS

<table>
<thead>
<tr>
<th>No</th>
<th>DC Start</th>
<th>Origin</th>
<th>Destination</th>
<th>Distance (OD)</th>
<th>Distribution</th>
<th>Parameter</th>
<th>E(X)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>k</td>
<td>p</td>
</tr>
<tr>
<td>1</td>
<td>BKK</td>
<td>BKK</td>
<td>NSN</td>
<td>254.67</td>
<td>Negative Binomial</td>
<td>1.0</td>
<td>0.447</td>
</tr>
<tr>
<td>2</td>
<td>BKK</td>
<td>BKK</td>
<td>UBN</td>
<td>600.19</td>
<td>Negative Binomial</td>
<td>2.0</td>
<td>0.728</td>
</tr>
<tr>
<td>3</td>
<td>BKK</td>
<td>BKK</td>
<td>UDN</td>
<td>564.11</td>
<td>Negative Binomial</td>
<td>1.0</td>
<td>0.275</td>
</tr>
<tr>
<td>4</td>
<td>NMA</td>
<td>NMA</td>
<td>CMI</td>
<td>741.36</td>
<td>Negative Binomial</td>
<td>3.0</td>
<td>0.341</td>
</tr>
<tr>
<td>5</td>
<td>NMA</td>
<td>NMA</td>
<td>SKA</td>
<td>1210.88</td>
<td>Negative Binomial</td>
<td>1.0</td>
<td>0.621</td>
</tr>
</tbody>
</table>

New customer service times at the origin where goods are picked up and at the destination where they are unloaded are described in Table 11.
TABLE 11
NEW ARRIVAL CUSTOMER SERVICE TIMES (MIN) INFORMATION

<table>
<thead>
<tr>
<th>No</th>
<th>Origin</th>
<th>Destination</th>
<th>Waiting time to load (Expo)</th>
<th>Loading time (Uniform)</th>
<th>Waiting time to unload (Expo)</th>
<th>Unloading time (Uniform)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>BKK</td>
<td>NSN</td>
<td>30</td>
<td>35</td>
<td>70</td>
<td>30</td>
</tr>
<tr>
<td>2</td>
<td>BKK</td>
<td>UBN</td>
<td>30</td>
<td>30</td>
<td>60</td>
<td>30</td>
</tr>
<tr>
<td>3</td>
<td>BKK</td>
<td>UDN</td>
<td>30</td>
<td>40</td>
<td>70</td>
<td>30</td>
</tr>
<tr>
<td>4</td>
<td>NMA</td>
<td>CMI</td>
<td>40</td>
<td>35</td>
<td>60</td>
<td>40</td>
</tr>
<tr>
<td>5</td>
<td>NMA</td>
<td>SKA</td>
<td>40</td>
<td>30</td>
<td>50</td>
<td>40</td>
</tr>
</tbody>
</table>

Currently, the carrier in this study provides 60 semi trailer six-wheeled trucks for its existing customers. To analyze the effects of new customer demand, the number of trucks will remain at 60, without requesting additional trucks to serve five new customer routes. Eighteen of these 60 vehicles (30%) will be allocated to DC BKK and 42 (70%) will be allocated to DC NMA. Running 50 simulations reveals that the existing number of trucks is not enough to serve both current and new customer demand. The carrier needs to outsource trucks from sub-contractors to meet about 30-40% of total cost after including new customer demand as illustrated in Table 12.

TABLE 12
COMPARING TOTAL COSTS AND OUTSOURCING COST AFTER INCLUDING NEW CUSTOMER DEMAND WHILE MAINTAINING THE CURRENT NUMBER OF TRUCKS

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Total cost (baht/7 months)</th>
<th>Cost per revenue dist. (baht/km)</th>
<th>% of outsourcing cost/total cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>13</td>
<td>89,051,325</td>
<td>23.51</td>
<td>39.73</td>
</tr>
<tr>
<td>14</td>
<td>89,635,974</td>
<td>23.57</td>
<td>35.98</td>
</tr>
<tr>
<td>15</td>
<td>90,818,146</td>
<td>23.73</td>
<td>40.54</td>
</tr>
<tr>
<td>16</td>
<td>89,677,609</td>
<td>23.41</td>
<td>35.84</td>
</tr>
</tbody>
</table>

According to Table 12, total cost per revenue distance of scenario 16 is lowest while scenario 13 (carrier’s policy) is next to lowest. Comparing total cost per revenue distance of scenario 16 after including new customer demand with existing customer demand total cost per revenue distance of scenario, the total cost per revenue distance including new customer demand is lower. This could mean that including new customer demand increases the use of one’s own trucks and consequently lowers total cost per unit. Truck utilization after including new customer demand is illustrated in Table 13.

TABLE 13
COMPARING TRUCK USE IN TERMS OF LADEN DISTANCE AND OPERATING DAY OF EACH SCENARIO FOR EXISTING CUSTOMERS

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Total Laden Dist. Of Existing customer</th>
<th>Total Laden Dist. After including new customer</th>
<th>% of increasing Laden Dist. after including new customer</th>
</tr>
</thead>
<tbody>
<tr>
<td>13</td>
<td>2,265,880</td>
<td>2,429,297</td>
<td>7.21</td>
</tr>
<tr>
<td>16</td>
<td>2,272,107</td>
<td>2,673,980</td>
<td>17.69</td>
</tr>
</tbody>
</table>

According to Table 13, it is revealed that scenario 16 provides the best performance comparing with scenario 1. Hence, this study also tests the scenario 16 by changing the number of additional trucks in the simulation model. Additional trucks are put into the simulation model starting from 5-30 trucks. Having more trucks of its own means a company needs to outsource fewer trucks. However, we cannot increase the quantity of trucks infinitely because each additional truck requires additional investment and a higher fixed cost as illustrated in Figure 6.
Hence, when deciding to invest in additional trucks to serve new customer demand, two vital factors to consider are amount of vacant trucks per day and amount of outsourcing trucks per day. That means carriers have to trade off between additional cost from investing in additional trucks and outsourcing cost when there are available trucks, and that customer service level is also taken into consideration. However, increasing additional trucks to serve customer demand uncertainty also increases the probability of vacant trucks especially on days without customer demand. The relationship between % outsourcing truck per total demand per day, % vacant truck per total own trucks, and number of additional trucks is illustrated in Figure 7.
CONCLUSION

This study introduces a full truckload simulation model by using ExtendSim8 to capture the stochastic patterns inherent in the operation of full truckload networks that are demand and service time uncertainty. To take advantage of the simulation model, this study uses it to mimic full truckload operation under different specified policies based on historical data. Truck assignment policies investigated can be divided into 16 scenarios. According to numerical analysis results, it can be concluded that the most cost-effective policies are assigning trucks to demand by considering the distance from the distribution center to the destination from max to min, moving vacant trucks after unloading to the nearest distribution center, and having a With-outsource policy. To arrange trucks for customer demand, moreover, our own trucks should be given first priority for long-distance deliveries while outsourced truck that is highly expensive is reserved for short distances. Simulation outputs will be useful information for truckload carriers for making any decision. It can assist them to select the best scenario in order to enhance their own trucks efficiency eventually.

Sensitivity analysis results present that simulation model can be used to investigate how new customer requirements affect to current customers operation. It assists truckload carriers select the appropriate truck fleet assignment strategies that enhancing truck utilization and energy efficiency in eventually.

ACKNOWLEDGMENTS

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FORECASTING RAIL FREIGHT DEMANDS IN A FAST DEVELOPING SOCIETY

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FORECASTING RAIL FREIGHT DEMANDS IN A FAST DEVELOPING SOCIETY

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ABSTRACT

Etihad Rail, as part of the Gulf Cooperation Council (GCC) wider network, is developing a 1200km mixed passenger and freight railway linking the principal centres of population and industry as well as maritime hubs of the United Arab Emirates (UAE) intending to create a safe, efficient and sustainable transport system to form a brand new transport mode opportunity with strategic and economic as well as social and environmental benefits. Assessment of competitiveness between alternative transport modes and traffic demand forecasting constitute underlying inputs for shaping size, performance and functions of the rail business. Unlike more conventional situations where observations and established methodologies are available, in a context characterised by a very rapid development growth, the unfamiliarity with the rail mode, the lack of existing rail systems in operation, a strong emphasis on the use of road vehicles boosted by low fuel costs and an extremely aggressive climate and environment, cost assessment and demand forecasting represent a challenge. Gaining from the experience in the United Arab Emirates, this paper explores and highlights the general requirements and challenges in developing a modelling system to assist with the planning and implementation as well as with the commercial strategy of the railway in a fast developing society. Focussing on the freight component, the paper identifies demand and supply characteristics to be considered and explains the specific modelling challenges outlining the proposed approaches for solution. Key considerations are the quantification of intermodal and bulk commodity demands, the determination of operation and maintenance costs as well as the verification and maximisation of economic performance of the rail system.

KEYWORDS
Transport Planning, Railway, Freight Demand Forecasting, Performance

INTRODUCTION

With a total estimated investment of $11 billion, Etihad Rail, as part of the Gulf Cooperation Council (GCC) wider network, is developing a 1200km mixed freight and passenger railway (Figure 1) linking the principal centres of population and industry as well as maritime hubs of the United Arab Emirates (UAE) intending to create a safe, efficient and sustainable transport system to form a brand new transport mode opportunity with economic as well as social and environmental benefits.
Etihad Rail intends to become not only a source of national pride but also the most trusted mode of transport across the UAE providing a safe, efficient and sustainable transport system forming a completely new logistics opportunity with the overarching strategic purpose of supporting trade and industry, connecting the Gulf region and creating jobs.

The development of the rail is a first in the region and Etihad Rail has the exciting opportunity to conceive an extensive heavy rail network and its operational details from scratch.

When developing a brand new rail network, there are multiple unknowns on the future system performances and decision makers depend on modelling and simulation to identify the main opportunities and risks of each of the rail system components.

Since the 1960s, transport models, mathematical representations of traffic patterns and of the behaviour of end-users of transport systems, have assisted the planning, engineering as well as the strategy disciplines. Over the decades, transport models have evolved in complexity and they have proven to be effective tools for forecasting the effects of policy and investment in an uncertain future. However, their real-life validation is limited by the scope of transport issues typically occurring in areas where observations are possible.

In the Gulf region, the scarcity of previous rail experience, lack of real-life operations, the fast pace of developments, the continuous and rapid changes in planning scenarios, and ultimately the unfamiliarity with the rail mode, challenges the conventional modelling approaches resulting in the need for adaptation of current best practice techniques to unknown conditions.

Gaining from the experience in the United Arab Emirates, this paper explores and highlights the general requirements and challenges in developing a modelling system to assist with the planning and implementation as well as with the commercial strategy of a brand new railway system in one of the fastest developing societies in the world.
MODELLING FREIGHT RAIL: UNDERSTANDING OF REQUIREMENTS

Traffic demand forecasting constitutes underlying input for shaping size, performance and functions of the rail business. Whereas in conventional situations much of even the future demand for and patterns of travel can be observed directly or extrapolated from the existing situation, in the UAE, the structure of the rail network is built up from scratch with no previous heavy rail experience in the region.

With no operational example from which to estimate the choice behaviour, demand must be built up from first principles, based on transport modelling practice developed in conventional situations, but adapted to the local environment.

An essential role for the model is to forecast what the UAE and the wider Gulf region are expected to look like in terms of the transport demands of the future, and the driving factors behind these, such as the geography and nature of goods consumption, the development of new ports and industrial areas, changes in trading and transport opportunities and such like.

Following the estimation and quantification of this most likely future, the effectiveness of alternative options can be compared. Specifically, recognising the overarching objectives of safety, sustainability, and efficiency, the model needs to be designed in a way which allows practical quantification and verification of performances for each scenario in order to assist decision makers in researching the optimal solution.

In this environment, the following list identifies the key modelling requirements:

- Forecast changes in freight demand patterns and traffic conditions in 10 and 20 years
- Reproduce the decision making process and alternative supply chains (e.g. direct deliveries, delivery through collection points and/or distribution centres, etc.) for the different potential freight markets and commodities.
- Estimate costs and time and other relevant deciding factors including their weights in the choice of the alternative transport options
- Assess the Operation & Maintenance costs for the rail and the other modes supplementing the rail mode or in competition with it
- Quantify the economic and environmental benefits resulting from the rail development (e.g. reduction of trucks on the roads, increased safety, reduction of carbon emissions, etc.)
- Assess the impacts on rail share and business case of alternative policies, regulations, planning scenarios, service levels, pricing levels and network alignment options
- Represent spatially individual customers and their connections with the road, rail and barge networks
- Evaluate the business case for sidings/branches from the main line to connect directly individual or groups of customers
- Summarise the results with easy-to-understand performance indicators and user-friendly maps accessible to non-experts
- Feed easy into more detailed analysis downstream in the design process

THE COMPONENTS OF THE MODEL SYSTEM

The Etihad Rail Strategic Traffic Forecasting Model

The freight demand forecasting model is part of a wider strategic multi-modal traffic forecasting model that Etihad Rail has developed to forecast future travel demands of both passengers and freight (Figure 2).
With a total of 1153 internal zones, the model covers in detail the areas of the seven emirates of the United Arab Emirates. Additionally 18 external zones are used to reflect the UAE interactions with the other GCC countries.

The model, coded in Cube software, interfaces with a multi-modal network representing all the existing and planned strategic highway, public transport and freight schemes for the base year 2009 and future years 2020 and 2030.

Given the number of dimensions and policy options that the model requires representing, plus the interdependencies of passenger and freight modes in the delicate demand-supply interaction mechanism, the complexity of an integrated multi-modal model cannot be avoided.

**Freight Model Overview**

The objective of the freight model is to identify and forecast the type and volumes of freight movements that are likely to use the rail system for all or part of the journey.

Since the choice behaviour between modes and their respective performances cannot be observed or extrapolated from real-life operations, to allow a sufficient representation of these movements and their characteristics, it is not feasible to employ simplified vehicle-based approaches and it is necessary to introduce more complex commodity-based methods allowing detailed representation of individual volumes and the way they are or could be transported when the new rail mode will be introduced.

In order to effectively compare different transport alternatives, these methods must include a synthetic representation of the performances of each leg of the journey including hauling, handling equipment, mode transfers, distribution centres, collection points, vehicles and border crossings.

While performances of existing supply chains can be extrapolated from the present conditions, the ones involving the rail mode cannot, and thus have to be studied more carefully.

Figure 3 summarises the scope and key characteristics of the freight model.
FIGURE 3
SCOPE AND CHARACTERISTICS OF THE FREIGHT COMPONENT
OF THE ETIHAD RAIL TRAFFIC FORECASTING MODEL

Extensive 2009–2010 freight traffic surveys

Market study including >100 stakeholders interviews

Road Side Interviews
>8000 truck drivers interviewed

Automatic Traffic Counts
Video recorded at 71 sites

Validation

The interviews cover 54% of total domestic truck traffic volumes moving on the UAE roads (with origin, destination, commodity, volume and travel time explained)

Satisfactory validation of base year model; 3% total variation over all screenlines

Highly Disaggregated

Commodity-based analysis detailed to individual market opportunities

Zoning system representing precise locations (e.g. an individual quarry, factory, etc.)

Detailed mode choice

O&M truck cost model validated with industry stakeholders

O&M rail cost model internationally benchmarked

Mode choice model behavioral parameters internationally benchmarked

Automatic sidings generation

Automatic elimination of movements not generating minimum rail service

Current Limitations

Limited to land-based modes

Competition with feeder vessels and barges not yet been included

In order to allow a robust representation of the potential market opportunities for the rail the model has to be disaggregated in relevant market segments.

The model segmentation was designed from an extensive market study aiming to understand the freight volumes and the way they are moved in the country today. It must be noted that avoiding to undertake a market study well before the model development stage would likely lead to inaccurate model design and representation of results.

The market study undertaken in the UAE revealed that the potential rail freight market can be categorised in the following two macro-segments:

- Intermodal Traffic
- Bulk Traffic

The macro-segments are further sub-segmented by different handling characteristics and commodity type as shown in table 1.
TABLE 1
FREIGHT MODEL SEGMENTATION

<table>
<thead>
<tr>
<th>Macro-segments</th>
<th>Handling</th>
<th>Commodity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intermodal Traffic</td>
<td>General Containers</td>
<td>Various goods</td>
</tr>
<tr>
<td></td>
<td>Commodity in containers</td>
<td>Polymers</td>
</tr>
<tr>
<td></td>
<td>(Bulk commodities typified by large volumes and suitable for container transport)</td>
<td>Waste</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ceramics</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Hay</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sugar</td>
</tr>
<tr>
<td>Bulk Traffic</td>
<td>Depot Distribution</td>
<td>Sand*</td>
</tr>
<tr>
<td></td>
<td>Point-to-point</td>
<td>Aggregates*</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cement</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Steel Finished Goods</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Steel Scrap</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Aluminium</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Clinker</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Iron Ore</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Steel Billets</td>
</tr>
</tbody>
</table>

*Point-to-point in some special cases (e.g. input to cement factory, export through port, etc.)

Now it is important to recognise that each of the sub-segments are typified by different supply chains as well as vehicles and handling equipment specifications and performances, hence they must be handled with separate modelling methods.

In order to deal with these differences, the model is divided in two major components:
1. General container model
2. Commodity model

The general container model (Figure 4) handles the movements of various goods transported in ISO containers (typically 20 feet and 40 feet containers) while the commodity model (Figure 5) deals with the bulk commodity movements from a single origin to a single destination (point to point), or movements that are distributed from bulk terminals (depot) to their final destination and on movements characterised by large and stable volumes of commodity suitable for container transport (commodity in containers).
Nevertheless, although different in some technical aspects (see paragraph 3.4), all proposed methods follow a similar underlying approach (Figure 6).
**Base Year and Future Year Demand**

First the model consolidates the identified potential rail market opportunities into demand matrices, then, for each of the future years of analysis, it projects these demands into the future taking into account expected markets growth (Figure 7), changes in dynamics and geography of trading as well as incorporating other potential future markets opportunities.

**FIGURE 7**

**ILLUSTRATIVE EXAMPLE OF UAE MARKET GROWTH ASSUMPTIONS FOR GENERAL CONTAINERS**

![Assumed growth in container traffic](image)

<table>
<thead>
<tr>
<th>Years</th>
<th>Low Case</th>
<th>Base Case</th>
<th>High Case</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010-2020</td>
<td>6%</td>
<td>8%</td>
<td>9%</td>
</tr>
<tr>
<td>2020-2030</td>
<td>4.5%</td>
<td>6%</td>
<td>8%</td>
</tr>
</tbody>
</table>

Standard outputs of the base year and future year model are, respectively, the consolidated 2009 freight demand matrix (in tons or TEU) and the total, over all possible modes, forecasted potential rail demand matrix (in tons or TEU).
**Mode Choice Model**

Once this likely future demands have been estimated, through a mode choice model which compares the costs and performances of alternative supply chains and/or routing options, the model assesses, per each movement, the probability of using rail for all or part of the journey.

The transport time and distance elements of single legs of the journeys, including hauling-time, congestion delays, mode transfer time, loading/unloading times, etc. are handled with a multi-modal network model of the UAE representing the planned highway and rail infrastructure.

The freight multi-modal network (figure 8) constitutes of:
- A zoning system defining the points at which freight movements start and end. Zones can represent individual assets such as quarries, factories, ports, geographic areas within the UAE, or surrounding countries
- A multi-modal network model of the UAE representing the highway and rail infrastructure, which allows times and costs to be computed for all movements.
- Container and bulk terminals at which container and commodity movements can transfer between the highways and railway

**FIGURE 8**

**MULTI-MODAL NETWORK (2030) IN THE CUBE MODEL**

The transport costs are measured through unit costs derived from separate Operation & Maintenance costs models (see paragraph 3.5) while other not measurable deciding factors such as reliability, flexibility, safety, etc. are taken into account in the model through bias factors.

Standard outputs of the mode choice model include rail volume, rail share, revenues and contribution levels for every selected movement and sub-segment, which can then be used for further downstream analysis in the design process as well as to inform and provide directions to the sales strategy and pipeline.

At present, the model only includes competition between land-based modes (truck vs. rail), while potential to compete with transhipment on feeder vessels has not yet been analysed in detail on the grounds that numerous international benchmarks reveal that rail is unlikely to be a competitive mode against coastal water transport.
Nevertheless, for the peculiar characteristics of the Gulf region rail might play a role in attracting away demand from the barge market and the Etihad Rail traffic model is currently being extended to include the capability to evaluate this potential additional market.

**General container model**

The process of the general container mode choice model consists of several stages as shown in figure 4 and described below:

1. Assumes that services are between all pairs of container terminals and computes costs and times for zone-to-zone container flows by rail, using truck access as needed with associated transfer costs. Also computes zone-to-zone costs using direct truck transport routes
2. Uses a probabilistic Logit model (Figure 9) to split movements between rail and road paths as a function of time, cost and access type
3. Compares volumes for each terminal-to-terminal pair against those needed to justify a regular service
4. Restricts the rail network to movements between terminal locations that have sufficient volume
5. Computes rail and road costs on the restricted network and re-applies the probable model to determine final container volumes for each service.

![Figure 9](image)

**FIGURE 9**

THE GENERAL CONTAINER MODE CHOICE MODEL USES A BINOMIAL LOGIT FORMULATION TO SPLIT MOVEMENTS BETWEEN RAIL AND ROAD PATHS AS A FUNCTION OF TIME, COST AND ACCESS TYPE

Given its probabilistic nature, the model is designed to assess the impacts on travel patterns and revenues when the structure of rail tariffs change and, in turn, can be used to evaluate the optimum points for revenue and contribution. Figure 10 shows the results of this analysis.
Commodity Model

The commodity rail model is designed to forecast bulk freight movements that are expected to use the rail system for all or part of the journey. It concentrates on movements of sufficient size to justify running a unit train consisting of a single commodity for which the exact location of the producer or of the consumer (or of both) is known. This model handles the following movements:

- movements from a single origin to a single destination (point to point),
- movements that are distributed from bulk terminals to their final destination or collected from multiple origins at collection terminals (depot)
- movements characterised by large and stable volumes of commodity suitable for container transport (commodity in containers)

For all of the above groups of movement, a key consideration in the computation of rail transport costs is the way that the commodities access the rail system. Therefore, it is vital that the model is able to compute whether a direct access siding can be justified or whether truck access will be more economical.

The steps of the commodity mode choice model process for each commodity and origin-destination pair, as shown in Figure 5, is described below:

1. Compute the potential savings for a zone/commodity group combination which is accrued from the provision of a siding, assuming initially that all such movements would use rail. Assign a siding, if justified
2. Compute truck cost for performing the movement, including line-haul, loading and unloading costs from the highway network. An empty back-haul movement is always assumed
3. Compute the terminal characteristics of the rail movement, based on the siding provision. At either end, there may be direct access to the rail system and truck feeders/de-feeders may be required, which have a major bearing on the rail cost
4. Compute the costs of the rail movement, including rail line-haul, loading and unloading, plus any necessary truck movements with the associated loading and unloading costs.
For some commodities, a final truck movement is needed from a depot location. If the total rail movement cost is less than the road movement cost, then the volume is included as a potential rail movement (All-or-Nothing approach) as shown in the example in figure 11.

5. Compute sidings based on the movements captured by rail in Step 4. If this is unchanged from the previous siding set then the process is complete. Otherwise Steps 3 and 4 must be recalculated until no further sidings are eliminated.

FIGURE 11
COSTS OF RAIL TRANSPORT VS. TRUCK – ILLUSTRATIVE EXAMPLE FOR AGGREGATES & SAND

The commodity model is characterised by a very detailed zoning system representing precise locations, consisting, for example, of an individual quarry, factory, or similar specific point (Figure 12).

---

1 Rail movement cost consists of the complete variable costs of moving a commodity by rail. It includes crew costs, depreciation and maintenance for the locomotives and wagons, energy costs, signalling, infrastructure maintenance, and the SG&A (selling, general and administrative) expenses.
For depot movements, characterised by an additional truck handling from the distribution centre to the end-consumer, the model distributes the volumes to the surrounding geographic areas in accordance with land-use densities.

It is important to recognise the importance of this detailed zoning system which allows an accurate calculation of access costs to the railway from precise locations. With a more conventional zoning system constituted by geographic areas only, the All-or-Nothing process explained above would not be able to provide accurate outputs.

**Operations & Maintenance (O&M) cost models**

Detailed parameterized cost models for both rail and truck transport were developed.

The trucking costs are calculated for five different truck types used for different commodities using specific sets of parameters for each. The sensitivities of varying yearly mileage, technical life, etc. were tested and the model results for trucking costs were verified by benchmarking them against both market rates paid by shippers today as well as cost data collected from shippers with own truck fleets.

The trucking costs model is based on the formulation used by the Highway Design and Management (HDM) Model developed by the World Bank (IBRD) which recognises that trucking costs increase when the average truck hauling speed decrease, for example as an effect of increased congestion.

The model takes this into account by creating speed-cost curves (Figure 13) for each truck type which are then used in the mode choice model to compute route costs based on actual congested speeds derived from the multi-modal network.
Rail costs are also calculated with a detailed bottom-up cost model, parameterized for different wagon types, train lengths, etc. for the various commodity segments. The results for various cost categories such as rolling stock maintenance and infrastructure maintenance as well as KPIs like yearly loco mileage, drivers per traction unit, etc. were benchmarked against international rail operations.

In addition to the line haul costs, the operating and maintenance costs of rail terminals had to be calculated. For this purpose, a number of terminal configurations for small, medium and large terminals and with different handling technology depending on the commodity type were developed. Again the costs were then calculated bottom-up based on handling equipment’s fuel consumption, operating personnel required, etc.

The rail input cost parameters were randomised in the model through a Monte Carlo Analysis (using Palisade @Risk software) to obtain cost ranges at defined levels of confidence. This was done in order to obtain a quantification of the risks connected to the uncertainty and potential high variability of some of the costs parameters in the unknown conditions.

One important thing to consider is that while trucking costs are mostly variable because the road network and its maintenance is considered “free” from the truck’s point of view, the rail costs have to be calculated for the different contribution levels. For the mode choice, it was then assumed, that the railway would offer a rail service only, if it can cover its variable costs. The difference between the rail tariff (which is assumed to be equal or slightly below the truck tariff) and the variable rail costs, are then the contribution earned to cover the railway’s fixed costs and amortize the infrastructure investment. This does of course assume unlimited network capacity and the results will therefore need to be tested for feasibility on, in our case, the given double track network.

Economic performance model

The rail mode, as a brand new transport mode in the region, has the opportunity to provide a positive change to the way passengers and freight move across the country boosting the economy and providing a sustainable transport alternative.

Sustainability concerns and an overall desire to increase road safety, reduce the carbon footprint, and improve the level of service of the transport network.
Economic and sustainability performances are primary objectives in the development of the Etihad Rail network, hence, when planning and designing, it is necessary to quantify and compare the effectiveness of alternative options in this regards.

Undertaking this analysis in great detail is particularly important in a society unfamiliar with the rail mode and where this way of transport needs to prove itself as effective for a society markedly road-vehicle based. Moreover, it allows more informed planning decisions and, overall, it significantly reduces the risks of a design not in line with its vision, mission and objectives.

Recognising the importance of this aspect, the Etihad Rail traffic model, taking inputs from the mode choice models, summarises these performances measuring, for each rail movement, the beneficial impacts introduced by the rail network through the following performance indicators:

- Saving of truck trips
- Saving of truck-km
- Saving of road congestion delays
- Saving of carbon emissions
- Saving of road accidents

This allows decision-makers to test multiple scenarios and identify which network configuration and market strategy can maximise the above benefits, to locally identify which are the best performing rail services and also to investigate which services, even if not competitive on a pure financial basis, may be fostered through subsidies.

DATA REQUIREMENTS

Modelling a freight rail system requires, in addition to a complex suite of modelling tools, a considerable amount of input data. These can be categorised into the following set:

**Market study data**

In order to build a solid understanding of the freight market, undertaking an extensive market data collection from industry stakeholders deemed likely to benefit from or influence future demand for rail freight, cannot be avoided. The study provides an order of magnitude assessment of current freight volumes that could be converted into rail freight in the future and need to be undertaken prior the model development phase.

The interviews should focus on traffic volumes of the major originators of freight, supply-chain providers, and government entities, with accountability for vision, policy and strategy development, and implementation. Interviewers should also seek information on future market growth to validate the future year projections of volumes. This information forms the base data set on volumes for each commodity flowing between origins and destinations and represents a vital input to the model.

**Traffic Surveys data**

Traffic surveys are necessary to capture the types of vehicles, magnitude as well as time and spatial distribution of volumes throughout the day. They are also required to validate model responses against observations (i.e. modelled traffic flows over corridors, travel time and trip length between zones).

Typically, the traffic survey set should include automatic traffic count (ATC) complemented by roadside interviews (RSI). The results of the RSIs for dispersal of freight trip origins and destinations are factored against the ATCs to develop the movement sampling.

The coverage of the RSIs compared to the ATC counted container movements should be at least 35-40% to provide a good statistical base for allocating movements.

**Travel behaviour data**

Travel behaviour data reflects mathematical relationships and associated parameters describing the travel choices of end users of the freight rail services, balancing the pros and cons of alternative modes or combination of modes, destinations, routes and other deciding factors such as reliability and frequency. Whilst these can be usually
observed from real-life behaviour, in the case of the UAE these parameters have inevitably been imported from studies validated elsewhere and adapted to the local environment.

**Land-Use Data**

These focus on the main drivers of travel demand, disaggregating the continuous nature of a region into convenient zones. Data are usually obtained from a census (in existing situations) or master plans (in future situations). They determine the potential of each zone to generate and attract freight movements.

**Demand management and policy data**

Demand management can include tolls, truck bans, truck weight restrictions, diesel prices etc. This data is determined by policy and plans and can be obtained from consultation with stakeholders. As most other data sources, changes in demand management inputs can affect significantly the results.

**APPLICATIONS**

The Etihad Rail Traffic Forecasting Model is a significant investment representing an essential strategic tool to inform many performance oriented decisions. Its use focuses on a wide range of design and planning issue, always recognising the need to maximise the financial and economic performance as well as to reduce risks in the development of the rail network.

**FIGURE 14**

THE MODEL GENERATES TERMINAL-TO-TERMINAL RAIL DEMAND FLOWS

Applications range from long to medium term planning options assisting with:
- Assessment of different alignment and terminal positioning options
- Evaluation of impacts of different demand management and policy options
- Comparing costs and times of transport modes (or combination of modes) in competition to assist with the pricing strategy
- Identifying impacts of different pricing levels
- Dimensioning of network and terminals
- Phasing of the network and terminals
- Optimisation of economic and sustainability performance of the rail network
- Pre-dimensioning of rail level of service
- Assessment of impacts on business case of different network, policy and planning assumptions
- Generation of inputs for the Benefit-Cost & Economic Analysis
- Identifying traffic with low financial competitiveness but high economic benefits and quantifying for subsidy requirements
- Informing the sales pipeline

CONCLUSION

Etihad Rail is planned to be the first heavy railway system in the UAE to create a safe, efficient and sustainable transport system.

The challenge for delivering a brand new rail network is to provide an effective and efficient transport mode while maximising the economic and sustainability performances.

The probability of success has been maximised by employing transport modelling techniques. Their use is well-established in more conventional environments, as input to design, funding applications and environmental appraisal.

Both the absence of observations of rail operations in the Gulf region and the uncertainties connected to the large size and fast pace of new developments provide challenges to the model design, development and validation requiring a very detailed analysis disaggregated to first principles and individual market opportunities.

A tiered modelling system has been developed, integrating individual components that simulate the demand for and performance of each element of the rail system and of its complementing and competing modes.

When implemented, Etihad Rail will be a test bed for the development of commercially viable and sustainable rail solutions, and future modelling tools to support their implementation elsewhere in similar environments.

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THE CASE OF THE MALDIVES

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INTRODUCTION

The Republic of Maldives is a small archipelagic nation in the Indian Ocean south of the sub-continent of India comprising of a vast number of tiny islands (Fig.1). While it offers the foreign visitor the feel of heaven on earth, the seclusion and isolation of each one of these low lying coral islands with their pristine white beaches and clear turquoise lagoons also has inherent problems, with a central focus on maritime transport. For the small communities inhabiting about a fifth of these islands, commuting by sea is a basic necessity for most of their social and economic needs. Inter-island maritime transport in the Maldives is the subject of investigation addressed in this paper. It affects the daily lives of all Maldivians in a very direct manner. For a nation where the primary mode of transport is by sea, this research sheds light on the current situation and looks into the various issues regarding maritime travel and transport, and the implications of these on the lives of the people. The investigations are conceptually based upon social, economic, political and environmental themes, though not strictly limited to them. A country which was one of the poorest countries in South East Asia in the early seventies now has the highest GDP figures among the SAARC nations (World Bank, 2011). However, the economic progress that the Maldives has made in the years prior to 2004 has been significantly affected with the heavy economic losses suffered due to the tragic events of the tsunami of December 2004. Highlighting the severity of the economic consequences, IMF Public Information Notice (IMF, 2005) stated that amongst the countries affected by the tsunami, the Maldives suffered the highest physical damage relative to the size of its economy. It further stated that while the cost of reconstruction was estimated at about USD 375 million, which amounted to about half of the 2004 GDP, significant damage was sustained by the tourism sector as well. The findings of this paper are mainly based upon primary research (Jaleel, 2008). The author visited 26 islands in eight atolls across the country and got feedback from over two hundred respondents. These included over fifty policy makers, inclusive of the public and the private sector; the rest are stakeholders from various walks of life. They represent fishermen, farmers, Atoll and Island Committee members, Women’s Committee members, traders, the health sector, and the education sector among others. Methods of data gathering include semi structured interviews, focus group meetings, use of questionnaires and direct observations. These methods were augmented by a literature review. While the subject at hand is very broad the author had to limit the scope of the work to fit the time, resources and other boundaries which the work had to fit in with.

KEYWORDS
Inter Island, Maritime Transport, Maldives

MARITIME COMMUNITIES

As with maritime communities and people of archipelagic nations in other parts of the globe, the close association between the people of the Maldives and the sea is abundantly evident. Whether for subsistence or for improving the conditions of living, the ocean has played and continues to play a definitive role in the life of the Maldivian.

While the very early history of the Maldives and its people is sketchy at the very best and there is very little literature on the subject, Maldivians even as late as the middle of the twentieth century based their life mainly upon fish and products of the coconut palm. Fishing has been the primary source of food and still remains so for many people. No prehistoric vessels are documented and in fact it is unclear whether the country was even inhabited until a few centuries before the Common Era. Maldivian history, from an archaeological perspective, is said to have been first documented by H.C.P. Bell, a British commissioner of the Ceylon Civil Service who was shipwrecked on the islands in 1879.
(Vermillion, undated). Some of the ancient chronicles of South India and the Mahavansa of Sri Lanka contain records about the Maldives. According to the Mahavansa, one of the ships that sailed with Prince Vijaya who went to Sri Lanka around 500 BC, went adrift and arrived at an island called Mahiladvipika, which is the Maldives. It is also said that at that time the people from Mahiladvipika used to travel to Sri Lanka (Latheef et al., 1999). Historians date early settlers back to 5th century BC with the Aryan immigrants coming from the neighbouring countries India and Sri Lanka. It is believed that Hinduism existed before Buddhism which was practiced until 1153 AD (O'Shea and Abdulla, 1999 and Maldivesisles, 2000). According to O’Shea and Abdulla (1999) there was evidence of a visit by a Maldivian delegation to the Roman emperor in the fourth century AD, while Thor Heyerdahl in The Maldive Mystery provides convincing proof of trade contact between the Maldives and the ancient Indus Valley port of Lothal. It is therefore possible that though Maldivians may not have ventured out into the ocean as early as some older civilizations had, they might have interacted with such civilizations during later periods in time.

Within this maritime community, the earliest known form of maritime transport is the ‘bokkuraa’, a wooden dingy, which is still used extensively. However, economic factors have seen the development and evolution of domestically built craft as well as the import of larger and speedier vessels of greater comfort. As in the case of other maritime communities such as the Shetland Islands (Smith, 1984), where the fishing requirement to venture out further necessitated better, larger and sturdier vessels which were later motorised, similar needs have led to the development of the local fishing fleets. Those which used sails until the 1970’s have all converted to diesel power and the sizes of the vessels have increased along with provisions to keep the catch chilled until they could be brought to the harbours. Fishermen today can venture out very much further than even their own generation did a few decades back. Tourism has been the primary motivator for the influx of a vast number of pleasure craft with very high speeds. An industry which necessitates luxury dictates that guests are transferred in comfort and with speed.

While the whole of the Maldives is one community by definition, it is in itself divided into many smaller, yet more coherent communities. Fricke (1973) describes a community as a “focus of social life, the common living of social beings.” The common denominator of the life of the Maldivians on a collective basis is rooted in ethnicity, culture and religion. The people are from the same ethnic origin and the whole country shares a common religious belief and all communicate in the same language. Because the small populations are scattered amongst a relatively large number of islands, each of these small groups of people, due to their sizes, form an even greater social bonds amongst themselves. Not unlike many other maritime communities of the world, the Maldives has been and remains a community dependent on the sea for its livelihood. Fishing has been and remains the occupation of most Maldivian males and many womenfolk are associated with the fish processing. Though it varies from island to island, each one has some fishing vessels, either for tuna or reef fisheries. These vessels are also used for travelling to other islands for social or other reasons. The Maldivian communities where an aquatic orientation is integrated into their basic way of life can be termed as ‘fishing people’.

While the Maldives as a whole still remain a maritime community very much engaged in fishery, evolution and acculturations have differentiated life between various communities within the nation. These differences are more pronounced between the urban populations living in Male’, and its proximity and the islands in outer atolls. The people living in the atolls have a more of an egalitarian social structure where differences in status amongst the people are less and resources are shared within the community, whereas in the capital most activities and relations are formalized and commercial in nature.

As described by Ragotzkie (1983) even in the case of the Maldives, social changes have evolved both naturally and spontaneously from within the culture as well as come about by acculturation as a result of contact with other cultures. With regard to fishery it is not known whether smoking, drying and salting of fish are natural evolutionary processes or imported ideas. However these curing processes led to the possibility of exportation even in times when refrigeration was not an available option. In the case of agriculture the severe drawbacks of poor soil has been to some extent been overcome by fertilisation and processes such as hydroponics which certainly have to be accredited to acculturation.

Fishery and to some extent agriculture and other small cottage industries have experienced marked development from the mid-seventies. The revolution in the motorisation of the fishing fleet and the proliferation of the tourism industry led to increased economic activities. With larger vessels independent of the wind the fishermen are able to venture out further resulting in better catch. The tourism industry and overseas buyers have broadened the market for the fish. Agriculture has also been encouraged by the tourism industry. Tourism has also led to diversification of economic activities. The vast majority who depended to a great extent on fishery are finding jobs in the construction industry in the development of resorts as well as in operational aspects of it. Though many have found work in tourist resorts near their native islands it is seen that the centralised nature of the country with Male’ still being the economic magnetic hub, is still attracting people to this overcrowded city of one square mile with a population of about 90,000. Though there are close
to ninety resorts and few are in far out atolls, most are located centrally in the vicinity of the capital. The government’s declared policy to spread it more evenly, if implemented, will have the potential to ease the pressure on the capital. In fact the recent upgrade of the airport in Gan in the southern most atoll to international status and the opening of the resort, ‘Herathera’, in the atoll has provide job opportunities to many of this atoll, many of whom were working in Male’ or resorts in its vicinity.

INTER-ISLAND TRAVEL AND TRANSPORT

Inter-island travel and transport within the Maldives is quite unique because both the geography and demography of the nation are very different from most other archipelagic nations. There are other island nations such as the Cook Islands, Kiribati, and Tonga (Table 1) which have land areas below 1000 square kilometres, though not as small as that of the Maldives. Tuvalu has even a smaller land area. However each of these countries has far fewer inhabited islands ranging from 36 in Tonga to 9 in Tuvalu compared to the 199 in the Maldives. The population per island is also much higher in most of the nations except Tuvalu which stands at an average of 221. In a way Tuvalu and the Maldives are quite similar with respect to the low population densities. In fact Tuvalu has even a lower average than the Maldives. However Maldives has almost 200 islands to provide transport compared with only 9 in Tuvalu. Other archipelagos like the Philippines and Indonesia, though they have a higher number of inhabited islands, are also more densely populated.

Fig.2 is a graphical presentation of the inter-island travel patterns within the Maldives. The illustration is based upon common knowledge and the author’s personal experience being involved in maritime transport projects and discussions with relevant parties as a focal point from the Transport Ministry and as a private maritime transport consultant. The diagram represents main areas, modes of transport and the reasons for travel. The height of the arrows (modes of travel and reasons for travel) shows the relative dominance of one form over the other.

The areas of travel represent the following:
- The capital Male’ which is the centre of the government, commerce and social services and its satellite ward Vilingili.
- The international airport which is the gateway to and from the outside world and Hulhumale’ the reclaimed land connected to the airport by a causeway.
- Tourist resorts which contribute to close to 40 percent of the national GDP.
- Inhabited islands within atolls
- Domestic airports which are located in four locations throughout the country

The modes of transport and reasons for travel are tabulated at the bottom of the figure.

As illustrated both in Fig.2 and from the large number of maritime vessels registered (Fig.3 and Fig.4), it is evident that the predominant mode of travel and transport within the country is by maritime vessels. As in the case of most maritime communities, the Maldivians are also dependent on fisheries for their livelihood. The boats they use for fishing are also used for travelling and transport of goods between islands. Unlike most communities, even maritime ones, where concentrated and relatively large populations exist, inter-island travel needs are seen to be more diversified in the thinly populated and dispersed islands of the Maldives. There is very little cross trade between islands compared with those between the islands and the capital Male’.

The underlying factor which makes the reasons for inter-island travel and transport more crucial and diversified compared with other island nations is the factor of ‘economies of scale’. Because of the diseconomy of scale, though basic education and health care and basic necessities to a great extent are available in all inhabited islands, they are not adequate enough to substantially reduce the need for inter-island travel. Therefore unlike most other maritime communities in the world, Maldivians require frequent travel by boat to consult a doctor, to get their children to school, to get to work and also for other social and economic needs. While all these needs require travel by sea, it is seen that maritime transport is quite unaffordable and inadequate and families spend a considerable amount on maritime transport even with the very limited and necessary travel undertaken and the fact that transport for work throughout the country is either provided or compensated for.

While inter-island travel for the general public is relatively costly, tourists are transported in high speed craft between closer destinations and by air to further distances. Because it is a commercial activity provision of such inter-island transport does not face the same economic issues encountered in transporting local people. In fact it provides limited opportunities for subsidised travel for the locals if and when seats are available on these aircraft.
The primary infrastructure to facilitate this inter-island travel is the island harbours. The research shows that most of the inhabited islands have man made harbours and that it is the government’s policy to provide for all such islands. While this would make the harbours more efficient and safer, concerns have been raised regarding the construction standards of some. The congestion and the consequences as a result of so many vessels entering the very limited space in Male’ inner harbour is also another issue of great concern.

Social and Economic

Social interaction and access to institutions are hindered by the fact that such services are not available in par with requirement in most islands (Fig.5 and Fig.6) and the lack of affordable transport. Though adequate transport at reasonable costs is available between certain island and the capital during holiday seasons, in general such transport is highly irregular and often necessitates hiring of vessels to satisfy travel requirements. It is a common belief that the small isolated populations do not provide economic justification to provide regular and scheduled transport. While scheduled ferries have proven to be commercially viable in some parts, as in the case of G.Dh Atoll and Vaavu atoll, and some high speed ferries operated between some destinations and Male’, the private sector appears to be reluctant to engage in the business in most parts of the country because of the potentially low or negative returns. Where there is a high demand for movement as the case between Male’ and Vilingili, the services are provided at very affordable rates.

The fact that during the process of this study the author found difficulty in some islands to locate people who have travelled to other islands does not mean that people do not need to travel. In those instances most of the fishermen had been out at sea and people who work in nearby resorts were also not present. In other words, other than the people who were required to travel by boat for work, very few did so unless absolutely necessary. The findings also indicate that families had spent substantially on travel for medical needs. The farmers in some islands also commented on the disincentive to increase their yields due to the high transport costs even to nearby prospective markets. While on an average, families spent about eleven percent of their incomes on travel by boat, and a considerable percentage of the populations spend a substantially higher percentage of their income, it may not appear that transport cost is that high compared to some developing countries. The expense has to be judged against the very limited amount of travel undertaken.

Carruthers et al. (2005) states that the percentage spent on public transport in some cities such as in China are so low because people tend to walk or use bicycles instead of paying for transport. In the case of the Maldives one does not have the option of walking or cycling to the next island. The only option is to limit one’s travel to the bare minimum. Carruthers et al. argue that therefore the amount spent on transport as a direct percentage of total expenditure is not a very representative means of demonstrating the affordability of public transport. The matter is further complicated by the fact that the information available uses inconsistent definitions of what costs are included and how income is measured, making comparison difficult.

To overcome this barrier of inconsistency, Carruthers et al. used an affordability index where the cost of sixty 10 kilometre trips per month using public transport was compared. The amount was represented in percentage as a fraction of the monthly income. This was termed the affordability index. A total of 27 cities were compared. The lowest was Bangkok with just 1% where public transport was relatively cheap against a relatively high income average. The highest was Sao Paolo at 11%. In the Maldives, where public transport is minimal, the cheapest is the fare of MRf. 3.00 for the 1.5 km trip between Male’ and its satellite ward of Villingili. Therefore taking it as the sample the equivalent value to use in the formula for calculating the affordability index as used by Carruthers et al. would be:

\[
\frac{10/1.5(\text{km}) \times 60(\text{trips}) \times 3(\text{MRf})}{1.5(\text{km}) \times 60(\text{trips}) \times 3(\text{MRf})} = \text{MRf 1200 (per month)}
\]

Using the above amount of MRf 1200 against three levels of income; MRf 2856 (based on GDP (P/C) 2005, Lower average income of MRf 2500 and Higher average income of MRf 5000 (based upon findings of this study), the ‘affordability indexes’ for the Maldives are 42%, 48% and 24% respectively.

It is seen that with any of the base monthly income values used the index is still very much higher than any other country in the list compiled by Carruthers et al. (2005), for the World Bank. Further the lower and higher monthly averages used for the Maldives are family incomes. If they are represented as individual incomes then again the index would be very much higher. Additionally, as most people have to hire vessels the actual affordability index will be extremely high.

In reality very little attention has indeed been given to understanding public mobility in nations like the Maldives where travel is basically dependent on maritime transport. There is very little literature on the subject. The fact
that even the International Association of Public transport’s (UITP, undated) recommendations to developing policies for sustainable mobility though in general addresses promotion of public transport, it specifically addresses land based modes with issues such as intelligent land use planning, restriction of private car use and the efficient use of parking fees show that public transport and maritime are not generally associated.

Accessibility is a key requirement for socio-economic development and poverty alleviation. The high cost of getting around hampers the attainment of these objectives.

Domestic maritime transport in the Maldives to a great extent is carried out on a commercial basis. That is the primary reason why it is so expensive to the general public. On the tourism front though most resorts have their own maritime transport, many also engage the services of transport providers. As such they run commercially viable operations. The fishing boats are also operated without any subsidies and also provide a relatively cheap alternative means of travel for many islanders when they make trips at the need and convenience of the vessel owners. In fact the fisheries are strong contributors to the economy. Tuna and tuna products are about the only produces that are exported from the nation. As such the developments in the size and speed of the fishing vessels can be viewed as a technological development with a positive economic outlook. The expansion of fish collection and cold storage facilities within the nations along with canning factories also make it easier for the fishermen to sell their fish while reducing the travel distances needed to reach such centres.

Though there are agricultural islands scattered throughout the nation, the industry is hampered by the lack of affordable transport to take the produce to prospective markets.

**Political**

When discussing transport policy issues in the Maldives, it is often difficult to dissociate social, economic and political issues. However some are more of one than the other. In this respect the issues discussed under this section, which have a direct or indirect bearing on maritime transport, is more of a political nature. The government agency responsible for the maritime travel and transport sector is the Maritime Section of Transport Authority under the Ministry of Transport.

Decentralisation and population consolidation are key policy areas in addressing the pressing issue of the high cost of transport. From various discussions it is seen that the economy of scale is the greatest hindrance to the provision of low cost public inter-island transport. If the government carries out the proposed plan of decentralisation with the associated relocation of peoples of thinly inhabited islands on larger land masses or ones with potential for future reclamation, then there exists the prospects of creating high enough population densities to justify commercially viable inter-island scheduled transport to and from these regions. The fact that larger flow volumes enable cheap travel, even at the levels of the Maldivian context, is demonstrated by the MRf. 3 fares between Male’ and Villingili and MRf. 10 between Male’ and the International Airport at Hulhule’.

Lack of adequate appraisals and assessments or political will have resulted in transport projects aimed at alleviating existing problems falling way short of expected targets. The two regional ports are such examples. Neither of these is fit for the intended purpose. The port in the south has such swells that it is dangerous to bring ships alongside. The one in the north was downgraded and many of the vessels intended to berth at the port have to discharge their cargoes using lighterage because of the shallow draft in the port basin. The main daily Maldivian newspaper ‘Haveeru’(Wajudhee, 2007), quoting the Maldives Ports Authority (now Maldives Ports Limited) reported that if the port was to be made practical it required the construction a 200m quay wall at a cost of 80m Rufiyaa to minimise the effects of the existing swell that makes berthing of vessels difficult. There are similar issues with regard to the island harbours. Public opinion as well as the author’s personal observation of the damages sustained by some of these harbours indicate that political will is needed to improve the construction practices of these harbours to make them more lasting.

Even though currently, apart from MTCC, it’s the private sector that is providing inter-island travel throughout the country there is agreement amongst the policymakers that the private sector should be involved further in the provision of transport services. While the private sector is reluctant to engage in the provision of these services, many believe that through provision of better infrastructure, capital investment and perhaps even direct subsidies the government should encourage more private sector participation including island communities.

The current trend, with the existing level of centralisation, is for people from all over the country to come to Male’ to get provisions, to seek medical care, to do business and also to go abroad. All the vessels involved, along with those engaged in tourism produce substantial congestion in the inner harbour in Male’. The consequences of this
congestion are long delays and danger to both people and vessels. Most policymakers believe that if the congestion issue is left unattended it will become very acute in less than a decade.

To reduce the need for inter-island transport a wider geographical distribution of tourist resorts as well as fish collecting vessels and cold storage depots are required. This approach is becoming increasingly important as the price of fuel has also been steadily increasing in the recent times.

It is interesting to note that about a fifth of the policy makers interviewed for this research believe that transport policy is not properly developed in the country at any level but rather is evolving spontaneously without proper strategy. This theory is supported by the fact that until the Sixth National Development Plan (MPND, 2007) transport policy was not clearly defined in any of the previous ones.

**Environment and safety**

While providing safe anchorages in inhabited islands appears to be an issue of high priority within the government as implied by the strategy to build protected harbours in all such islands, making maritime transport safe and more environmentally friendly does not appear to be adequately addressed. The phenomenon of transport at low cost to the commuter and high price to the environment as well as at the expense of safety is not uncommon in many of the developing countries. For example, in his paper, ‘A study on inland water transport accidents in Bangladesh: Experience of a decade (1995-2005), Awal (2006) demonstrates that the accidents are mainly due to of overcrowding of vessels in a cyclone prone nation.

In the case of the Maldives, it is apparent that as there are so many vessels (Fig.3 and Fig.4) plying the domestic waters, the waste from them can have a significant impact on the environment if left unchecked. While the study indicates that garbage and oily residues are not disposed of properly in many cases, the discussions with Environment Ministry officials and the stakeholders highlighted the deficiency in the advice, awareness creation and means for proper disposal. While the Ministry advises vessel operators to dispose of their waste in the island of Thilafushi near Male’ it is highly impractical as a solution for those in the outer atolls. Though still far from adequate, this issue is slowly improving with the provision of waste disposal facilities in other islands as well.

The potentially negative environmental effects of marine operations are not limited to domestic vessels. While Maldives imports all its fuel oil by ships and are discharged in the vicinity of Male’ and the international airport of Hulhule’ the potential consequences of an oil spill disaster are huge. Yet there is no comprehensive maritime oil pollution response and coordination contingency plan.

Though maritime operations pose environmental threats, the environment itself pose an even greater threat to the Maldives. The very existence of the nation which is on average 3 feet above water is at stake with potential sea level rise as a result of global warming. The tsunami of December 2004 highlighted the vulnerability of the Maldives thus strengthening the need to take all measures possible to protect these small and vulnerable communities.

With regard to safety of navigation and maritime accidents and incidents, the public in general are very satisfied with the government’s initiative in providing navigational aid beacons throughout the nation. This has greatly enhanced safety of travel and even made night travel possible where previously it was not. The only area where there is a slow speed enforcement zone, from dusk till dawn, is in the vicinities of the capital Male’ and the Male’ International Airport, where there is very heavy traffic. The number of maritime accidents and incidents in the country is difficult to assess for many reasons. Firstly many are not reported to the authorities. Secondly, those that are reported to the Ministry of Transport are not recorded in a data base for easy reference and recall. Rather they are noted down manually in record books and those that may need court interventions are passed on to the Attorney General’s Office for action. Others are attended to by the Ministry. The NSS Coast Guard, however, keeps a record of the incidents and accidents that they are alerted to. However as stated earlier, these will account only for the reported incidents and therefore may not represent the actual scenario.

**CONCLUSION**

While the Maldives shares many similar issues both on inter-island and international maritime transport with other archipelagic and maritime nations, in a sense it is quite unique and it is this uniqueness that makes maritime transport, especially inter-island, so crucial and at the same time highly inadequate and extremely costly. With the fabric of Maldivian life very much entwined with maritime transport, development and its sustenance is very much dependent on it. A transport network which has evolved without a holistic strategy and almost totally dependent on the private
sector and scheduled according to the needs of vessel owners to a great degree is unable to provide an efficient and affordable service in most parts of the nation. This finding is also supported by the frequent articles on the main daily newspaper ‘Haveeru’ on the severe shortfalls and the importance of inter-island maritime transport. As stressed by Idhrees (2007) the lack of a scheduled nationwide transport network proves to be a barrier in equity and distribution of wealth. The initiatives of the current government, which began about a year ago, to provide affordable public transport throughout the country appears to have a positive impact on the situation. However it is still too early to judge if the approach adopted to providing these services is either achieving the intended objectives or if they are sustainable in the long term. Further there appears to be a lack of tangible indicators to measure the performance and success of the project. Political initiatives such as population consolidation and regional growth centres which would enhance economies of scale, together with other measures to reduce the need for transport also have the potential to facilitate better access to social and economic services at lower cost.

The centralised nature of both development and administration appears to have taken a toll on the Inner Harbours of Male’. Immediate steps need to be taken to address the severe congestion issue and to alleviate the consequences even before the potential positive effects of decentralisation hopefully eases the situation in the long term.

Means of proper disposal of solid as well as liquid waste, including oil and oily water, from maritime operations are inadequate. The cumulative effect of current practices could have serious consequences on the fragile ecosystem, especially the reefs that protect the tiny islands. Though the authorities appear to have adequate regulations regarding navigation and safety at sea, the level of implementation and auditing appears less than satisfactory. Similarly preparedness for maritime disasters such as a major oil spill seems to be inadequate. Measures to protect the islands from natural calamities are also essential.

While studies such as these may be a baseline or springboard for policy makers for further research, more in-depth and detailed studies such as transport needs assessments and cost benefit analysis have to be carried out to address these pressing issues and develop strategies in a comprehensive and holistic manner.
Source: adapted from Godfrey T (1999)
The main reasons for travel

- Travel for medical and health needs
- Travel to attend schools
- All business-related travel except for trade
- Travel for social needs other than health and education
- Tourist travel
- Travel for trading purposes
- Travel to work

The common vessels used for travel

<table>
<thead>
<tr>
<th>type</th>
<th>hull</th>
<th>built</th>
<th>description</th>
<th>LOA (m)</th>
<th>carrying capacity</th>
<th>comfort level</th>
<th>speed (knots)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fishing dhoni</td>
<td>wooden</td>
<td>locally</td>
<td>open deck, no cabin</td>
<td>8 to 30</td>
<td>10 to 50</td>
<td>no seats, very uncomfortable</td>
<td>8 to 15</td>
</tr>
<tr>
<td>Ferry</td>
<td>wooden</td>
<td>locally</td>
<td>covered by awning</td>
<td>8 to 35</td>
<td>20 to 100</td>
<td>bench, reasonable comfort</td>
<td>8 to 15</td>
</tr>
<tr>
<td>Passenger/cargo vessel</td>
<td>wooden</td>
<td>locally</td>
<td>covered, 2 decks and cargo hold</td>
<td>12 to 35</td>
<td>25 to 100</td>
<td>no seats, flat dk, not very comfortable</td>
<td>10 to 12</td>
</tr>
<tr>
<td>Speed ferry</td>
<td>GRP</td>
<td>imported</td>
<td>covered with cabin</td>
<td>8 to 40</td>
<td>30 to 150</td>
<td>airplane seats, very comfortable</td>
<td>25 to 35</td>
</tr>
<tr>
<td>Speed boat</td>
<td>GRP</td>
<td>imported</td>
<td>open, cabin or awning</td>
<td>3 to 15</td>
<td>4 to 16</td>
<td>good seats, comfortable</td>
<td>25 to 40</td>
</tr>
</tbody>
</table>
FIGURE 3
VESSELS REGISTERED IN 2008, 2009 AND 2010

FIGURE 4
TOTAL REGISTERED VESSELS AS AT APR 2011

Source: Transport Authority, Maldives

FIGURE 5
% OF ISLAND WITH AVAILABILITY

1) food and sundries  2) construction/building material
3) clothing  4) furniture  5) Pharmaceuticals  6) kerosene
7) petrol  8) Cooking gas  9) marine engine spares  10) fuel for vessels
FIGURE 6

% OF ISLAND GET THESE SERVICES

% of islanders get these services

<table>
<thead>
<tr>
<th></th>
<th>in the island</th>
<th>in the atoll</th>
<th>in adjacent atoll</th>
<th>at Male'</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
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<td>2</td>
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<td>7</td>
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</tbody>
</table>

1) primary education 2) education up to GCSE 3) A/L education 4) basic healthcare including midwives 5) minor surgeries and pregnancy complications 6) major medical operations 7) postal services

TABLE 1
LIST OF ISLAND NATIONS SHOWING SIZE, POPULATION AND OCCUPATIONS

<table>
<thead>
<tr>
<th>Country</th>
<th>Land area (sq km)</th>
<th>Coastline (km)</th>
<th>No. of islands</th>
<th>No. of inhabited islands</th>
<th>Ave. inhabitants per inhabited island</th>
<th>Total population</th>
<th>Waterways (km)</th>
<th>Fishing</th>
<th>Agriculture</th>
<th>Tourism</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cook Islands</td>
<td>237</td>
<td>120</td>
<td>15</td>
<td>8</td>
<td>1,391</td>
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<td>17,508</td>
<td>6,000</td>
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<td>234,693,997</td>
<td>21,579</td>
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<td>7,107</td>
<td>1,000+</td>
<td>101,833</td>
<td>101,833,938</td>
<td>3,219</td>
<td>36% agriculture, 15% industry, 49% services</td>
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REFERENCES


Note: Maldivian Currency (MRf) is not an international currency. It is pegged to the US Dollar. The exchange rate at 1 September 2011 was approximately MRf 15 per US Dollar.
A SURVEY ON MASS RAPID TRANSIT TYPES SUITABLE FOR BANGKOK METROPOLITAN

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ABSTRACT

Bangkok Metropolitan has long been a big capital city in the world but in the beginning stage in developing its mass rapid transit, or electrified train, network serving its people with three mass rapid transit lines – 2 elevated and 1 underground. Bangkok now plans to construct 10 electrified train lines. This mega project involves huge capital and time to complete. To bridge the gap mainly between the two parties involving the project in which the two parties are the developers and the users, this paper uses questionnaire surveying the two parties about the mass rapid transit types suitable for Bangkok Metropolitan. These mass rapid transit types can be categorized as underground, on ground, or elevated system. Data collected shows that the factors determining the types of mass rapid transit system are financial factor, environmental factor, engineering and technology factor, traffic and transportation system factor, and political factor. The result can help in realizing the important factors and determining the suitable types.

KEYWORDS
Bangkok Electrified Train, Mass Rapid Transit Types

INTRODUCTION

Bangkok metropolitan has endured a high traffic congestion as same as other metropolitans in the world. The Thai public sector has tried many possible ways to alleviate the traffic problem. One solution of this problem for Bangkok metropolitan is to develop a mass rapid transit, or electrified train, network by extending more electrified train lines. Building an electrified train line is a huge investment with a long time period. Basically there are three types of an electrified train line which are elevated, on ground, or underground. The type of an electrified train line that is finally developed is decided by the public sector in running the feasibility study. By the nature of this investment decision making, there is a discrepancy between the developer which is the public sector and the users which are the ordinary people. To narrowing this discrepancy, this work uses a set of questionnaire surveying the two parties, the developer and the users, to determine the factors affecting the selection on the mass rapid transit types which can be an elevated, on ground, or underground.

LITERATURE REVIEWS

Several literature review papers has be used to develop the questions used in the work’s surveying questionnaire. Viewing to the benefits of the mass rapid transit system, Indraragoses, 1995 mentioned that this mass transit system can transport mass passengers, resulting in a better usage of the urban are than the private cars can do. To transport 700 passengers during a rush hour, this transportation needs 500 private cars, or 14 buses, but only 1 electrified train. An electrified train can transport 50,000-60,000 passengers per hour per direction. This mass rapid transit system is better for its environment due to its lesser noise and lesser pollution. Its usage life can lasts 50-100 years while the road system can stand 10-15 years before getting overcrowded. This mass rapid transit system also has fewer accidents compared with the road network.
Deen D. T. 1979 mentioned the factors affecting the construction of a mass transit system, which are 1) the financial and management factor. This factor can affect the government in selecting a mass transit system because construction organizations are different in their operations, planning, construction techniques, and scheduling. 2) Attitude factor. Ordinary peoples as users have their own opinions toward different mass transit systems. Also, peoples in different areas also may have different viewpoints. 2) Physical factor. The physical conditions of the construction areas also affect the types of mass transit system. The construction techniques need to adapt to that physical conditions with a given budget.

Ariyavanich 2007 determines factors used in selecting which lines out of the 7 lines of mass rapid transit projects in Bangkok, Thailand should begin construction first. The four factors used in prioritizing are the financial factor, social factor, political factor, and technological factor. The result shows that factor that has the most effect is the financial factor.

Meemusaw 2010 studies about the attitudes and opinions in the factors affecting the investment in the mass transit projects using analytic hierarchical process in analyzing the data. The data is from interviewing three management groups which are the public sector group, state-owned enterprise group, and the private sector group about the five factors which are the financial factor, the engineering factor, the political factor, the environmental factor, and the safety factor. The result shows that the political factor is the most important, then engineering, and financial factor.

The International Tunneling Association (ITA) Working Group, 2004 take a data collection in 30 cities from 19 countries during 1995 to 1998. The initial assessment shows that the construction costs of on ground, elevated, and underground follows the ratio of 1/3/6. However, this ratio is not certain but varied considerable by the conditions of the environments, areas, and others. Comparing on the averages shows that the construction costs of on ground, elevated, and underground follows the ratio of 1/2/4.5. ITA also shows not only financial factor but the scenery factor also has effect in selecting underground type instead of elevated type, or on ground type. Example of this underground type decision is the Singapore downtown. ITA also mentions one disadvantage of underground type is that a too deep underground station reduces the number of users because the user might use on ground instead. In conclusion, the factors mention in ITA study are the construction cost, economic, scenery, number of users, extension capability, construction impact, the existing mass transit system beforehand, etc.

Reviewing the aforementioned papers shows that there is no study about the factors affecting the types of the mass rapid transit in Bangkok Metropolitan whether the project should be an on ground, elevated, or underground. The review shows that the important factors initially are financial, political, social, and engineering.

DATA COLLECTION

This work uses survey research as a tool to compare the factors affecting of selection of the mass rapid transit types between the two groups. The first group is the ordinary people which are the users. The second group is the employees from the developer organizations such as the State Railway of Thailand, Mass Rapid Transit Authority of Thailand, Bangkok Mass Transit Authority, Office of Transport and Traffic Policy and Planning, Ministry of Transport. The sample size for the developer group (public) is 190 and the sample size from the user group (people) is 400.

THE QUESTIONNAIRE

There are five parts in the questionnaire in which its details are as follows.

Part 1: General information of the respondents such as gender, age, status, education level

Part 2: Behavioral information such as the behaviors in using mass rapid transit system and the involvement of mass rapid transit system and the respondents.

Part 3: Comparison information of the factors affecting the selection of the mass rapid transit types. The factors is grouped into environmental and social impact factor, engineering and technological factor, financial factor, traffic and transportation factor, and political factor.

These five main factors are classified more with detailed factors listed as follows:

The environmental and social impact factor is classified into the detailed factors of noise pollution, air pollution, new or old city, scenery and tourist attraction, service convenience, distance from downtown, and safety.
The engineering and technological factor is classified into the detailed factors of construction difficulty, land use of the construction location, main contractor capability, construction period, and other construction delays not mentioned in the construction contracts.

Financial factor is classified into the detailed factors of construction cost, system and facility cost, land compensation cost, maintenance and service cost, transportation fee, return on investment, and capital sources.

The traffic and transportation factor is classified into the detailed factors of traffic and traffic pavement impact, connection with the existing mass transit system, and effectiveness in solving traffic problem.

The political is classified into the detailed factors of government policy, responsible organizations, and government stability.

Part 4: The weight importance of the factors in Part 3.
Part 5: The overall view in concluding the selected mass rapid transit type for Bangkok Metropolitan.

**THE RESULTS**

**The Main Factor Results:**

The developer group (190 public officers) determines the most important factor as follows:

- Financial factor: 23.45%
- Environmental and social impact factor: 22.81%
- Engineering and technological factor: 18.52%
- Traffic and transportation factor: 17.97%
- Political factor: 17.26%

The user group (400 people) determines the most important factor as follows:

- Environmental and social impact factor: 26.21%
- Financial factor: 20.13%
- Engineering and technological factor: 20.13%
- Traffic and transportation factor: 18.03%
- Political factor: 12.49%

**The Detailed Factor Results:**

Grouped by the five main factors with the rating scale from 1 to 5 with 1 is the least important and 5 is the most important, the detailed factor results are as follows:

**Environmental and social impact factor:**

- The developer group rates the most important detailed factors in safety (4.44), service convenience (4.24), and distance from downtown (4.00). Considering only this factor, this group prefers elevated type.
- The user group rates the most important detailed factors in safety (4.25), service convenience (4.16), and distance from downtown (3.78). Considering only this factor, this group prefers elevated type. Note that this group has similar results as the developer group.

**Engineering and technological factor:**

- The developer group rates the most important detailed factors in land use of the construction location (4.14), construction difficulty (4.10), and construction period (3.98). Considering only this factor, this group prefers underground type.
- The user group rates the most important detailed factors in construction period (4.02), land use of the construction location (4.01), and main contractor capability (3.83). Considering only this factor, this group prefers elevated type.

**Financial factor:**

- The developer group rates the most important detailed factors in construction cost (4.34), system and facility cost (4.15), and maintenance and service cost (4.15). Considering only this factor, this group prefers elevated type.
- The user group rates the most important detailed factors in transportation fee (4.02), maintenance and service cost (3.91), land compensation cost (3.88), and capital sources (3.88). Considering only this factor, this group prefers elevated type.
Traffic and transportation factor:
The developer group rates the most important detailed factors in effectiveness in solving traffic problem (4.25), connection with the existing mass transit system (4.19), and traffic and traffic pavement impact (4.18). Considering only this factor, this group prefers elevated type.
The user group rates the most important detailed factors in effectiveness in solving traffic problem (4.19), connection with the existing mass transit system (3.86), and traffic and traffic pavement impact (3.74). Considering only this factor, this group prefers elevated type. Note that this group has similar results as the developer group.

Political factor:
The developer group rates the most important detailed factors in government policy (4.34), government stability (4.04), and responsible organizations (3.94). Considering only this factor, this group prefers elevated type.
The user group rates the most important detailed factors in responsible organizations (4.03), government stability (3.91), and government policy (3.89). Considering only this factor, this group prefers elevated type.

From the five main group factors, two main factors in the environmental and social impact factor and the traffic and transportation factor have the same results between the developer group and the user group.

The Mass Rapid Transit Type Results:
The developer group prefers the elevated (49.7%), underground (46.2%), on ground (4.1%).
The user group prefers the elevated (54.4%), underground (32.8%), on ground (12.8%).

CONCLUSION

Based on the survey results both the developer group and the user group select the same result in the types of mass rapid transit system suitable for Bangkok Metropolitan in which the two group prefers the elevated, then underground, then on ground, respectively. However, the preference levels are not much different in the user group as in the developer group.

Considering only the five main grouped factors, the developer group pays more attention to the financial factor then the environmental and social impact factor whereas the user group pays more attention to the environmental and social impact factor then the financial factor.

For the detailed factors inside the five main factors, both the developer group and the user group have the same result in the two main factors which are the environmental and social impact factor and the traffic and transportation factor. The result of this work can be used to bridge the gap between the public who provide the service and the people who use the service.

REFERENCES


IMPROVE THE INTERMODAL OPERATIONAL EFFICIENCY SAME AS PERFORMANCE MANAGEMENT AND BECOME ENVIRONMENTAL FRIENDLY

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ABSTRACT

Herein we discussed actions to be taken to promote and enable operation efficiency through performance management with consequences on CO2 reduction, fuel saving, climate change and better environment, based on support of two main aspects which are Intermodal transport best practice and online benchmarking pilot trial. Intermodal best practice reflect the ongoing increase in man-made climate change perception, link between fuel saving and CO2 reduction with its undoubted importance motivated by the realization of increasing fuel costs and man-made climate change. What do we need to succeed? First of all, it is necessary to create joint research on operation efficiency and performance management through profound cooperation between involved countries through a pilot trial. Creation of intermodal chain, providing intermodal operations with a system where they may compare their operations with accepted benchmarks for the sector, allowing the operator to easily vary the operational parameters, enabling the operator to improve efficiency, reduce costs and lower overall carbon and other emissions principally through reduced fuel use, improvement of Infrastructures with more detailed understanding of intermodal logistics industry. The success of creation of intermodal transport chain and intermodal best practice is in reduction of emission from road haulers through close partnership between all countries involved in intermodal transport chain. In this way intermodal transportation chain could established a good baseline to develop further strategies and to meet the needs of the road haulage sector at all levels in cutting its environmental impacts.

KEYWORDS
Intermodal Operational Efficiency, Intermodal Transport Chain, Performance Management, CO2 Reduction, Climate Friendly

INTRODUCTION

The aim of this paper is to present a project address to promoting operation efficiency through performance management and creation of a new intermodal transportation chain, with consequence on CO2 reduction, fuel saving, climate change and better environment.

The idea is based on two main aspects which are intermodal transportation best practice and online benchmarking pilot trial in a new international intermodal transportation chain connection.

The climate change is basically global, social problem and the green house gas emission in EU has been reduced in most sectors over the last 15 years. The only exception is transportation which has shown a 25% increase as demonstrated by data available in Eurostat (2006). In order to achieve a reduction, different measures could be taken. The one commonly suggested is a shift in transport mode, from faster, more polluting road transportation into slower and less polluting modes such as rail and sea transportation. In this way the flexible and available truck transport is combined with low cost, CO2 efficient, rail transport for the longer part of the journey. Eurostat (2011) data shows that with this type of mode shift CO2 emission can be reduced by 20-50%, or more, depending on how the electricity for the train part is produced. With a share of 19.5% of total emissions in 2008, transport is the second largest source of emissions in the EU and it is the sector that has exhibited continuously growing emissions (Eurostat 2011).

It is evident in data shown in Table 1 that road transportation has the highest energy consumption respect to all other transportation modes.
TABLE 1
FINAL ENERGY CONSUMPTION BY TRANSPORT MODE, 1990-2004

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<td>Inland navigation</td>
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<td>5.7</td>
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<tr>
<td>% share</td>
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<td>1.6%</td>
<td>1.5%</td>
<td>1.5%</td>
<td>1.6%</td>
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</table>

Source: Eurostat (Energy)

In the same time it has the highest greenhouse gas emission (see Fig. 1). The main goals of the EU Sustainable Development Strategy are to achieve a balanced shift towards environmentally friendly transport modes to bring about a sustainable transport and mobility system. This shift would certainly decrease GHG emissions as well.

**FIGURE 1**
GREENHOUSE GAS (GHG) EMISSIONS BY TRANSPORT MODE, 2004

Source: European Environmental Agency
*Data cover diesel (and some coal-powered) trains only: electric traction is therefore excluded
PROJECT IDEA

Our project idea starts from creation of unaccompanied combined transport chain of intermodal transport units in South East Europe between Bari Logistic Center and Logistic Railways Terminals in Bosnia and Herzegovina, Serbia, Romania, Montenegro, Croatia and Bulgaria. In this way could be avoid the road traffic and reduction of CO₂ using short sea shipping by Ro/Ro vessels and block trains. The European Commission focuses on promoting intermodal transport which is completely implemented in this project. Intermodal transport has been strongly advocated because of environmental concerns and safety reasons. The startup action should be to organize railways practice in all Balkan countries (see above) mixing private and public consortium which will be able to move merchandise from/to Southern Europe to/from Eastern Europe. However, a common railways practice is necessary to create a Intergovernmental Working Group on Railways - new railway management model able to take care of the opportunities given by all existing European Programs on intermodal transport sector. The aim of European Union policy has been to reduce and in the future to eliminate technical and operational differences among national railway systems and achieve harmonization in terms of technical specifications for infrastructure, signaling, telecommunications and rolling stock as well as certain operational rules (CEC 2001; CEC 2006). This means that mentioned group should create common intermodal policy and at the same time create a program of intermodal best practice, operational efficiency and performance management.

WHAT DO WE NEED TO SUCCEED?

First of all it is necessary to create intermodal chain. Second, creation of joint research on operation efficiency and performance management through profound cooperation between involved countries and check it through a pilot trial. Then, it is necessary to provide intermodal operations with a system where it is possible to compare own operations with accepted benchmarks for the sector. Obviously, allowing the operator to easily vary the operational parameters, enabling the operator to improve efficiency, reduce costs and lower overall carbon and other emissions principally through reduced fuel use, improvement of infrastructures with more detailed understanding of intermodal logistics industry.

Do not forget that: “If you can’t measure it, you can’t manage it” (James 2008). This means that Key Performance Indicators (KPI) should be established and measured with a application of the Performance Management Tool based on PC software.

Establishing on line benchmarking (OLB) of the new intermodal transport chain which will be easily run with possibility to compare own performances through benchmarks for similar operations. In this case we are able to reduce costs and emissions improving efficiency.

FINAL REMARKS

The success of creation of intermodal transport chain and intermodal best practice is in reduction of emission from road haulers through close partnership between all countries involved in intermodal transport chain. In this way intermodal transportation chain could established a good baseline to develop further strategies and to meet the needs of the road haulage sector at all levels in cutting its environmental impacts. This means to find and promote sustainable transport development as a tool to change policy to contain and reduce congestion and reduce environmental impact. OLB would enable users to access performance improvement information specific to their operation. This would offer relevant advice and operational improvements.

This project could give outputs for Governments and freight operators:
 a) Governments would benefit in high mobility of freight and persons, obtain information regarding sustainable distribution, reducing carbon emissions, accidents and congestion
 b) Operators would benefit in better understanding of their own comparative performance, competitiveness and priorities to improve business performance and productivity.

Finally we could say that intermodal transportation best practice is environmental friendly.
REFERENCES


STUDYING AND CREATING PRACTICES THAT SICHANG ISLAND MUNICIPALITY SHOULD ADOPT TO MANAGE THE KOH SICHANG HARBOR

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STUDYING AND CREATING PRACTICES THAT SICHANG ISLAND MUNICIPALITY SHOULD ADOPT TO MANAGE THE KOH SICHTANG HARBOR

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ABSTRACT

The Mayor of the Sichang Island Municipality in Thailand, seeks an advice on how to best mitigate the environmental damage related to lighter boat anchorage and improve maritime traffic safety and efficiency. This will involve a study of the maritime logistics of the water area under jurisdiction of the Sichang island Municipality and possible recommendations may involve charging taxes, regulations and fees. This research is to address how to improve harbor safety and minimize environmental damage related to the maritime activities of light and tugboat operations. We recommends and provides guidance on upgrading current harbor services and infrastructure, for the Koh Sichang Municipality to assess a daily harbor usage fee, commence a garbage collection service and install a formal lighted traffic channel. With implementing these recommendations will help in protection of the marine environment and in increasing operator functionality and safety. Additionally, our recommendation is to generate a consistent revenue stream to the municipality. The action items contained in this research are feasible and effective, the success of these initiatives are heavily dependent upon successful promotion and enforcement. Promoting new rules and regulations effectively and peacefully can be done through theories and techniques used in the psychology of persuasion. In order to assure compliance with the regulations, the municipality must maintain stringent patrols and fines for violators. In order to become success, the Municipality must preserve a consistent, transparent and significant enforcement system. Considering potential opportunities outside of the current state of the municipality, the authors recommend that Koh Sichang be given additional jurisdiction to capture value from the master vessels, as well as to confront the more significant environmental challenges these vessels pose. Finally, the authors recommend that the Port of Koh Sichang Island obtain a free port status in order to increase economic viability and overall sustainability.

KEYWORDS
Harbor, Garbage Collection Service, Lighted Traffic Channel, Safety and Environment, Koh Sichang Island Municipality

INTRODUCTION

This report seeks to address the Koh Sichang Municipality’s ability to improve harbor safety while minimizing environmental damage related to the maritime activities of light and tugboat operations. Our recommendation for these challenges recognizes the need to generate revenue for the municipality and provides guidance on upgrading current harbor services and infrastructure. The authors recommend that the Koh Sichang Municipality assess a daily harbor usage fee, commence a garbage collection service and install a formal lighted traffic channel. Implementing these recommendations will protect the marine environment and increase operator functionality and safety, while providing a consistent revenue stream to the municipality. While the action items contained in this report are feasible and effective, the successes of these initiatives are heavily dependent upon successful promotion and enforcement.

Statement of and Significance of Problem

The Koh Sichang Harbor is a natural port and has become a valuable resource and critical component of Thailand’s maritime transportation industry. As the maritime industry has grown on a national level, so has vessel traffic in the Koh Sichang Harbor. Currently, up to 500 light-boats and tugboats operate within the harbor each day (Kho Sichang Municipality Office). Though increased harbor usage has provided a slight boost for the local economy, the negative externalities,
especially those related to the environment, threaten commercial fishing, tourism and related industries on the island. A limited harbor waste collection infrastructure has resulted in an increase in pollution and the increase in vessel traffic has resulted in threats to harbor safety. These facts necessitate the initiation of a formal harbor management system. From the research performed, the authors have concluded the following:

The primary sources of environmental degradation are:
- Garbage dumping from anchored vessels
- Increased anchoring in environmentally sensitive areas
- Dumping associated with the cleaning and maintenance of light-boats
- Hazardous waste byproducts of commercial vessels (fuel, paint, etc.)

The primary threats to safety in the harbor are:
- Increased light-boat and tugboat traffic
- The lack of a formal channel for ferry and fishing traffic
- Limited visibility for night-time navigation

**Objective of Study – Project Relevance and Application**

The objective of this study is to support a legislative and infrastructural investment in Koh Sichang through the design of an initial harbor management system which includes the establishment of a garbage collection system, the collection of fees and the introduction of navigational aids. This system will serve as the foundation for continued development of the harbor and assist in the economic growth and preservation of natural resources for future generations. The current recommendations relate solely to the light-boats and tugboats operating within the harbor. The authors recommend an expanded jurisdiction of the municipality to include areas where master vessels operate; additional measures must be taken to address the larger, more significant environmental issues.

Since a formal harbor management system does not currently exist, this project focuses primarily on harbor user behavior, the sentiments of both owners and operators, and the steps required to catalyze changes in behavior and use patterns within the harbor. Currently, the island is responsible for maintaining their coastline as garbage floats to their beaches. This practice is unsustainable due to the considerable cost and the labor intensive nature of collecting trash. Additionally, as Koh Sichang is largely dependent on the fishing industry, it is necessary for the island to address long term concerns which threaten their livelihood. Finally, Koh Sichang has supported the maritime transportation industry with minimal reciprocal benefit. Due to the increase of trade within South East Asia and throughout the globe, a municipality sponsored garbage collection system is not feasible. The municipality has an unreasonable level of responsibility and cost for maintaining the harbor when they are not responsible for causing the pollution. Similarly, as the number of light boats in the harbor increases a traffic organization system is essential for ensuring the continued safety of all harbor users.

**Scope of Study, Assumptions & Limitations**

This study includes an analysis of pollution and environmental degradation within Koh Sichang Harbor, harbor safety and organization, as well as a cost-benefit analysis of a number of possible solutions. An operational overview of each component of the harbor management system is provided, including a timeline for implementation and suggestions for the promotion and enforcement of the initiative described herein.

The authors made key assumptions at the start of this project based on information obtained from the Koh Sichang Municipality. These assumptions and the rationale for each are provided as follows:
- Assumption 1 - The municipality can effectively enforce regulations within the Koh Sichang Harbor.
  - This assumption is based on the fact that the municipality has jurisdiction over the boundary indicated in the attached Figure 1 and that they have or can obtain the personnel and ability required to enforce compliance with a management program.
Assumption 2 - The municipality can accommodate a moderate (~4 ton per day) increase in garbage
   - This assumption is based on information obtained from the Koh Sichang Municipality. Specifically, the authors were informed that the current system is not currently operating at capacity and that it will be replaced by a larger system within 12 months.
Assumption 3 - All interviews and survey results obtained accurately reflect the beliefs/practices of the larger harbor user population.
   - Interviews were conducted at random throughout the harbor over the course of two days. Names of interviewees were not recorded and the authors have no reason to believe that those contacted differ in any significant way (in respect to beliefs and behaviors) from the large population of harbor users.

Limitations/Out of Scope – This report does not address the following:
   - Recommendations relating to master vessels as their operations are beyond the jurisdiction of the Koh Sichang Municipality.
   - The drafting of regulations or the recommendation of fines/punishment. The development of any regulatory or governmental proposals is outside of the project’s scope.
   - The operation and/or upgrade of the incinerator operated by the Koh Sichang Municipality.

RESEARCH APPROACH AND METHODOLOGY

The research process detailed herein was comprised of multiple phases which led the authors from an initial issue comprehension phase through the final recommendation. There were four specific phases of our research process:

Consables Analysis – This initial research phase provided an understanding of international standards for the maritime transportation industry and best practices at successful ports. Although Koh Sichang is a unique port which currently accommodates traditional shipping methods (vs. container ships), many of the theories and practices learned from

FIGURE 1
KOH SICHANG MUNICIPALITY JURISDICTIONAL BOUNDARY MAP

Source : http://www.kohsichang.go.th/generalprofile-378.html
researching large international ports are universally applicable. Comparable analysis was especially relevant to the promotion and enforcement elements of this project (Matlack, 1993).

**User Behavior Analysis** – Once the authors achieved an understanding of the industry and challenges, they utilized user behavior analysis of owner/operators in Koh Sichang Harbor. This phase of research primarily focused an understanding of the current habits and operations of boat operators in the harbor. A second goal of this phase was to develop an understanding of harbor user awareness of environmental issues and sentiments surrounding clean-up responsibilities (Miller, 2005). Included in this goal was understanding the level of urgency among the harbor users. This phase of research involved surveys and interviews in Koh Sichang and the Bangkok Port, as well as meetings with Koh Sichang Residents and the Port Authority of Thailand.

**Feasibility Assessment** – This third stage of the research process was dedicated to the analysis of garbage collection, fee assessment, and channel installation options. The option and criteria considered for garbage collection are detailed in Appendix 2 of this report. The options considered for fee collection are presented in Appendix 3. Generally, the criteria used were the municipal capabilities, user willingness to cooperate, and an assessment on the likelihood to succeed based on team interviews and observations. Sustainability and operational complexity was considered for each option (Rypkema, 2007).

**Cost-Benefit Analysis** – The final stage of our research was a cost benefit analysis of a number of garbage collection and fee assessment options (Mankiw & Tay, 2006). Costs considered were those which impacted the municipality. These included costs related to infrastructure investment, employment and operational expenses.

**SURVEY RELIABILITY AND DATA ACCURACY**

The surveys completed by boat owner/operators in Koh Sichang Harbor are believed to represent a fair sample of the attitudes and opinions of the greater harbor population. The survey respondents were selected at random and were interviewed without future knowledge of our purpose or intent. Survey respondents were not asked to give a name or identifying characteristic beyond their occupation and there is no reason to believe that the results were adversely affected by the survey design. The translation of the survey and respondent answers are assumed to be accurate.

Statistically, the owner/operator survey results attained through field interviews are considered to be 95% accurate within 11% of the population mean. This is based on a sample size of 66 and a population of 400 owner operators (a 16.5% response rate) (CreativeResearchSystems). A complete copy of all survey results is included in Appendix 4.

**Primary Research Findings & Takeaways**

Based upon our questionnaire findings, the authors gained insight into operator and owner preferences and an understanding of the situation. Below are significant survey questions and insights gained from them.

The first major finding resulted from the question “How do you store/contain garbage onboard your vessel?” From this question, the authors surmised that 95% of respondents have containment capabilities for their garbage. The containment varied between vessels but was primarily composed of small garbage cans and garbage bags. This result provided the insight that no behavior change was necessary to convince operators to collect garbage; however, since the operators are currently containing their garbage, the municipality must develop a method for collection and disposal.

The next behavioral insight came from the question “How do you currently discard of your waste/trash?” The authors discovered that 80% of respondents indicated that they throw their garbage overboard. As no disposal system is available, this is the only option for most operators. While a small number of operators retain their garbage and dispose of it on shore, the authors recognized that the disposal challenge is not a result of a few bad elements, rather, the challenge is pervasive throughout the entire population.

The authors gauged insight into the operators’ attitudes and understanding of the challenge through the question “What is your current awareness of the pollution in Koh Sichang harbor?” The finding resulted in 78% of respondents indicating that they were aware of the marine pollution problem in the Koh Sichang harbor. The level of awareness indicates that the problem is substantial and that the municipality can focus the majority of their promotion efforts on describing
corrective measures instead of creating awareness. 81% of respondents indicated that action should be taken to remedy the pollution in Koh Sichang regardless if they realized that it as a problem or not.

The next survey question- “Who is responsible for cleaning up the Koh Sichang harbor?”- gauged the respondents’ attitudes relating to the environmental cleanup. For this question, respondents were given the ability to choose multiple parties which they believe are responsible for maintaining the harbor. The authors found that 67% of all respondents indicated that owners and operators were personally responsible for harbor maintenance while 49% of all respondents indicated that the municipality was responsible. This finding signifies that respondents believe there is joint responsibility between the owners/operators and the Koh Sichang municipality. This is a positive result considering that the harbor management system requires cooperation and communication between both parties in order to succeed.

The next survey question analyzed what services the respondents valued within a harbor management system. The question, “In order to maintain the harbor, what services should Koh Sichang include?” provided the authors with an understanding of what services the operators most valued. Nearly 70% of all respondents said that Koh Sichang should have a garbage collection service. In keeping with other findings, this result indicates that most operators do not need to be convinced that this service is necessary; rather, operators must have information about the system when it becomes available.

The last major finding on the survey resulted from the question “What could Koh Sichang install in order to promote safety within the harbor?” The authors concluded that although the survey results were mixed, the vast majority of responses pointed to increased harbor organization. The results indicated that 9% of respondents asked for improved sign, 22% of respondents asked for designated anchoring areas, 30% of respondents asked for lighted navigational buoys, and 5% of respondents asked for channel markers. An additional 30% of respondents indicated that they had weather related concerns which were unfeasible to address. Taken as a whole, the best method to address all of these concerns is a lighted navigational channel.

RECOMMENDATION

Summary of Recommendation

Koh Sichang faces both environmental and safety challenges within their harbor. In order to deal with these challenges, the municipality must take three corrective actions- develop a garbage collection system, implement a harbor usage fee for boat owners, in addition to creating a navigational channel for boats sailing in and out of the harbor.

Operational Overview

Garbage Collection

Based on the data collected, operators within the harbor are interested in a garbage collection and disposal system; however, currently there is no place available for them to dispose of their garbage. The authors additionally learned that the operators would refuse to pay any fee for garbage service, no matter how small. Given these considerations, successful garbage collection in Koh Sichang must be convenient for operator use, as well as free of charge.

The first component of the garbage collection system consists of placing 4 barges within the Koh Sichang harbor. These garbage barges provide convenience to light boat operators; furthermore, the placement of the barges can be adjusted to match weather conditions and light boat anchorages of the respective season. This collection will be provided without a fee to the operators who bring their garbage to the unmanned barge closest to them.

The second aspect of this system includes transportation of the barge to shore and transportation to the incinerator. The municipality will use a tugboat to transport the barge to shore and transport the garbage from the shore to the incinerator. With an estimated harbor population of approximately 1100 creating an average of 3.67 kilograms of solid waste a day, there will be an increase of approximately 4 tons of garbage per day.
Implementation of a Harbor Usage Fee

In order for the municipality to have the resources necessary to affect change, the system in place must have the capability to be sustainable, thereby generating revenue. Based on our research, owners are responsible for paying harbor usage fees at other ports but are unwilling to pay for a fee if it is directly linked to garbage collection. With these considerations, Koh Sichang should implement a “harbor use fee” for boats to use their harbor in lieu of a “garbage collection fee”.

The success of the fee collection depends upon consistent and reliable data gathered from tugboat operators who will radio in the information of the light boats they are pulling in and out of the harbor. When a tugboat operator has the information of light boats they are transporting to enter the Koh Sichang jurisdiction, the operator will radio in this information to a designated radio channel monitored by a municipality employee. Upon receiving this information, the municipality radio operator will enter the information of the boats entering or exiting the harbor into a spreadsheet on the computer. Given this information, the municipality can then determine the length of stay for each light boat. For each day a boat is in the harbor, Koh Sichang can charge the owners a daily rate and then calculate the number of days the boat is in the harbor.

Every month, the municipality will send a bill to the owners based on their harbor utilization. While the success of this system heavily relies upon informing the owners and operators, as well as enforcing the imposed fines, the system provides a fair method for collecting revenue from the boat owners. Given current cost estimates and complete success in collecting fees, the authors have concluded that the municipality will be profitable if it charges owners 10 baht/ per boat/ per day.

An additional consideration for the harbor usage charge is to limit the impact on the profitability of the owners. If the owners perceive the municipality to be unreasonable with the fee assessment, there will be a stronger resistance to cooperate. The municipality will also have the ability to adjust this rate as the system is accepted among owners; however, it will be easier for the municipality to achieve initial owner acceptance with a lower rate. The harbor usage fees will be assessed monthly to the light boat owners through the postal system and payments can be made via bank transfer.

Lighted Navigational Channel

In order to provide better organization for the light and tugboat traffic within the harbor, the Koh Sichang municipality should create a ship channel to direct traffic and indicate areas where boats can anchor. This channel is marked with lighted navigational buoys which are easily visible during the day or night. Within the ship channel, boats are able to travel freely in and out of the port; however, they are not allowed to anchor. Creating a channel will also allow the municipality to restrict areas that are especially sensitive to the harmful effects of anchoring such as underwater electric lines and pipelines (Marine-Movers Boat Transport).

In order to emphasize the importance of this channel, fines and penalties must be assessed for violations. As a comparison, the U.S. fines for anchoring within a sensitive area can incur a penalty close to $1 million baht. The authors recommend that the municipality enforce the highest level of fine possible for violations of anchoring within the ship channel. Effective enforcement is critical for ensuring proper usage of the channel since it is newly developed and unfamiliar to boat operators and a costly fine will dissuade offenders from a repeat offense.

As the authors observed from the questionnaire results, respondents were concerned with the lack of traffic organization, as well as the lack of lighted buoys. In order to remedy both challenges, Koh Sichang municipality should invest in lighted navigational buoys for the harbor to demarcate the ship channel. In addition to defining the channel route, these buoys would assist boats who sail to and from the port at night. Currently, visibility is limited in the evening, posing safety concerns to the harbor community. As the amount of trade and number of light boats increase, boater safety becomes a much larger and dangerous issue.

Prior to implementing a channel of lighted navigational buoys, the Koh Sichang Municipality must have a map of the harbor to determine the depths of the harbor. The Thai navy is responsible for conducting the assessment of the region. Currently, the authors have estimated that the ship channel will run for approximately 2 km with buoys alternating on each side of the channel every 200 m. After this assessment is complete, the Koh Sichang municipality will have the necessary
information to implement a shipping channel. Based upon the price quotes the authors have received, Koh Sichang will spend approximately 675,600B for 23 channel markers and their lighting to be spaced every 200 m.

After receiving a navigational chart for the harbor, the municipality must receive agreement from the harbor community. The ship channel is currently recommended to be located at the main entrance into the harbor. In order to gain commitment from the boat operators, the municipality should contact the tugboat owners to inform them of the channel and its significance. Owners will face significant fines for operator violations such as anchoring within the channel; however, the municipality should provide an educational grace period to allow operators to adjust to the new harbor development. See Figure 2 for a suggested map for the ship channel.

FIGURE 2
PROPOSED BARGE AND CHANNEL LOCATION MAP

![PROPOSED BARGE AND CHANNEL LOCATION MAP](image)

CRITICAL SUCCESS FACTORS

Promotion

One of the most important and challenging elements of this project will be inducing habitual change in people who are accustomed to their present way of life. Change in behavior is likely to be most successful if theories under the study of Psychology of Persuasion are used (McGuire, 1961). The Theory is based upon the same principles of the reasons why someone would receive a vaccine in defense of a virus. If all who will be affected by the change can become immune prior to implementation, the adjustment has been proven to be a more passive transition. The main point of Inoculation Theory is that attacks make beliefs and attitudes stronger.

There are three steps of effective inoculation:

1. Warn the receiver of the impending change
2. Make a weak attack
3. Get the audience to actively defend the attitude

To warn the receiver of what is to come, Koh Sichang should consider having frequent communication to their stakeholders through the use of schools, NGO’s, local media and environmental groups, thereby, helping to ameliorate the process of introducing change.
The second step of the theory, making a weak attack, comes from addressing preemptive concerns which could arise. Identifying and proactively responding to what people could say would help the transition be more peaceful and with less confrontation. Harbor users could oppose the change by saying that new regulations could mean more work for municipal employees, while vessels could avoid the harbor, potentially impacting local economy, as well as stating that irrespective of any new laws, boat owners would simply ignore them.

Finally, the last step requires people to build a defense. This comes naturally after the second step is in place. Realizing their concerns are less serious than the potential harm which exists, people would naturally abide by the rules in order to avoid negative impacts. By following the laws, the audience would avoid excessive fines, improve safety within the harbor and protect resources for them and future generations. This comes through the realization of the permanent impact garbage has on oceanic chemistry, marine life and tourism.

Campaign

Encouraging the promotion must be a widespread effort throughout the island; one method to actively involve the audience would be to formulate a campaign. The participants of this project have created an example of what a potential campaign could resemble. It is meant to be only an example and should be amended to best fit its audience.

The “Save the Squid” campaign was created as a vehicle for all ages to participate in. A logo of a “Happy Squid” is used on a garbage can so that people have a jovial connection to a potentially malodorous subject. Some suggestions include: Producing a garbage bin which is given to boat owners and operators to remind them of the importance of using the garbage barge. The promotions can be done via banners, local media, billboards, flyers, T-Shirts, as well as calendars that explain the new regulations and include navigational charts. The municipality could also incorporate a regional holiday holding events to increase awareness and publicly recognize the efforts of those involved.

Proposed Implementation Timeline

We have suggested a way to methodically implement a scaled process to ease the audience into new behavior. In a similar manner as the Euro was introduced into 12 countries of the European Union, so to can the municipality introduce pollution control measures (Reid, 1999).

The “Phase in Process” could begin at least 6 months prior to inception. The first 3 months can be used to promote, educate and commence a campaign. Months 4-6 may be used to initiate a ‘soft start’ where new services are offered on a free basis. The municipality would use this opportunity to refine procedures, identify and address challenges, along with issuing warnings to those who choose to disregard procedures. The last phase is when a start date has been chosen and the program firmly begins. The municipality must start collecting harbor use fees, perform random patrols and strict enforcement must begin. Those who are identified as ignoring procedures must be stringently fined and held accountable.

Enforcement

Effective enforcement is required for a sustainable and successful program. Without consistent and effective enforcement, boat owners and operators will fail to comply with the regulations leaving the system in danger. Successful enforcement must be applied to all parties who are involved, including light-boat operators for dumping garbage into the water, tugboat operators for failing to radio in light-boat information and boat owners for failing to pay harbor fees in a timely fashion.

Effective enforcement covers the environmental and safety oversight of the harbor system. To create an enforcement system, the municipality will rely on two major components. The first component of the system is accuracy. As the system requires the municipality to accurately record the number of days each boat stays in the Koh Sichang Harbor and charge an associated standardized fee, correct data is essential. Accurate documentation of light-boat usage is necessary for the municipality to consistently charge owners and for proper enforcement. If the data is not correct, owners could easily reject the system if proved to be inaccurate.

The second component of the system requires adequate surveillance through boat patrols. In order to ensure that harbor users are compliant with the rules through applying fines for violations, the harbor needs to employ a patrol boat to observe regulation compliance within the harbor. The operators must understand the implications for breaking the regulations...
if the regulations hope to succeed. While data accuracy and successful patrols are necessary to have enforcement in place, they alone are not enough to provide credibility.

After ensuring accurate data and effective patrols, the municipality must operate the system with three critical principles: consistency, transparency, and significance. The municipality must ensure that they not only create an effective system, but they must also operate this system effectively to ensure future success.

Firstly, the regulations must be consistent with all the harbor users. All the ships in the harbor must be charged a usage fee, and all the people who violate the rule must be fined and punished, even if they are financially or politically influential. If specific people are excluded from violations and all the others’ are strictly fined, users would feel inequality and start to ignore the rules, thus, jeopardizing the system.

Secondly, transparency is critical for enforcement. Transparency details all of the regulations that are clearly recorded, understood and disclosed to public. If the regulations are not understood or clear, enforcement becomes a much bigger challenge. A ship’s harbor usage must be recorded systematically and methodically via computer. These records must be mutually exclusive and collectively exhaustive. Information should be disclosed immediately at a user’s request, and all requests must be answered. Transparency through these behaviors enables the municipality to be trusted, which would result in compliance with the regulations and ease enforcement.

Finally, the presence of enforcers and cost of fine must be significant enough for all harbor users to want to avoid. The penalty fee to boat owners and operators must be so grave that behavior is easily altered. Nevertheless, the required behavior must be achievable and systems need to be in place for users to act accordingly. However, the harbor usage fee does need to be placed at a reasonable fee users can afford and will accordingly oblige. It is the penalty fee that needs to expensive enough for a first-time offender to evade a second.

**GROWTH OPPORTUNITIES FOR KOH SICHANG**

A free port is an area where items imported into a country can be held, processed, and redistributed without paying customs or duties. The free port status can greatly increase the prominence and affluence of a port. While free ports allow for free transportation of their goods, the ports greatly benefit through increased service and fees collected from shipping vessels. Notable free ports in SE Asia include ports in Macau, Hong Kong, Singapore, Taiwan, and the Philippines.

**Benefits**

Within the South East Asia region, Koh Sichang enjoys an enviable location near Bangkok. Vessels find it relatively easy to use Koh Sichang harbor as its location is in transit to other ports, making it a convenient stop on their route. It is at the intersection of a large portion of international trade within the region and an ideal spot for shipping lanes giving it a significant opportunity to attract shipping companies. However, in order to increase the attractiveness of the port, Koh Sichang should consider eliminating tariffs and duties on trade as this is a major concern for international shipping companies when considering which ports to use. If Koh Sichang Island is looking for a way to increase economic viability, converting their port into a free trade zone will surely aide the effort and prove to be profitable.

**Expanding Jurisdiction**

Singapore’s rise to prominence heavily depended upon a free port. In order for Koh Sichang to generate additional shipping interest, they must have the ability to attract international shipping companies to develop an effective working relationship with these companies. The first step to reaching these companies requires an increased jurisdiction of the Koh Sichang municipality to include master vessel anchorage areas.

Expanding jurisdiction will allow Koh Sichang to capture unrealized value from a revenue source more significant than the light boat owners and operators. Since the master vessels have a larger crew, more significant needs, and stronger economic support, the municipality and the country would greatly benefit from capturing this untapped resource. Through greater jurisdiction, Koh Sichang has the ability to work with the international shipping companies which could also provide partnership opportunities that will expand financially viable interests.
Additionally, increased jurisdiction will allow the municipality to address larger environmental issues which stem from the greater capacity of the master vessels and their inefficient transfer of material to the light boats. Current transfer practices involve significant marine pollution due to inefficient transfer methods of materials such as cassava, charcoal or cement mix. These materials accumulate on the ocean floor destroying marine habitat. Despite these harmful practices, Koh Sichang is unable to remedy the problem since these master vessels are currently outside the area under their control.

CONCLUSION

Given the current state of the Koh Sichang municipality and after extensive research, the authors recommend a harbor management system that includes a harbor usage fee, a garbage collection system, and a lighted navigational channel. Promoting new rules and regulations effectively and peacefully can be done through theories and techniques used in the psychology of persuasion. In order to assure compliance with the regulations, the municipality must maintain stringent patrols and fines for violators. Preserving a consistent, transparent and significant enforcement system is paramount to success. Considering potential opportunities outside of the current state of the municipality, the authors recommend that Koh Sichang be given additional jurisdiction to capture value from the master vessels, as well as to confront the more significant environmental challenges these vessels pose. Finally, the authors recommend that the Port of Koh Sichang Island obtain a free port status in order to increase economic viability and overall sustainability.

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- Thamon Phunsong

REFERENCES


APPENDICES

Appendix 1 – Garbage Barge Example
Appendix 2 – Garbage Collection Methods and Criteria

We Considered Various Options for Garbage Collection...

<table>
<thead>
<tr>
<th>Collection Method</th>
<th>Implementation Cost for Municipality</th>
<th>Operational Complexity for Municipality</th>
<th>User Resistance Expected</th>
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Appendix 3 – Daily Use Fee Collection Options

A Daily Fee Charge to Owners Will Be the Most Effective

Option #1: Tiered (fleet size)
- Charge owners based on fleet size and classification
- Fees are based on # of vessels, not harbor use

Option #2: Daily fee per boat
- Charge owners based on actual harbor utilization
- Fees based on days in harbor, usage will be documented by municipality

Option #3: Deposit system
- Charge operators based on harbor utilization
- Through the use of deposit system, municipality incentivizes cooperation
ACCEPTANCE OF ROAD PRICING IN VIENNA: AN EMPIRICAL STUDY REGARDING THE ACCEPTABILITY AND PATTERNS OF PREFERENCE WITHIN THE CAR-DRIVING POPULATION

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ABSTRACT

This article investigates the acceptability of road pricing for Vienna. Although the implementation of road pricing can be seen as an effective way to solve main traffic problems it does not enjoy great popularity within the (car-driving) population resulting in low acceptability. Often, however, public acceptability is one of the most critical challenges economists face today. To test the acceptability of road pricing for Vienna a replication study was conducted. For this purpose the questionnaire survey – which was carried out in the EU-research project AFFORD (“Acceptability of Fiscal and Financial Measures and Organisational Requirements for Demand Management”) – was adapted according to Vienna’s conditions and broadened by a conjoint analysis. Based on the heuristic acceptance model by Schlag & Schade the cognitive conditions of the acceptability for road pricing were tested. The study investigates three main questions. Firstly, how high is the current acceptability of concrete policy packages within Vienna’s car drivers? Secondly, which factors influence the stated acceptability? Thirdly, what patterns of preference can be detected for designing a road pricing model for Vienna? The survey reveals that – as expected – both road pricing strategies are not accepted. According to the multivariate analyses the variables “personal outcome expectations”, “social norm” and “perceived effectiveness” account for more than 50% of the criterion variance therefore this are the most influential predictors.

KEYWORDS

Road Pricing, Car Driving, Acceptability, Heuristic

INTRODUCTION

Pricing policy is a popular research topic, especially in the field of economics (May 1992). In particular, road pricing has witnessed a rapidly growing interest (Ubbels and Jong 2009; Ubbels and Verhoef: 2006; Fujii et al. 2004, Verhoef et al. 2008). It is publically known that pricing measures are not generally accepted. The low acceptability of urban road pricing in Europe is the main obstacle to its introduction (Frey 2003: 63-65; Sikow-Magny 2003: 20; MC-ICAM 2003). The preference order of relevant measures as illustrated by Figure 1 is nearly identical in all studies. Thus, the improvement of public transport obtains the highest acceptability followed by Park&Ride (P+R), access restrictions and reduction of parking space, respectively. Pricing measures are evaluated worst and any kind of road pricing trails behind the rest. One reason for this strong defensive attitude is the rising costs for the car drivers who, from one day to the next, have to pay additional fees for using certain roads (Schade and Schlag 2004: 213).
FIGURE 1
ACCEPTABILITY OF VARIOUS TRAVEL DEMAND MANAGEMENT MEASURES


FIGURE 2
ACCEPTABILITY MODEL

In the following the central acceptability variables are described in brief.

Problem perception

A high rate of problem perception is seen as a fundamental precondition to the introduction of restrictive measures against traffic-related problems (Schade 2003: 112).

Important aims to reach (objectives)

According to several studies the pursuit of social aims (e.g. more space for pedestrians or more bicycle paths) correlates positively with the acceptability of road pricing while pursuing individual aims (e.g. ‘I would like to use my car whenever I like’) is negatively correlated (Schade and Schlag 2000; Jaensirisak, May and Wardman 2003).

Attribution of responsibility

Steg and Vlek (1997) as well as Schade and Schlag (2004) show that a higher attribution of internal responsibility is positively related to the acceptability of measures; i.e. a person feeling responsible is more likely to accept road pricing than a person who allocates responsibility to external authorities like the government (Harland, Staats and Wilke 1999).
**Subjective knowledge**

Schlag and Teubel (1997) as well as Schlag and Schade (2000) document that such an unawareness concerning road pricing leads to a reduced acceptability. Due to psychological reasons the objective knowledge is less important than the subjective one.

**Perceived effectiveness**

In this context assumptions of strategic responses are relevant as people evaluate a measure as ineffective in order to give a reason for its refusal (Rienstra, Rietveld and Verhoef 1999: 190). As a result, a converse impact of the acceptability of a measure on its (perceived) effectiveness would occur (Schade and Schlag 2004: 215).

**Perceived equity**

Many studies confirm that in general the perceived equity in the form of expected personal advantages of road pricing can be considered as an important reason for its acceptability (Ittner, Becker and Kals 2003; Jakobsson, Fujii and Gärling 2000; Bamberg and Rölle 2003; Fujii et al. 2004; Viegas 2001).

**Social norm**

The confirmed assumption can be made that a measure is more likely to be accepted if this is expected by the social environment (Schade 2005; Jakobsson, Fujii and Gärling 2000; Bamberg and Rölle 2003).

**Socio-economic factors**

Quite often it is argued that acceptability of road pricing is subject to socio-economic impacts (Schade 2003: 114). For example, income is assumed to be a predictor variable, meaning that the rate of rejection is higher in low income groups than in groups with higher income (Schade and Schlag 2004: 216).

**EMPIRICAL EVIDENCE**

**Research design and method**

To test the acceptability of road pricing among the Viennese car driving population a replication study was conducted based on Schade’s and Schlag’s (2000) questionnaire used for the EU-founded research project AFFORD. However the questionnaire was adapted to local conditions.

For the purpose of evaluating the above described problem a structured questionnaire was used comprising 26 mostly closed questions including both questions of fact and questions of opinion. The full questionnaire can roughly be divided into three parts including traffic problems in Vienna in general, the behavioural response to road pricing analysed by two separate pricing strategies and socio-economic characteristics.

The road pricing strategies used in the questionnaire and described below are based on those of the AFFORD-study and were adapted according to Steininger/Gobiet (2005) and Frey/Rauh (2006). For both pricing strategies charges based on driven kilometres have been used. Parking charges, fuel and other taxes remained unchanged.

Strategy “A” (Figure 3) represents the so called “strong” pricing strategy:
The second strategy “B” (Figure 4) reflects the so called “acceptable” pricing model.

Sample

The sample of 250 car drivers was taken from an existing panel of persons willing to participate in market research studies. All participants had to be Vienna residents, hold a valid driving licence for private vehicles and own a car or at least have one available on a regular basis. The sample consisted only of car drivers because they are most directly concerned by the implementation of road pricing. The survey was carried out in December 2009 and January 2010.

RESULTS

Schade and Schlag’s approach was applied in terms of its representation as well as its conducted analysis and resulting outcome. The results are shown subdivided both descriptive and multivariate.

Descriptive results

Table 1 summarises the characteristics of the sample. 250 respondents participated at the survey and thereby form the basis for the following analyses.
In Table 2 the results for pricing strategy “A” and “B” are listed. The ‘subjective knowledge’ of such strategies is quite low, which is not surprising due to the fact that they do not exist in practice yet. The ‘perceived effectiveness’ is considerably higher than the level of ‘subjective knowledge’. Therefore, it can be argued that the respondents evaluate the strategies to a certain degree as effective regarding the reduction of urban traffic and as a consequence have
confidence in these strategies despite low subjective knowledge (Schlag and Teubel 1997: 136). The ‘expectation of personal benefits’ reveals that respondents link both pricing strategies, rather to disadvantages. Although, the estimation for the “acceptable” strategy “B” is significantly more positive. The ‘social norm’ or pressure is very low for both strategies. All in all, both pricing packages are not accepted though there is a significant increase in acceptability of strategy “B” compared to strategy “A”.

### TABLE 2
EVALUATIONS OF STRATEGY “A” AND “B” (MEANS)

<table>
<thead>
<tr>
<th>Strategy</th>
<th>Subjective Knowledge</th>
<th>Perceived Effectiveness</th>
<th>Personal Benefit Expectation</th>
<th>Social Norm</th>
<th>Acceptability</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>1.48</td>
<td>2.55</td>
<td>-.42**</td>
<td>1.85</td>
<td>1.92**</td>
</tr>
<tr>
<td>B</td>
<td>1.45</td>
<td>2.54</td>
<td>-.23</td>
<td>1.93</td>
<td>2.22</td>
</tr>
</tbody>
</table>

All means can vary from 1 (e.g. know nothing at all, absolutely unacceptable) to 4 (know a lot, totally acceptable) with one exception – personal benefit expectation – where means can vary from -1 (expected disadvantages) to +1 (expected advantages).

Wilcoxon signed ranks test:

** Difference between strategy “A” and “B” is significant at $p < .01$

The detailed analysis of the acceptability is shown in Table 3.

### TABLE 3
ACCEPTABILITY OF STRATEGIES “A” AND “B” (%)

<table>
<thead>
<tr>
<th>Strategy</th>
<th>Absolutely Unacceptable</th>
<th>Rather Unacceptable</th>
<th>Rather Acceptable</th>
<th>Totally Acceptable</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>45.2</td>
<td>25.6</td>
<td>20.8</td>
<td>8.4</td>
</tr>
<tr>
<td>B</td>
<td>33.6</td>
<td>21.2</td>
<td>35.2</td>
<td>10.0</td>
</tr>
</tbody>
</table>

Results of multivariate analyses

In this section the results of multivariate analyses, i.e. factor analyses and multiple regression analyses are presented. The methods were applied in order to respond to the following questions:

- Why is the acceptability of certain pricing strategies within car drivers in Vienna so low?
- Which factors have an impact on the level of acceptability?

Factor analysis

Table 4 summarises the analyses of the factors ‘problem perception’, ‘important aims to reach’, ‘expectations’ and ‘attribution of responsibility’. The theoretical differentiations can be corroborated, e.g. concerning the ‘attribution of responsibility’ a distinction between ‘internal’ and ‘external responsibility’ is identifiable.
**TABLE 4**
SELECTION OF FACTORS CREATED BY FACTOR ANALYSIS AND THEIR DESCRIPTIVE VALUES (MEANS)

<table>
<thead>
<tr>
<th>Factor</th>
<th>Number of items</th>
<th>Alpha Cronbach</th>
<th>Mean</th>
<th>Total variance explained</th>
</tr>
</thead>
<tbody>
<tr>
<td>Traffic related problem perception</td>
<td>3</td>
<td>.512</td>
<td>2.86</td>
<td>58.96%</td>
</tr>
<tr>
<td>Environment related problem perception</td>
<td>3</td>
<td>.722</td>
<td>2.73</td>
<td></td>
</tr>
<tr>
<td>Social aims</td>
<td>5</td>
<td>.642</td>
<td>2.96</td>
<td>45.39%</td>
</tr>
<tr>
<td>Individual aims</td>
<td>5</td>
<td>.670</td>
<td>3.21</td>
<td></td>
</tr>
<tr>
<td>Positive outcome expectation</td>
<td>3</td>
<td>.683</td>
<td>2.42</td>
<td>59.29%</td>
</tr>
<tr>
<td>Negative outcome expectation</td>
<td>4</td>
<td>.695</td>
<td>2.88</td>
<td></td>
</tr>
<tr>
<td>Internal attribution of responsibility</td>
<td>2</td>
<td>.588</td>
<td>2.83</td>
<td>54.91%</td>
</tr>
<tr>
<td>External attribution of responsibility</td>
<td>6</td>
<td>.653</td>
<td>2.88</td>
<td></td>
</tr>
</tbody>
</table>

**Regression analysis**

The regression analyses of strategy “A” in Table 5 show that the ‘personal benefit expectation’ accounts for 44.3% of the criterion variance. Hence, a higher acceptability of strategy “A” is to be expected if personal advantages are expected, if the social pressure is high, and if the strategy is regarded as effective. These three significant variables in total account for 55.8% of the criterion variance. The variable ‘subjective knowledge’ is not significant and therefore not listed.

**TABLE 5**
STEPWISE MULTIPLE REGRESSION ANALYSIS OF THE ACCEPTABILITY OF STRATEGY “A”

<table>
<thead>
<tr>
<th>Predictor variables</th>
<th>$R^2$</th>
<th>$B$</th>
<th>$\beta$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Personal benefit expectation</td>
<td>.443</td>
<td>.619**</td>
<td>.470</td>
</tr>
<tr>
<td>Social norm</td>
<td>.531</td>
<td>.414**</td>
<td>.310</td>
</tr>
<tr>
<td>Perceived effectiveness</td>
<td>.558</td>
<td>.196**</td>
<td>.172</td>
</tr>
<tr>
<td>Constant</td>
<td>.918**</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

$F$ total = 103,631; df = 3/249

**significant at $p < .01$**

$R^2 =$ coefficient of determination

$B =$ regression coefficient

$\beta =$ standardised regression coefficient

As displayed by Table 6, the regression analysis for strategy “B” corroborates the findings of strategy “A”. The ‘personal benefit expectation’ is slightly lower compared to strategy “A” but accounts for 36.2% of the criterion variance and therefore still represents by far the highest value. Together with the ‘perceived effectiveness’ and the ‘social norm’ all three variables account for 53.9% of the criterion variance. The variable ‘subjective knowledge’ is again not significant.
In a further step the background variables (‘traffic related’ vs. ‘environment related problem perception’, ‘social’ vs. ‘individual aims’ and ‘internal’ vs. ‘external attribution of responsibility’) were integrated with the already analysed variables (‘subjective knowledge’, ‘perceived effectiveness’, ‘personal benefit expectation’, ‘social norm’ and ‘acceptability’) into one model. Combining strategy A and B arithmetic means were generated for all variables (Schade and Schlag 2003b: 56).

As shown in Table 7, the ‘personal benefit expectation’ has the highest predictive power again and accounts for 43.8% of the criterion variance. Furthermore, ‘social norm’ and ‘perceived effectiveness’ play a major role regarding the predictive power of acceptability. Within the background variables, the ‘social’ as well as the ‘individual aims’ proved to be useful predictor variables. If ‘social aims’ (e.g. more space for pedestrians or more bicycle paths) are uprated by the respondent, as expected, this has a positive effect on acceptability. However, if ‘individual aims’ are uprated, it has a negative effect on acceptability. All other (non-listed) variables are not significant.

### Strategic response

Partial correlations measured between ‘personal benefit expectation’ and ‘perceived effectiveness’ (r = .02) and between ‘perceived effectiveness’ and ‘acceptability’ (r = .371**) depict that the relation between ‘personal benefit expectation’ and ‘acceptability’ is affected only to a minor extent by the ‘perceived effectiveness’. As a consequence, it can be claimed that strategic responses are not likely in this study.

### Socio-economic impacts

The acceptability of those people who mainly use the car for transport to work is lower. The hypothesis that higher income groups rather accept the introduction of road pricing cannot be confirmed by the available results. In total, all five variables account only for 23% of the criterion variance, which states a very low impact of socio-economic variables on the acceptability of road pricing.
CONCLUSION

The implementation of road pricing can be seen as an effective way to solve main traffic problems especially in urban areas. Nevertheless, road pricing is unpopular within the (car-driving) population resulting in low acceptability.

The survey reveals that – as expected – both pricing strategies are not accepted, however, acceptability regarding the “acceptable” pricing strategy is higher than that concerning the “strong” one.

The multivariate results are in line with the expectations raised before on the theoretical level as well as on the basis of the previous studies. The variables ‘personal benefit expectation’, ‘social norm’ and ‘perceived effectiveness’ account for more than 50% of the criterion variance, though the variable ‘personal benefit expectation’ is by far the most influential predictor. This rather selfish view is not amazing and confirms at the same time the assumption that people who rather perceive advantages after the introduction of a road pricing scheme are more likely to accept it. Furthermore, the higher the ‘social norm’ and the ‘perceived effectiveness’, the higher is the acceptability of road pricing.

The combined analyses of general acceptability show that ‘social aims’ (e.g. more space for pedestrians or more bicycle paths) have a positive effect on acceptability while ‘individual aims’ have a negative effect.

Strategic responses where respondents who mainly perceive personal disadvantages out of the introduction of road pricing evaluate it as ineffective in order to justify their refusal were not detected. Moreover, the assumption that income may have a certain effect on acceptability could not be confirmed by the data used for this study. Out of all other socio-economic variables only the car (as a mainly used transport mode) qualified as a moderate predictor regarding acceptability. Thus, the acceptability of those people who mainly use the car as a transport mode to work is lower.

In order to increase the acceptability of road pricing and to find further predictor variables, numerous acceptability analyses will be necessary. Furthermore, it would be desirable if the acceptability of road pricing was not discussed isolated from its effectiveness (Gärling et al. 2008: 205). Hopefully, Vickrey’s (1963: 452) often quoted finding “in no other major area are pricing practices so irrational, so out of date, and so conducive to waste as in urban transportation” will soon be out of date.

REFERENCES


THE ROLE OF SHIPBUILDING IN SHIPPING: PRESENT STUDIES AND NEW ECONOMIC PERSPECTIVES FOR EXTENSION

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ABSTRACT

This paper reviews the variables and topics most studied in shipbuilding. It aims to discuss the trend and new economic issues in shipbuilding from a dynamic point of view and identify the role of shipbuilding in the large shipping world. The reason why shipbuilding is considered so important is that it may change the economic picture of the entire shipping world. What happens in shipbuilding does not just affect ship builders; it is also the primary means of changing the supply of cargo carrying capacity of the shipping industry for the next decade. Most studies focus on the technological issues of shipbuilding; there are relatively fewer studies on shipbuilding from the perspectives of strategy, policy and economics. We can find only a handful of studies discussing exclusively about shipbuilding economics. This paper reviews the literature relevant to shipbuilding and specifically lists those studies from the economic perspective. It is found that most of the earlier economic studies on shipbuilding focus on structural modelling for estimating purpose. They assumed that the shipping prices react to market information simultaneously, and did not fully consider its time-varying nature. However, given the unpredictable and ever-changing nature of shipping industry, it is not convincing to study the market statically, hence time lag issues need to be largely considered in the analysis. This paper proposes a more delicate way to look into the dynamics between freight and shipbuilding markets: the interaction among freight rate, shipbuilding order and delivery. It focuses specifically on the factor of ‘time lag’ between different shipping segments through econometric analysis.

KEYWORDS
Shipbuilding, Review, Dynamics

INTRODUCTION

Shipbuilding is known as an attractive industry for nations under development. Take the three largest shipbuilding countries for example, Japan used shipbuilding in the 1960s to rebuild its industrial structure; South Korea made shipbuilding a strategic industry in the 1970s, China keeps pace with these two countries and overtook South Korea in 2010. China is by far the world's largest shipbuilding nation in terms of compensated gross tons of ships, at a total of 15.9 million tons, followed by South Korea with 11.77 million compensated gross tons. Figure 1 shows the share of shipbuilding contracts received by Japan, South Korea, China, Europe and other areas from 1996 to 2009. The traditional European maritime countries were the leading shipbuilders in the first half of 20th century. Now the entire European countries' total market share has fallen to a tenth of South Korea's. This illustrates shipbuilding industry’s significance to a country’s early development.
The shipbuilding market brings about cash inflow to the shipping industry through trading new ships. A ship functions on two levels in shipping markets: firstly, it is an asset in the capital market. The sale of one merchant ship is a large capital transaction and involves generally millions of US dollars. The capital involved in the shipbuilding process is a huge amount of sunk cost, owning a large and expensive item of capital investment already involves a lot of risk. Secondly, a ship contributes to the supply of carrying capacity in the freight market. In most cases, the shipowners do not invest in ships for speculative purposes; they focus more on the future payoff by chartering out ships in the freight market. To choose a right time to build new ships is essential in this circumstance: since new ships need to be designed, constructed and commissioned before coming into services, the duration from order to final delivery may take two years or longer. When the ship is delivered, the market situation may become totally different.

There are four shipping markets in shipping, trading different commodities: sea transport for freight market, second-hand ships for Sale and Purchase (S&P) market, new ships for shipbuilding market and scrap ships for demolition market. The four shipping markets interact with each other and together make the shipping industry function. The Shipbuilding market is unique in many ways: it is in a way more complex than the sale and purchase market since it involves the whole process of building new ships from ship design to delivery. According to Bruce (1999), the shipbuilding process consists of five steps: contract design, basic design, detailed design, parts manufacturing and assembly. The duration may take two years. Shipbuilding domino effect has been observed by the industry: the types of ship and the yards building them are widely different; however, the prices of different types of ships tend to co-move along the time. This shows the information transparency of shipbuilding market, namely, a perfectly competitive market (Dikos, 2004).

Shipbuilding has not been known as a decisive driver in the future of the shipping and port sector. Many studies discussed shipping economics and focused on freight market exclusively (for example, Hawdon, 1978; Beenstock and Vergottis, 1993). Shipbuilding was only involved in these studies as related variables. However, the reason why shipbuilding market is so important is that what happens in shipbuilding does not just affect ship builders; shipbuilding is the primary means of changing the supply of cargo carrying capacity of the shipping industry, thus in turn changing the economic picture of shipping markets in all.

Shipbuilding has been studied in the literature from the following four perspectives: economics, policy, strategy and technology. Most studies focus on the technological part of shipbuilding, such as ship design and shipbuilding innovation. There are relatively fewer studies on shipbuilding from the perspectives of strategy, policy and economics. We can find only a handful of studies discussing exclusively about shipbuilding economics, and most studies discussed shipping economics in a general sense or focused on the freight market. Shipbuilding was only involved in these studies as related variables. This
paper is structured as follows: chapters 2-5 reviewed the shipbuilding related studies from the perspectives of economics, policy, strategy and technology. Chapter 6 concludes the paper through raising new research angles to look into the shipbuilding market.

ECONOMIC RELATED RESEARCH

Shipbuilding


The shape of the demand curve for shipbuilding has been studied by Stopford (2008) and others. When the shipbuilding price is high, the demand curve is of lower elasticity. It is because at this high shipbuilding price level, only those very few shipowners with very profitable trading opportunities will order new ships. At the lower end of shipbuilding prices, orders will be limited due to lack of trading opportunities, financial limitations and longer delivery times from the shipyards. However, the demand and supply proposition is not practically useful. Firstly it gives a very static picture of the shipbuilding market and is of limited value for a dynamic analysis of the shipbuilding market. Secondly, shipyard capacity as the supply variable was proven to be a very difficult one to find data for. In the absence of shipyard capacity data, the demand and supply proposition cannot be applied in practice.

In the cost-based proposition, the shipbuilding cost is the most influential factor in determining the shipbuilding price. However, subsidies are commonly applied in the shipbuilding industry. The efficiency varies across yards. As a result, the shipbuilding cost is not a reliable indicator for the fluctuation in shipbuilding price.

The asset pricing proposition has been adopted in most studies, e.g. Beenstock and Vergottis (1989). Under this asset pricing proposition, newly built ships and second-hand ships are perfect substitutes with shipbuilding discounted time value; the shipbuilding prices co-move with second-hand ship prices over time.

Many studies have discussed shipping economics and focused on freight market exclusively. Shipbuilding has only been involved in these studies as related variables. Table 1 summarises the studies on shipbuilding market from economic perspective. Two variables about shipbuilding market have been discussed most: orders for new ships and ship prices. Other related variables include ship investment, fleet size, demand for vessels and shipbuilding delivery.

Hawdon (1978) wrote one of the first few papers on modelling the freight rate. He studied the determination of tanker freight rates in the short and long run. In the long run, he mentioned the shipbuilding market’s influence to the gross investment decisions of the shipowners, such as shipbuilding price, the size of the fleet and overall size of the ship ordered. He modelled orders for new tankers and ship prices for tanker shipbuilding market. Orders of new tankers is regressed against price of new tankers, world international seaborne trade in oil and tanker voyage freight index; while Ship prices are regressed on tanker voyage freight index, world tanker fleet, past price of new tankers and average size of tankers in the world fleet.

Charemza and Gronicki (1981) provided aggregated long-run models for world shipping and world shipbuilding. In the world shipbuilding segment, the models include demand for shipbuilding orders, supply of shipbuilding orders and ship prices. Demand for shipbuilding orders is affected by the fleet existing at the beginning of the period, tanker freight rate and oil shipment volume. Ship prices depend on previous ship price, tanker freight rate and oil shipment volume.

Nielsen, Kristensen, Bastiansen and Skytte (1982) performed macro forecasts of demand for and supply of transportation in the maritime sector. The authors presented a causal loop diagram of the dynamic development of contracting and deliveries. The lead time from contracting of new ships to the time of delivery is approximately 2 years. This long production time makes the system unstable because the contractings respond very quickly to marginal changes in the freight rates. The authors also mentioned that if the requirement for DWT is greater than the supply, it results in expansion of the orderbook by contracting, and a period with high contracting followed by low growth economy will for a long time result in surplus tonnage.
Beenstock and Vergottis (1989) for the first time investigated the freight and ship markets in an interdependent setting in which freight market developments depend on the markets for ships and vice versa. The size of the fleet affects freight rates while freight rates affect the stock demand for vessels. Freight rate, shipbuilding prices and fleet size are dynamically interdependent. The models are based on efficient markets/rational expectations hypotheses. In the shipbuilding sector, deliveries of new ships depend on past values of deliveries and orderbook; the size of the dry cargo orderbook is related to past values of shipbuilding orders, deliveries of new dry cargo vessels and shipbuilding prices; shipbuilding prices are an index of expected future second-hand ship prices.

Marlow (1991) wrote a trilogy about investment incentives and shipping industry, and in the third paper specifically discussed the major determinants of investment in the UK shipping industry. Ship investment is functioned by a series of variables: capacity utilisation (percentage of active fleet in total world fleet); total world fleet; demand for shipping (world seaborne trade); investment incentives; credit arrangement and expectations of the shipowners.

Dikos (2004) drew the conclusion that the pricing by shipyards is determined only in terms of production costs and market share conditions, not the ordered deadweight in each period. New vessel prices seem to be sub-optimal and inelastic with respect to the demand for new vessels. The dependence of costs on the demand for new vessels is relatively weak.

Mulligan (2008) presented new models for estimating shipbuilding costs from the ship design and construction perspectives. Shipbuilding costs are modelled as a first-order function of PPI (producer price index) and a third-order function of deadweight function for various types and standard ship sizes.

Engelen, Meersman and Van de Voorde (2006) used system dynamics approach to model the different shipping markets. In the new-building market part, order rate, delivery time and shipbuilding price are modelled. The ordering behaviour is claimed to depend on the level of rates, since the earning potential of a ship (freight rate) over its lifetime is considered as the price of the ship. The shipbuilding price is determined by the long-term equilibrium freight rate. The authors also mentioned that the time lag between the ordering and delivery of the vessel explains part of the structural inequality in shipping, this delay triggers additional dynamic behaviour within the system.

Bessler, Drobetz and Seidel (2008) did an empirical analysis of the relationship between spot and forward prices in freight markets. They studied the dynamics of spot and forward freight rates, such as cointegration and equilibrium, from a ship investment perspective. Their findings suggest that time series properties of freight rates need to be well understood before investing in ship funds.

Lun and Quaddus (2009) developed an empirical shipping market model to predict fleet size. Their study incorporated the key variables in four shipping markets: shipbuilding, second-hand and scrap vessel prices, freight rate, fleet size, and seaborne trade. Seaborne trade and freight rate are proved to be positively related to fleet size. Freight rate has a significant impact on shipbuilding, second-hand and scrap vessel prices.

From the above studies, we can observe that orders for new ships is commonly regressed on the following variables: 1. demand for shipping service, which is often represented by world seaborne trade, 2. supply of shipping service, such as total world fleet, existing orderbook, deliveries of new vessels; 3. freight rate level, and 4. several other prices, such as shipbuilding prices and second hand ship prices. Another frequently studied variable ship prices is commonly regressed on previous ship prices, freight rate, fleet size, second hand ship prices and production cost.
The pricing of ships: second hand ship price and scrapping price

The pricing of ships has been studied as a capital asset with the asset pricing determined by measuring the net present value of expected earning potential (for example, Dikos, 2004; Alizadeh and Nomikos, 2007). Besides shipbuilding prices, Second hand ship price and Scrupping price have also been studied in previous research.

Dikos and Marcus (2003) applied structural partial equilibrium model to explain the prices of second-hand vessels by the prices of new vessels and the charter rates. Alizadeh and Nomikos (2007) investigated the long-run cointegration relationship between price and earning of investing second-hand market for ships through cointegration VECM. The analysis part focused on investment timing and strategies.

Knapp, Kumar and Remijn (2008) studied the dynamics of the ship recycling market using econometric modelling. The variables include scrap price and basic ship information, such as ship type, tonnage and ownership.

POLICY RELATED RESEARCH

There are two types of studies on shipbuilding policy: first, the effect of public policy on shipbuilding investment, and second, a country’s policy towards its shipbuilding industry.

Shipbuilding is a very attractive industry for a country as it can bring a substantial amount of foreign direct investment. There has been a handful of research on the effect of fiscal policy and investment incentives on shipbuilding investment. Marlow (1991) mentioned that during the mid-1960s it was less common than before for shipowners to finance investment from their own funds. Since then the governmental investment schemes on shipping industry have become so favourable that the real rate of interest has been negative in some cases. Shipowners would naturally tend to obtain investment funds from other sources instead of their own funds, among which one of the most popular nowadays is foreign direct investment (FDI). There have been a handful of studies on the impact of FDI on the maritime industry. Kind and Strandenes (2002) used Singapore as an example to analyse the host country effects of FDI. They argued that the main reason why Norwegian maritime industry considers investing in Asia is the public policy there, which was formed to consciously encourage FDI in export oriented manufacturing and services, and host clusters seem to be more important for service providers in transport or repair and maintenance markets than for industrial manufacturers.

Akselsen (2000), Tenold (2000), and Kind and Strandenes (2002) all discussed the location advantage to the shipping investment in their study of FDI and maritime industry. The location advantage of the maritime cluster to the different home countries also differs, for example, the tax heaven, low transaction costs, low barriers to trade, and closer to customer market.
Zeien (1991) wrote a monograph to discuss different types of shipyard subsidies and their effects on shipbuilding industry in the United States. The author drew the conclusion that to eliminate subsidies is beneficial to the world-wide shipbuilding market. He also discussed the United States’ role to create a level playing field for the world shipping industry.

In respect to a country’s shipbuilding policy, here we list three papers discussing the shipbuilding policy in China, Korea and around the world. Song (1990) discussed the shipping and shipbuilding policies in China. The author mentioned that the two industries were under greatest development ever and becoming increasingly important to China’s national economy. Lee (1990) discussed the role of the Korean government in Korean shipping: the government plays both direct and indirect roles in Korean shipping growth. The paper also concluded that the expansion of shipping in Korea was a response to the export-oriented industrialization policy. King (1999) discussed the new directions in shipbuilding policy around the world in the 1990s. He mentioned shipbuilding policy in Europe is very different from other shipbuilding states, such as Japan, South Korea and China. While shipbuilding in Europe has been more or less accepted by the industry and academics as ‘an out-dated and poorly managed’ industry, in Japan, and later in South Korea and China, shipbuilding industry has been identified as a key and strategic industry which has gained enormous government support and enjoys specially created green field sites with state protection.

STRATEGY RELATED RESEARCH

We categorise the studies on shipbuilding behaviour, such as investment timing and tonnage, into strategy related research. These papers use dynamic simulation to model the cycle of the market and shipbuilding process to help improve the ship investment decision in the cyclical shipping market.

Koskinen and Hilmola (2005) used system dynamics simulation to model investment cycles in the shipbuilding market of ice-strengthened oil tankers. The variables in the simulation models include future transport demand, terminal capacity and shipbuilding tonnages. Bendall and Stent (2005) applied real option approach to simulate ship investment under uncertainty. They proved that real option approach is a useful tool to value the flexibility of ship management to adapt a project in conditions of uncertainty. Dikos et al. (2006) developed and implemented system dynamics models to help managers improve their investment decisions in the cyclical tanker market. The results revealed the key factors that affect taker rates and unforeseen dynamics. Audia and Greve (2006) used data in shipbuilding firms to analyse how firm size and firm performance affect risk taking decision in shipbuilding industry. They applied Generalized Estimating Equations (GEE) models.

TECHNOLOGY RELATED RESEARCH

There have been plenty of studies on the technological part of shipbuilding, such as ship design and shipbuilding innovation. Here two papers are quoted to illustrate the large amount of papers on shipbuilding technology. Motora (1997) discussed 100 years of history of Japan’s shipbuilding industry from the technological perspectives. Pires Jr., Lamb and Souza (2009) applied Data Envelopment Analysis (DEA) and Analytic Hierarchy Process (AHP) methods to assess shipyard performance. They suggested a methodology for shipbuilding performance assessment.

NEW RESEARCH PERSPECTIVES ON THE SHIPBUILDING MARKET

Cash flow and time lags among four shipping markets

As previously mentioned, there are four shipping markets in shipping trading different commodities: sea transport for freight market, second-hand ships for S&P market, new ships for shipbuilding market and scrap ships for demolition market. Stopford (1997) described the cycle of the four shipping markets (Figure 2): at the beginning when shipping supply cannot catch up with demand in freight market, freight rates rise and cash starts to flow into the cycle. Shipowners thus have the financial confidence to buy second-hand ships in S&P market, or order new ships due to the economic reasons or lack of appropriate second-hand ships. With more and more arrival of shipbuilding ships after a period of time, shipping supply surpasses demand, freight rates fall, the shipowners act reversely.
We are aware of the fact that there are lead and lag relationships between different shipping markets. Since it takes time for market information to flow from one market to another, and the responding rate to new information varies across different shipping markets. The time lags were most often discussed between markets in the literature. However, in terms of freight market and shipbuilding market, time lags between the two markets actually act in a more delicate way. The three most commonly discussed variables are chosen in these two markets: freight rate, shipbuilding order and delivery. Figure 3 illustrates the time lag or dynamics among them.

**FIGURE 2**

CYCLE OF FOUR SHIPPING MARKETS

Source: Maritime Economics (Stopford, 1997)

**FIGURE 3**

DYNAMICS AMONG FREIGHT RATE, SHIPBUILDING ORDER AND DELIVERY
Figure 3 illustrates the dynamics among freight rate, shipbuilding order and delivery. First, the cash flows from freight rate (the freight market) to shipbuilding orders (the shipbuilding market). Often there is a lag between these two markets, since it takes time for the market information to deliver and the ship-owners to perceive. Second, after the shipowners make the decision to build new ships, the new ships need to be designed, constructed and commissioned before coming into services, the duration from shipbuilding order to final delivery may take two years or longer. Third, when the ship is delivered, it immediately constitutes the new ship supply of the market, the fleet size trading in the market thus changes, and in turn affects the freight rate, the freight market situation may become totally different by then. There are two lags in this cycle: from freight rate to shipbuilding order and from shipbuilding order to delivery. Several research issues are raised as follows to analyse the dynamics among freight rate, shipbuilding order and delivery.

Dynamics between shipbuilding market and other shipping markets

The first research issue concerns from freight rate to shipbuilding order. From the above cash flow analysis on the four shipping markets (see Figure 2), we understand that shipbuilding demand is a derived demand, as it depends mainly on the operating environment of the freight market, usually with a lag. It is believed that shipowners make the shipbuilding order of ships based on their judgment of the freight market situation (see Figure 3). The prosperity of the shipbuilding market is driven by freight rate, vessel demand in the freight market. Shipbuilding demand is a derived demand, as it depends mainly on the operating environment of the shipping market. While one can imagine the existence of a relationship between shipbuilding price and freight rate, the direction of causality between them is not known, that is, whether freight rate leads shipbuilding price or vice versa or a bidirectional causality exists. Many existing studies have focused on the characteristics of shipping freight rate and looked at factors influencing these rates (Hawdon, 1978; Beenstock and Vergottis, 1993). Beenstock and Vergottis (1989) concluded a regression analysis of shipping market and found that shipbuilding price responds very little against the freight rate and no time delay is observed across shipping markets. New studies need to examine and clarify the dynamic relationships between freight rate and shipbuilding price. Thus, rather than building a regression model for freight rate or shipbuilding price (e.g. Dikos, 2004; Mulligan 2008), the directional relationship between freight market and shipbuilding market need to be analysed.

Determinants of shipbuilding activities

The second research issue refers to the Shipbuilding order segment in Figure 3. Shipping industry is known as a capital intensive industry, the capital involved in the shipbuilding process is a huge amount of sunk cost, owning a large and expensive item of capital investment involves huge risk. There have been studies on modelling the shipbuilding prices and orders for new ships. However, few of them analysed how and why the amount of shipbuilding orders fluctuates dramatically over time. To our best knowledge, there is no rigorous study on the determinants of shipbuilding activities. Previous studies on shipbuilding have been mainly about modelling the shipbuilding prices, or involving shipbuilding as related variables when discussing other shipping markets. They assumed that the newly built ships and second-hand ships are perfect substitutes and their prices are linked according to the net present value. However, few of them analysed how and why the amount of shipbuilding orders fluctuates over time. The few papers on ship investment behaviour discussed it from individual countries’ cases (Marlow, 1991; Kind and Strandenes, 2002).

Dynamics between fleet size and freight volatility

The third research issue concerns with the closing arrow from delivery to freight rate. It was mentioned earlier that the duration from shipbuilding order to final delivery may take two years or longer. The delivery causes the change of the supply of fleet trading in the shipping markets, while the freight market situation may become totally different from the shipowners’ expectations when they made shipbuilding orders. The highly volatile nature of freight rate is widely acknowledged, however, the impacts and the causes of the time-varying risk in shipping markets has been left unstudied. Of all the variables that might cause the high volatility of freight rate, fleet size is believed to be the one that changes most severely along the time, due to the habitual massive shipbuilding orders in shipbuilding market and the lag between the shipbuilding order and delivery. In other markets, such as stock market, the positive relationship between stock price volatility and trading volume has been widely confirmed (see, for example, Gallant, Rossi and Tauchen, 1992; Jones, Kaul and Lipson, 1994). In shipping economics studies however, few have discussed the relationship between fleet size and freight rate volatility, while an abundance of research has been done to understand the time-varying characteristics of freight rate volatility (Kavussanos, 1996; Kavussanos, 2003; Lu, Marlow and Wang, 2008; among others). It is widely
acknowledged of the highly volatile nature of the freight rate, however, the impacts and the causes of the time-varying risk in shipping markets has been left unstudied.

In terms of the methodology trend in shipping economics research, research methodology has been shifted from structural modelling to more advanced econometric analytical tools. Dynamics between shipbuilding market and other markets and the possible impact brought by what happens in shipbuilding market are left unexamined in the literature, a series of time-series and panel techniques are suggested to analyse the shipbuilding market in a wide context.

REFERENCES


THE ROLE OF YARD CRANES’ COORDINATION IN IMPROVING THE CONTAINERS’ PICK-UP PERFORMANCE IN AUTOMATED CONTAINER TERMINALS

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ABSTRACT

Advocated by the sustainable growth of global economic activities, worldwide maritime container traffic has posted persistent positive growth. For the container terminals (CTs), the positive prospect opens up not only bigger business opportunities, but also more severe competition. To win the rivalry, CTs strive to provide better container handling performance by conducting attempts to improve their operational efficiency. For some leading CTs, automating container handling activities is considered as a promising strategy to cope with the increasing demand. In response, we focus on the automated container pick up (import) operation. Adopting the multi agent system approach, we propose a coordination strategy for synchronizing the activities of numerous yard crane agents (YCA) in serving the import containers pick up requests of the incoming drayage trucks (DTs). While in the previous research the automated pick up operation is executed by employing automated YCAs that work selfishly, in this paper we incorporate coordination ability to the YCAs such that unproductive moves can be eliminated. To assess the proposed concept’s performance (i.e. cranes’ travelled distance, DTs waiting and service time, DT’s queue length) in different occupational conditions, we conduct numerous series of multi agent simulations.

KEYWORDS
Automated Container Terminals, Multi Agent Systems, Coordination

INTRODUCTION

Motivated by the success stories from some leading container terminals (CTs) in Europe (e.g. CTA Hamburg, ECT Rotterdam), automated container terminal operations have received an increasing attention both from the practitioners and the research communities. While for many years the CT automation topic has been a very fruitful area for conducting operation research (OR) studies (Stahlbock & Voß 2007), a growing research interest has also emerged from the agent-based research community (Davidsson et al. 2005). While OR researches perform well in delivering solutions for numerous design and operational planning tasks (Guenther & Kim 2005), the area of real-time control of the CT’s operations is largely unexplored. Known for its reliability in providing solutions for highly complex and highly dynamic environments, agent based method is considered as a suitable and a natural approach for the task of CTs’ real time operation control. For the task, numerous agent based studies have been conducted in the full range of CT’s operation categories: the marine side interface, the container handling and storage operations, and the landside interface operations (Davidsson et al. 2005).
In this paper we concentrate on the landside interface services area. More specifically we are interested in improving the performance of container’s pick up service fulfillment requested by the incoming drayage trucks (DT). In the previous research, Vidal and Huynh (2010) have conducted a simulation study that reflects the operation of an automated containers pick up service. In their model they employ two yard crane agents (YCAs) that work selfishly in fulfilling the containers pick up requests sent by the DTs. Building upon the work of Vidal and Huynh (2010), we are also interested in analyzing the performance of an automated containers pick up service. Not like the previous study, in our model we employ four YCAs that work collaboratively. In line with Durfee et al. (1989) suppositions, we conjecture that the implementation of collaboration logic for the YCAs will reduce the amount of unnecessary effort duplications, improve YCAs’ operational efficiency, and result to a better DTs’ service performance.

**PROBLEM DESCRIPTION**

The container pick up (physical) operation is started whenever a DT reaches the CT’s gate-in to pick up a container. After finalizing the gate in’s formalities, the DT then enter the container yard and go to the location of the previously requested container, wait until the finalization of the container delivery operation, proceed to the gate out location for the final checking procedures, and depart from the CT (Geweke & Busse 2011).

In modeling the containers pick-up process, Vidal and Huynh (2010) have built an agent based simulation platform that employs two YCAs that are responsible for four containers block area (see Figure 1). In their model, each crane agent’s main concern is to maximize their own utility (either picking the nearest located container or the container that have waited the longest). The YCAs are working selfishly and have no intention to communicate and collaborate with its partner to improve the system performance.

**COORDINATION SCHEME**

To operationalize our study, we have modified the YCAs’ logic from the selfish mode to the collaborative mode. Recall that in the previous study (Vidal and Huynh, 2010), in aiming the DT candidate, each YCA is only interested in maximizing its utility without paying any attention to its YCA partners’ intention. From our analysis to the previous study, we have remarked the cases in which several YCAs are running to service the same DT, since that DT...
offer highest utility values for several YCAs concurrently. Since in the end there will be only one YCA that can serve the most preferred DT, inefficiency can rise due to the efforts parallelization.

**TABLE 1**

<table>
<thead>
<tr>
<th>CRANE AGENTS’ COORDINATION LOGIC.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. to-report define-goal-position</td>
</tr>
<tr>
<td>2. let truck-candidate max-one-of (trucks with [not waiting]) [utility myself]</td>
</tr>
<tr>
<td>3.</td>
</tr>
<tr>
<td>4. if(truck-candidate) = nobody [</td>
</tr>
<tr>
<td>5. report nobody</td>
</tr>
<tr>
<td>6. ]</td>
</tr>
<tr>
<td>7.</td>
</tr>
<tr>
<td>8. let this-crane-utility [utility myself] of truck-candidate</td>
</tr>
<tr>
<td>9. let previous-crane-utility [my-utility] of truck-candidate</td>
</tr>
<tr>
<td>10. let previous-crane [my-crane] of truck-candidate</td>
</tr>
<tr>
<td>11.</td>
</tr>
<tr>
<td>12. if (previous-crane = nobody)[</td>
</tr>
<tr>
<td>13. ask truck-candidate [set my-crane myself]</td>
</tr>
<tr>
<td>14. report [position] of truck-candidate</td>
</tr>
<tr>
<td>15. ]</td>
</tr>
<tr>
<td>16.</td>
</tr>
<tr>
<td>17. if (this-crane-utility &gt; previous-crane-utility) [</td>
</tr>
<tr>
<td>18. ask truck-candidate [set my-crane myself]</td>
</tr>
<tr>
<td>19. ask truck-candidate [set my-utility this-crane-utility]</td>
</tr>
<tr>
<td>20. ask previous-crane [set goal []]</td>
</tr>
<tr>
<td>21. report [position] of truck-candidate</td>
</tr>
<tr>
<td>22. ]</td>
</tr>
<tr>
<td>23.</td>
</tr>
<tr>
<td>24. return nobody</td>
</tr>
<tr>
<td>25. end</td>
</tr>
</tbody>
</table>

To avoid the inefficiencies caused by the effort duplications of the selfish YCAs, we have developed a coordination scheme for the YCAs. The Netlogo (Wilensky 1999) code overview is portrayed in Table 1. As shown, the codes between line 2 and line 6 are basically applying the previously studied selfish agent behavior. Those codes reflect the YCAs’ intention to always seek for a DT candidate that offers higher operational utility. The codes between line 12 and line 22 show the logic that is utilized to avoid any effort duplication for the service of a specific DT. The main thinking is that a DT can be served by a YCA whenever one of the two cases rises. First, a DT is not previously booked by another YCA. Second, if a DT is already booked, the YCA that bids at the latter time has to offer bigger operational utility to invalidate the previous YCA reservation.

**SIMULATION SETUP AND RESULTS**

Recall that our main interest is to analyze the impact of applying coordination concept to the automated containers pick up operational performance. To do this we assess the concept under different levels of occupation, we simulate the CT’s performance in four different truck arrival rates. In our study we apply the distance based (Vidal & Huynh, 2010) utility functions as the main incentive for the YCAs. In the simulation, all YCAs work opportunistically (i.e. each crane agent evaluates its utility value at each simulation tick) both in the coordination mode and the previously studied selfish mode. In total, we run 4*2 different experiment scenarios (i.e. four truck arrival alternatives and two agents’ collaboration modes) (see Table 2). Each experiment run lasts for 201,600 ticks (7 working days). We treat the first 57,600 ticks (2 days) as the warm-up period, meaning the results generated within this period are disregarded. In addition, we employ 4 cranes, so that each crane will be responsible for one containers block area (see Figure 1). Note that other than the customizations stated in this paper, all simulation set-up details will be aligned to the benchmark paper (Vidal & Huynh, 2010).
TABLE 2
SIMULATION SCENARIO

<table>
<thead>
<tr>
<th>Control Variable</th>
<th>Simulation Setup</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Simulation Length</td>
<td>00:463s</td>
<td>int</td>
</tr>
<tr>
<td>MTU up Period</td>
<td>0:0000</td>
<td>mile</td>
</tr>
<tr>
<td>Truck Arrival</td>
<td>0.75, 0.83, 0.75,</td>
<td>truck/minute</td>
</tr>
<tr>
<td>Delivered Units Duration</td>
<td>Short Distance</td>
<td>mile</td>
</tr>
<tr>
<td>Installation Period</td>
<td>Short Time Coordination</td>
<td>Agent</td>
</tr>
</tbody>
</table>

In this study, we measure the containers’ pick up service performance in terms of gate in’s queue length, DT’s waiting time, DT’s service time, and the distance travelled by the YCA per single truck pick-up service finalization. The overview of the simulation results is portrayed in the Table 3. As portrayed, compared to the selfish agents mode, the application of the proposed coordination logic to the automated crane agents has improved (reduced) the average travelling distance spent per-single pick up request. However, the magnitude of the improvement decreases as soon as the DTs’ arrival rate is getting higher. While from the CT side the implementation of the coordination scheme elicits positive impact, from the DTs’ perspective, the YCA coordination scheme only performs well in a low truck arrival rate conditions. As soon as the CT receives too many pick up requests, the proposed coordination scheme does not lead to satisfactory service level.

TABLE 3
SIMULATION RESULTS

<table>
<thead>
<tr>
<th>Agent Type</th>
<th>Truck Arrival Rate (trucks/minute)</th>
<th>Queue Length (trucks)</th>
<th>Waiting Time (minutes)</th>
<th>Travelling Distance (miles)</th>
<th>Service Time (minutes)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>μ</td>
<td>σ</td>
<td>μ</td>
<td>σ</td>
</tr>
<tr>
<td>Coordinating</td>
<td>0.25</td>
<td>0.62</td>
<td>0.99</td>
<td>4.57</td>
<td>0.14</td>
</tr>
<tr>
<td>Coordinating</td>
<td>0.5</td>
<td>1.63</td>
<td>1.97</td>
<td>5.14</td>
<td>0.06</td>
</tr>
<tr>
<td>Coordinating</td>
<td>0.75</td>
<td>2.00</td>
<td>2.78</td>
<td>5.84</td>
<td>0.08</td>
</tr>
<tr>
<td>Coordinating</td>
<td>1</td>
<td>286.01</td>
<td>286.81</td>
<td>13.00</td>
<td>5.27</td>
</tr>
<tr>
<td>Selfish Agents</td>
<td>0.25</td>
<td>0.99</td>
<td>1.99</td>
<td>5.11</td>
<td>0.07</td>
</tr>
<tr>
<td>Selfish Agents</td>
<td>0.5</td>
<td>1.99</td>
<td>2.97</td>
<td>5.41</td>
<td>0.06</td>
</tr>
<tr>
<td>Selfish Agents</td>
<td>0.75</td>
<td>2.96</td>
<td>2.97</td>
<td>5.74</td>
<td>0.05</td>
</tr>
<tr>
<td>Selfish Agents</td>
<td>1</td>
<td>3.96</td>
<td>3.97</td>
<td>6.78</td>
<td>0.06</td>
</tr>
</tbody>
</table>

We conjecture that as soon as the CT’s workload increases, the time that is spent on the communication and coordination of the container’s booking phase actually has reduced the time allocation that is actually can be allocated to do productive service moves. We conjecture that at the high CT’s occupancy, the probability for each YCA to find a DT’s request that is located nearby is high. In this situation, spending time in aligning the coordination measure will have a diminishing return. However, we need to confirm this conjecture in the future research by operationalizing the time allocation profiling analysis.

CONCLUSION AND FURTHER RESEARCHES

Taking a context of automated containers pick up activities, we report our ongoing attempt to develop a coordination scheme for the YCAs. From the simulation result, we understand that our coordination proposal has managed to increase the working efficiency of the YCAs in terms of travelling distance per pick-up request finalization. The proposed scheme however cannot manage to bring satisfactorily performance for the CT’s customers (i.e. the DTs) (i.e. queue length, waiting time, service time). The indications have invited us to explore other agent based coordination schemes that works well both in the low and high occupancy period. Moreover we also will do activity - time allocation profiling to verify the conjecture that the communication elaborations do actually reduce the YCAs’ productivity in a high occupancy period. The time profiling results will stand as a starting point in designing better YCAs’ coordination schemes.
REFERENCES


DEFINING AND MEASURING MULTIMODAL TRANSPORT SERVICE

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ABSTRACT

The ‘Multimodal Transport’ concept can be defined as the combination of various types of transport modes used in national or international transport operations, in which provides door-to-door services under the responsibility of one single transport operator (UNCTAD, 1995; 2001). However, according to the literature, there are similarities between the definitions of ‘Intermodal Transport’ and ‘Multimodal Transport’ and several authors have used them interchangeably. The authors of this paper argue that these two terminologies should not be used in an interchangeable manner. Under an international transport environment, clarification of documentation and fulfilment of transport policies are, indeed, critical in an international transport operation of any length. It is clear that multimodal transport provides logistics services, and several authors have highlighted key attribute-measures through the investigation of product / service offerings from various types of industries. However, little or no research has quantified these measures. A considerable body of literature on quantifying logistics services exists but there is only a limited literature in relation to service satisfaction in multimodal transport and transport in general. Combining academic journals and government reports, the multimodal transport service construct is empirically developed and rigorously tested. The current study is pioneering research, which incorporates statistical techniques to examine service satisfaction phenomena between shippers and multimodal transport operators. This multimodal transport service construct can thus be taken into account when undertaking multimodal transport –related research in the future.

KEYWORDS
Multimodal Transport Service, Measurement, Definitions, Statistical Analysis, Structural Equation Modelling

INTRODUCTION

As trade and transport networks were taking shape through series of development, together with growth of containerised transport and improvement of cargo transfer system between different modes, modern transport practices such as Multimodal Transport has significantly affect current transport systems. In this study, Multimodal Transport is defined as involvement of cargo movement through the usage of combination of modes from shipper to consignee under a single rate, with through billing and through liability in providing door-to-door services (UNCTAD, 1981). Universal momentum toward efficiency has been revolutionised through various driving forces at a global scale. As logistics and Multimodal Transport services are being recognised for their pre-eminent role in the globalised economy, three interrelated adaptive changes have emerged, namely: industrial process, the organisation of international trade and international trade patterns themselves. Rondinelli and Berry (2000) has pointed out the four driving forces for Multimodal Transport are economic globalisation, speed-to-market product delivery, agile manufacturing and business practice, and integrated supply chain management. These subtle driving factors mirror the UNCTAD report (1995), which shows that regardless of trade development, a continuum of network development is crucial through transport integration with adaptive use of Multimodal Transport systems. Referring to the Multimodal Transport literature in the area of Southeast Asian transport, extensive work focusing on Indo-China and parallel research on Baltic trades has been widely distributed (Carruthers, et al. 2004; Banomyong and Beresford, 2001; Rodrigue, 1996). From shippers’ perspective, point-to-point transport is one of important characteristics of Multimodal Transport logistics and containerisation has assisted to improve the performance of modal transfer of general cargo at ports and terminals. Nevertheless, Multimodal Transport is highly considered as a catalyst for removing trade barriers, providing a model for achieving supply chain integration (Islam, et al. 2005).
DEFINING MULTIMODAL TRANSPORT

The ‘Multimodal Transport’ terminology was first coined by the United Nations Convention on Trade and Development (UNCTAD) on International Multimodal Transport of Goods in 1980\(^1\), which authoritatively defines the term as “the carriage of goods by at least two different modes of transport on the basis of a multimodal transport contract from a place in one country at which the goods are taken in charge by the multimodal transport operator to a place designated for delivery situated in a different country (UNCTAD, 1981).” The concept can be defined as the combination of various types of transport modes used in a national or international transport operation, in which provides door-to-door services, under the responsibility of one single transport operator (UNCTAD, 1995; 2001). Practically, this particular concept is not new and may even have been practiced long before the introduction of this terminology. According to Woxenius (1998), the early form of combining transport modes dates back to Roman times where horses and carriages were the primary form of interchangeable transport modes. An effort of introducing adequate legal framework for Multimodal Transport operation was found in the work of ‘International Code of Affreightment’ in the early 1910s. However, during that time, transportation was considered as a segmented industry based on unimodal operation and contracts. It was not until the introduction of large-scale containerisation in the 1970s, did Multimodal Transport gain considerable momentum (Faust, 1985). According to Muller (1995), only 1 per cent of world-containerised cargo was moved intermodally under a through bill of lading in 1979. Today, most containerised cargo does.

Until the introduction of containerisation in the 1960s, physical movement of goods had been through evolutionary changes of innovation in an attempt to achieve efficiency and effectiveness (Hayuth, 1987). However, based on the emergence of driving forces such as technology, economy, regulation, social environment and business competitiveness, the complexity of transport operations has driven the need to introduce a more structured concept. This in turn brought with it a terminology which would encapsulate the key considerations of transport practices and which would be agreed upon at an international level (Hayuth, 1987; UNCTAD, 1993). As a component of international trade, Multimodal Transport has generated considerable commercial values for shippers in comparison to other alternative transport systems. According to Campisi and Gastaldi (1996), Banomyong (2000), SLA (2008), and Islam, et al. (2008), some of its many advantages are:

- Reduction of time, risk of lost or damaged goods through a planned and coordinated single transport operation,
- The establishment of a seamless communication link maintained by single Multimodal Transport Operator,
- Increase market access opportunity through speedy transfer and transit time,
- Reduction of multiple documentation,
- Cost saving through possible reduction of freight rate,
- Minimising confusion through a single point of contact (the Multimodal Transport Operator),
- Ultimately, an improvement in the competitive position of companies in the international market place,
- Different solutions can be easily benchmarked for performance,
- and Reduction in energy used, thus provides environmental and social benefits.

According to these inherent benefits, it is clear that Multimodal Transport has the potential in providing numerous commercial advantages for shippers, consignees and freight forwarders. Needless to say, it is an integrating tool in offering shippers a great choice of cost control, flexibility, competition, reliability and a one-stop service (Islam, et al. 2005). The distinguished features of the Multimodal Transport concept are: combination of various types of transport modes, international transport operation and responsibility of one single operator. Transport terminologies such as ‘Intermodal Transport’ and ‘Multimodal Transport’, has been widely used in context of cargo movement through flow of traffic, which in some cases share similar meanings such as the movement of goods by more than one mode of transport and a through freight rate (Banomyong, 2000). In this research, literature regarding passenger transport has been excluded because of the fundamental difference between passengers who move themselves and goods, which need to be moved (Bontekoning, et al. 2004).

The term ‘Intermodal Transport’ or communally known as ‘Intermodality’, was defined by Hayuth (1987) as “the movement of cargo from shipper to consignee by at least two different modes of transport under a single rate, through-billing, and through liability.” The purpose of the concept was to further imply the cooperation and coordination throughout the entire transport chain in the most cost- and time-effective manner. Other definitions for intermodal transport are found with slight differences from each other. According to Banomyong (2000), the European Conference of Ministers of Transport (ECMT) and European Committee for standardisation (CEN) defines the term as “the movement of goods in one and the same loading unit or vehicle which uses successively several modes of transport

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1 United Nations Conference on a Convention on International Multimodal Transport, held at Geneva from 12th to 30th November 1979 as the first part of the session and the resumed session was from 8th to 24th of May.
when dealing with Multimodal Transport, the ability to design and provide combination of mode choice has been agreed the involvement of the movement of cargo from origin to destination using two or more different modes. Therefore, according to Table 1, the first part of the definition shares the same understanding among different authors in the current and recent literature, therefore, various definitions of Multimodal Transport have been found as presented in Table 1.

Table: Definitions and Interpretations of Multimodal Transport Applied in the Literature in Approximate Chronological Order

<table>
<thead>
<tr>
<th>Authors</th>
<th>Date</th>
<th>Definitions</th>
</tr>
</thead>
<tbody>
<tr>
<td>UNCTAD</td>
<td>1980</td>
<td>... means the carriage of goods by at least two different modes of transport on the basis of a multimodal transport contract from a place in one country at which the goods are taken in charge by the multimodal transport operator to a place designated for delivery situated in a different country.</td>
</tr>
<tr>
<td>Faust</td>
<td>1985</td>
<td>Defined as the transport of goods by at least two different modes of transport on the basis of a single multimodal transport contract.</td>
</tr>
<tr>
<td>Hayuth</td>
<td>1987</td>
<td>... as the carriage of goods by at least two different modes of transport on the basis of a multimodal transport contract from a place in one country at which the goods are taken in charge by multimodal operator to a place designated for delivery that is situated in a different country (UNCTAD, 1981).</td>
</tr>
<tr>
<td>McKinnon</td>
<td>1989</td>
<td>Where more than one mode is used on a single journey...under the control of a single agency, they can be regarded as a single composite mode.</td>
</tr>
<tr>
<td>Rodrigue</td>
<td>1996</td>
<td>The usage of containers shows the complementarily between freight transportation modes by offering a higher fluidity to movements and a standardization of loads (Mahoney, 1985).</td>
</tr>
<tr>
<td>Schijndel and Dinwoodie</td>
<td>1997</td>
<td>... carry goods by at least two different modes of transport and to assume responsibility for the complete performance of the agreed move by the multimodal transport operator.</td>
</tr>
<tr>
<td>Wood</td>
<td>1998</td>
<td>A series of interconnected commercial arrangements that bring together some or all of the following parties: shipper; banker; insurer; freight forwarder; terminal operator; carrier; and consignee.</td>
</tr>
<tr>
<td>Beresford</td>
<td>1999</td>
<td>The ability of other modes, especially rail, to compete with road transport over medium to long distances.</td>
</tr>
<tr>
<td>Banomyong</td>
<td>2000</td>
<td>Where the carrier organising the transport takes responsibility for the entire door-to-door transport and issues a multimodal transport document.</td>
</tr>
<tr>
<td>Rondinelli and Berry</td>
<td>2000</td>
<td>Is a process of transporting freight “by means of a system of interconnected networks, involving various combinations of modes of transportation, in which all the component parts are seamlessly linked and efficiently coordinated” (Boske, 1998).</td>
</tr>
<tr>
<td>Van Schijndel and Dinwoodie</td>
<td>2000</td>
<td>Multimodal transport involves the movement of cargo from shipper to consignee using two or more different modes under a single rate, with through billing and through liability (Hayuth, 1987).</td>
</tr>
<tr>
<td>Islam, et al.</td>
<td>2005</td>
<td>Multimodal Transport includes carriage by at least two different modes and international multimodal transport covers the door-to-door movement of goods while under the responsibility of single contract (UNCTAD, 2005).</td>
</tr>
<tr>
<td>Lowe</td>
<td>2006</td>
<td>The use of variety of different transport modes for the movement of unitised freight from its place of origin to the final destination.</td>
</tr>
<tr>
<td>Qu and Chen</td>
<td>2008</td>
<td>... are those in which two or more different transportation modes are linked end-to-end in order to move freight and/or people from point of origin to point of destination.</td>
</tr>
<tr>
<td>Goh, et al.</td>
<td>2008</td>
<td>... the use of more than one mode of transport to move freight without the actual handling of goods.</td>
</tr>
<tr>
<td>Paixao-Casaca and Marlow</td>
<td>2009</td>
<td>... seamless integration of transport modes in offering door-to-door transport services.</td>
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</table>

Source: Compiled from Literature

According to Table 1, the first part of the definition shares the same understanding among different authors in the involvement of the movement of cargo from origin to destination using two or more different modes. Therefore, when dealing with Multimodal Transport, the ability to design and provide combination of mode choice has been agreed

\(^2\) UN/ECE: United Nations Economic Commission for Europe
upon all authors listed above. It is interesting to note that transport terminology between Multimodal and Intermodal Transport shows great similarities in terms of its definition and functions. Due to their similarities, the term is often used interchangeably by several academic authors (Goh, et al. 2008; Lowe, 2006; Rodrigue, 2006; Arnold, et al. 2004; Rondinelli and Berry, 2000; Rodrigue, 1996; Hayuth, 1987).

The second part of the definition draws the difference by the use of one single Multimodal Transport operator (MTO) under a single Multimodal Transport contract. It is worth noting that while all authors agreed on the involvement of combination of mode choice, 7 out of 16 authors included the feature of Multimodal Transport contract or MTO within their definition. Reflecting on the terminology of Multimodal Transport, it was found that authors who excluded the evolving nature of ‘Multimodal Transport contract’ or ‘Multimodal Transport operator’ generally uses the term Multimodal Transport and Intermodal Transport interchangeably. Therefore, according to the above literature review, one of the key characteristics in distinguishing multimodal and intermodal transport in the context of transport are the arrangement of MTO under one single Multimodal Transport contract.

Another key difference found in between Multimodal and intermodal transport is the common use of cargo types in a transport operation. According to TRB (1998), Murphy and Daley (1998), Taylor and Jackson (2000), Slack (1996), Spasovic and Morlock (1993), Evers (1994) and Nozick and Morlok (1997), containerised goods are, by definition, considered as the main form of cargo when dealing with intermodal transport operation. As for Multimodal Transport, little to no specific cargo forms have been mentioned (UNCTAD, 1981; 2001; Banomyong, 2000; Beresford, 1999; Kindred and Brooks, 1997). Based on this, it could be argued that it is insufficient to solely use this key feature in identifying a particular transport system in a specific operation. However, this could be used as a ‘check-list’ to distinguish the key differences in a specific operation.

The ‘intermodal transport’ terminology is arguably a more ‘mature’ concept in both definition and practice when compared with the ‘Multimodal Transport’ terminology. Due to the late introduction of Multimodal Transport in the early 1980s, the intermodal transport terminology has been used and practiced for almost a century. According to Hayuth (1987), characteristics of providing combinations of modal choice in both of the concepts are virtually identical to each other. However, it should not be used in an interchangeable manor due to its distinguishing features in a transport operation and chronological difference in the introduction of these two terminologies. According to SLA (2008), various types of transport documents might be involved in an intermodal transport operation, depending on how the responsibility of the entire transport chain is shared. In Multimodal Transport, the operator organises the entire transport journey and takes the responsibility for the entire process through a Multimodal Transport document. The intermodal transport terminology features more on the operational aspect of transport research, whereas Multimodal Transport deals greatly with regulation and control in providing clarification of legal liabilities and responsibility of involving parties (Wong 1997).

In terms of transport research, it must not be omitted that these two terms are greatly similar in its operational value. Even though very few literatures has discussed the differences in between these two concepts, based on their founding nature of functions and practicality, a replacement of intermodal transport to Multimodal Transport would be possible but in the long term. Due to the evolving nature of academic research, it is very difficult to encapsulate a complete definition of ‘Multimodal Transport’, as new roles are constantly being engaged within the concept itself and 25 years of further evolution have taken place since this observation. According to Faust (1985), Multimodal Transport has become a mandatory application in connecting both developed and developing countries together. However, it must be acknowledged that these two terminologies should not be used in an interchangeable manor.

MEASURING MULTIMODAL TRANSPORT SERVICE

Traditionally, services provided by the MTOs are usually involved with container activities such as: full container load (FCL), less than container load (LCL) and consolidation services (SLA, 2008). However, due to market competition in the transport industry, these services are often insufficient. The increase of service coverage such as: the use of information and communication technology (ICT) and infrastructural capability, security and safety, facilitation, legal aspects and market access has become a rising phenomenon in the competitiveness of Multimodal Transport (UNCTAD, 2003). According to Banomyong (2000), MTO’s competitiveness is highly dependent on his or her managerial and operational techniques in each specific transport links. Thus, with overlapping characteristics of logistics services, a review of MTS is provided hereunder with its attributes and its relation with logistics services.

As it is clear that Multimodal Transport is providing logistics services, and several academic authors have been trying to provide key attribute-measures through investigation of product / service offerings from various types of industries. Noted by Mentzer, et al. (2001), the definition of logistics service varies from industry to industry and has
changed as business environments have broadened to include several other operational aspects of logistics, such as packaging, third party inventory management, bar-coding and information and control systems. La londe and Cooper (1989) relate logistics service to customer service as they are (i) activities to satisfy customers’ needs, (ii) performance measures to ensure customer satisfaction, and (iii) a philosophy of firm-wide commitment. However, it was argued by Mentzer, et al. (2001) that these components were focused on the provider but not on the customer. They believe that since logistics service is focused on customers, measurement of customers’ perception of value created for them by logistics will help to determine the quality of service provided by the firm. Building on the previous empirical research, logistics service has been widely explored in terms of attributes. To the best of this author’s knowledge, little to no research has explored MTS attributes. Therefore, in relation with MTS attributes a list of existing logistics service studies are selected and examined (Table 2). It was found that various attributes found in the logistics service literature could be closely related with MTS. According to Banomyong (2000), there are several overlapping activities found in logistics, transport and Multimodal Transport due partly to their terminologies; but it should be noted that shippers’ service demand will lead to pursuit of competitiveness in MTSs.

**METHODOLOGY**

A considerable body of literature in relation to the concept of logistics was found but only a few publications are found in relation to Multimodal Transport or transport in general. In order to capture the concept of transport service within the framework of Multimodal Transport, contextual analysis of white papers (i.e. UNCTAD, UNESCAP, ADB) was performed in parallel with logistics service-related journal papers (e.g. Lai, et al. 2002; Lu, 2007; Yang, et al. 2009). According to the compiled list of services (Table 2), they can be divided into three main groups: transportation, facilities, and communication and information. Adapting this, grouping using the work of Williamson, et al. (1990), these three main groups of services can be viewed as dimensions of MTS which portrays the capabilities of MTOs. However, to the best of author’s knowledge, these three dimensions have not been verified through any quantitative analysis. Referring to the MTS attributes, some items are revealed to have similar characteristics. For example, on-time pick up (item 2), transit time (item 3) and schedule reliability (item 4) are all related to ‘time’. Furthermore, availability of booking space (item 7) and frequency of schedule (item 8) might portray similar meanings. It is challenging to decide which aspects to keep or eliminate. Therefore, these 25 items (Table 3) will be statistically tested and filtered through exploratory factor analysis (EFA) and followed by confirmatory factor analysis (CFA).

Exploratory factor analysis (EFA) is commonly used in specifying the structure among a set of variables. The main purpose of EFA is to define a group of measurable characteristics into factors which are, by definition, highly intercorrelated while retaining the nature and the characteristics of the original value (Hair, et al. 2010). EFA is commonly used for situations where links between the observed and latent variables are uncertain (Byrne, 2001). A recommended method for factor analysis is varimax rotation with Kaiser-Meyer-Olkin (KMO), which was commonly used to clarify the factors (Chen and Paulraj, 2004). Varimax rotation, also known as orthogonal factor rotation, is the simplest case of rotation, which maximises the sum of variances of required loading of the factor matrix (Hair, et al. 2010). The retained items are then grouped based on the separation of the factor loading. Overall, the goal of rotating the factor matrix is to “redistribute the variance from earlier factors to later ones to achieve, a simple, theoretically more meaningful factor pattern” (Hair, et al. 2010: 149).

The next output that was used in parallel to the output of varimax rotation was the KMO test. The KMO value indicates the extent to which a set of items is appropriate for factor analysis (Kaiser, 1970). According to Kaiser (1970), KMO output of: 0 to .49 is ‘unsatisfactory’, .50 to .59 is ‘miserable’, .60 to .69 is ‘mediocre’, .70 to .79 is ‘middling’, .80 to .89 is ‘meritorious’ and .90 to 1.00 is ‘marvellous’. It was suggested by several scholars that KMO values of .60 or more are recommended (Hutcheson and Sofroniou, 1999). As the objective of EFA was to identify the appropriate variables for the subsequent application of CFA, factor analysis through data reduction using varimax and KMO test will be employed. When the variables are grouped, attempts to assign some meaning to the pattern of factor loadings are required. A name or label was assigned to accurately reflect the variable loading on the factor’s conceptual meaning. In the following section, the MTS construct which has been previously conceptually explored are grouped and validated through EFA.
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<td>✓</td>
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<td>✓</td>
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</tr>
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<td>Quality of data transmission (e.g. EDI, e-mail.)</td>
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<td>✓</td>
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<td>✓</td>
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</tr>
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<td>Customise service (e.g. JIT)</td>
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### TABLE 3
DIMENSIONS AND MEASUREMENT ITEMS OF MTS

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<th>Dimensions</th>
<th>Measurement Items</th>
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<tr>
<td><strong>Transportation</strong></td>
<td>MTS1) Accurate documentation</td>
</tr>
<tr>
<td>[TRANS]</td>
<td>MTS2) On-time pick-up</td>
</tr>
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<td>MTS3) Transit time</td>
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<td>MTS4) Schedule reliability</td>
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<td>MTS5) Special cargo handling</td>
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<td>MTS6) Consolidation</td>
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<td>MTS7) Availability of booking space</td>
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<tr>
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<td>MTS8) Frequency of schedule</td>
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<td>MTS9) Arrangement of door-to-door service</td>
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<td><strong>Facilities</strong></td>
<td>MTS10) Inland transport arrangement</td>
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<td>[FACI]</td>
<td>MTS11) Warehousing service</td>
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<td>MTS12) Customs clearance</td>
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<td></td>
<td>MTS13) Insurance service</td>
</tr>
<tr>
<td></td>
<td>MTS14) Service coverage</td>
</tr>
<tr>
<td></td>
<td>MTS15) Tariff flexibility</td>
</tr>
<tr>
<td></td>
<td>MTS16) Payment flexibility</td>
</tr>
<tr>
<td><strong>Communication &amp; Information</strong></td>
<td>MTS17) Cargo safety</td>
</tr>
<tr>
<td>[COIN]</td>
<td>MTS18) Advance notice of delays</td>
</tr>
<tr>
<td></td>
<td>MTS19) Quality of data transmission</td>
</tr>
<tr>
<td></td>
<td>MTS20) Cargo tracking</td>
</tr>
<tr>
<td></td>
<td>MTS21) Knowledge of personnel</td>
</tr>
<tr>
<td></td>
<td>MTS22) Courtesy of inquiry</td>
</tr>
<tr>
<td></td>
<td>MTS23) Response to customer complaint</td>
</tr>
<tr>
<td></td>
<td>MTS24) Response to cargo claim</td>
</tr>
<tr>
<td></td>
<td>MTS25) Cargo or damage record</td>
</tr>
</tbody>
</table>

Source: Adapted from Williamson et al. (1990)

The early development of the model was based on regression analysis, followed by path analysis and confirmatory factor analysis (CFA) (Schumacher and Lomax, 2004). In contrast to EFA, CFA is used when the underlying structures of latent variables are confirmed based on knowledge of theory or empirical research (including EFA), or both (Byrne, 2001). It is worth noting that CFA focuses on the relationship between latent factors and their indicators within the framework rather than relationships among factors. Therefore, CFA is to be conducted between latent factors and measurement items in order to present the evidence of unidimensionality. Indices that were used under this category are adjusted goodness-of-fit index (AGFI) and parsimony normed fit index (PNFI). These fit indices are commonly used to establish the acceptability of the model. However there has been on-going debates on which index or indices constitutes an adequate fit (Hair, et al., 2010). According to Hair, et al. (2010), fit indices will be select based on the two questions: (i) what are the best fit indices to objectively reflect a model’s fit and (ii) what are the suggested objective cut-off values of a good model fit.

Prospective informants were people who deal with Multimodal Transport as part of their business operation in Thailand. According to Thai National Shippers’ Council (TNSC) list, 27 different categories are found under the characteristics of exported goods. There were total of 2,782 shippers listed in 2010. According to Saunders, et al. (2007), the larger the sample size, the lower the likely error in generalising to the population. If the research uses probability sampling, then it will comprise the accuracy of the finding. Effort was devoted towards achieving an accurate model based on an absolute sample of a population provided by the TNSC. In order to ensure a high response rate, postal questionnaire are distributed to all members of the TNSC (Kaplowitz, et al. 2004). The postal questionnaire was conducted over a period of 8 weeks, starting from the first week of August 2010 until the last week of September 2010. Once the completed questionnaires were returned, the reference numbers were then matched with TNSC’s list of shippers to identify the distribution of samples in terms of geographical location and industrial sector.
RESULTS

According to previous section, 25 items were identified under the three dimensions of MTS. The three dimensions namely: transportation, facilities and, communication and information were derived from the work of Williamson, et al. (1990). These dimensions conceptually portray the capabilities of the MTO in delivering services to shippers. All items were simultaneously put into data reduction analysis using SPSS software package (Version 16.0) with varimax rotation. The results showed that all items have cross-loading values of .50 or more. Thus, these items are significant (Hair, et al. 2010). The KMO value had exceeded .90 (.937), which was considered as ‘marvellous’ in Kaiser’s standard of KMO interpretation (Kaiser, 1970). The MTS construct was consolidated from logistics and transport service attributes reviewed under the multimodal transport conceptual framework. The MTS measurement items have been operationalised and validated through EFA. The 25 items retained from the EFA results were then tested in the CFA (Figure 1). According to the EFA results, the grouping of the items mirrors the work of Williamson, et al. (1990). The MTS measurement model is composed of three factors, which are Transportation (TRANS), Facilities (FACI), and Communication and Information (COIN). The MTS measurement model was examined to confirm the validity and reliability of the constructs. The result of the initial analysis, including all the observed variables showed an unacceptable model fit of: $\chi^2$/df= 3.26 ($\chi^2= 885.9, df= 272$); GFI=.768; RMSEA=.097; CFI=.85; TLI=.834. The three factors are inter-correlated by the two-headed arrows. Through a repeated examination, a total of 7 items (MTS24, MTS15, MTS21, MTS8, MTS5, MTS4 and MTS23) was eliminated due to reasons of; lost in translation and overlapping meanings.

FIGURE 1
MTS MEASUREMENT MODEL

Note: MTS = Multimodal Transport Service, TRANS = Transportation, FACI = Facilities, COIN = Communication and Information
TABLE 4
MTS MEASUREMENT MODEL

<table>
<thead>
<tr>
<th>Construct</th>
<th>Items</th>
<th>Std. Factor Loading</th>
<th>t-value</th>
<th>CR</th>
<th>AVE</th>
<th>Cronbach’s Alpha</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Transportation</strong></td>
<td>MTS1</td>
<td>.68</td>
<td>9.52</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>[TRANS]</td>
<td>MTS2</td>
<td>.64</td>
<td>8.94</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>MTS3</td>
<td>.63</td>
<td>8.84</td>
<td>.83</td>
<td>.50</td>
<td>.85</td>
</tr>
<tr>
<td></td>
<td>MTS6</td>
<td>.80</td>
<td>11.22</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>MTS7</td>
<td>.69</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>MTS9</td>
<td>.72</td>
<td>10.07</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Facilities</strong></td>
<td>MTS10</td>
<td>.72</td>
<td>10.78</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>[FACI]</td>
<td>MTS11</td>
<td>.72</td>
<td>10.72</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>MTS12</td>
<td>.69</td>
<td>10.35</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>MTS13</td>
<td>.74</td>
<td>10.96</td>
<td>.84</td>
<td>.52</td>
<td>.87</td>
</tr>
<tr>
<td></td>
<td>MTS14</td>
<td>.73</td>
<td>10.77</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>MTS16</td>
<td>.73</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Communication</strong></td>
<td>MTS17</td>
<td>.71</td>
<td>11.64</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&amp; Information</td>
<td>MTS18</td>
<td>.79</td>
<td>*-</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>[COIN]</td>
<td>MTS19</td>
<td>.84</td>
<td>14.37</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>MTS20</td>
<td>.86</td>
<td>15.00</td>
<td>.86</td>
<td>.61</td>
<td>.90</td>
</tr>
<tr>
<td></td>
<td>MTS22</td>
<td>.78</td>
<td>13.18</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>MTS24</td>
<td>.68</td>
<td>11.13</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Overall Goodness-of-Fit Statistics**

\( \chi^2/df = 2.28 \) \((\chi^2 = 301.2, df = 132); \) GFI = .876; RMSEA = .073; CFI = .931; TLI = .92.

Note: * fixed parameter

CONCLUSION AND DISCUSSION

Through reviews of Multimodal Transport related research, similar characteristics of logistics service attributes and capabilities were found. According to Banomyong (2000), MTO’s competitiveness was highly dependent on his or her managerial and operational techniques in each specific transport links. As MTO is providing logistics services, measurements of logistics service attributes were adapted to operationalise the MTS construct. Following a systematic review of logistics service attributes, 25 measurement items were identified and operationalised. One noteworthy observation was that the MTO construct was compiled from the literature, which had not yet been verified. Therefore, the procedure of exploratory factor analysis (EFA) was used to ensure the groups of measurable factors were aligned with the conceptualised dimensions. After the EFA procedure, the MTS measurement model was examined in the confirmatory factor analysis (CFA).

During the CFA process, seven measurement items, namely: MTS4 (Schedule Reliability), MTS5 (Special Cargo Handling), MTS8 (Frequency of Schedule), MTS15 (Tariff Flexibility), MTS21 (Knowledge of Personnel), MTS23 (Response to Customer Complaint) and MTS25 (Cargo Loss or Damage Record) were eliminated due to measurement redundancy, low factor loading, high Modification Index (MI) value and high standardised residual covariance value. Theoretical justifications through consultation of residual diagnostics for changes were provided in the trimming process of the measurement model. A total of 18 measurement items were retained under three dimensions of MTS. This indicates that Multimodal Transport Service is a multi-dimensional construct, which cannot be represented by only one factor or dimensions. In this research, the MTS construct was empirically developed based on conceptualised theories into operationalised measurement model with an acceptable goodness-of-fit. Regarding to the high regression weights, the sub-dimensional factors (TRAN, FACI and COIN) have demonstrated that the MTS construct explains or influences the three phenomena. Therefore, a MTO with a high level of Multimodal Transport Service must have; high satisfactory of transportation service, including accurate documentation, on-time pick-up, transit time, consolidation, availability of booking space, arrangement of door-to-door service (TRANS: MTS1, MTS2, MTS3, MTS6, MTS7, MTS9); adequate facilities, including inland transport arrangement, warehousing service, customs clearance, insurance service, service coverage and payment flexibility (FACI: MTS10, MTS11, MTS12, MTS13, MTS14, MTS16); established a high level of communication and information service including, cargo safety, advance notice of delays, quality of data transmission, cargo tracking, courtesy of inquiry and response to cargo claim (COIN: MTS17, MTS18, MTS19, MTS20, MTS22, MTS24).
The findings of this study would help to clarify the conceptual differences between the Multimodal Transport system and other systems (e.g. intermodal transport, combined transport and through transport). It is a strategic decision to incorporate appropriate transport systems in the international trade arena. Even though it was evidenced that the concept of ‘Multimodal Transport’ was evolving in the body of academic research, it is crucial to relate this phenomenon to real world transport practices and to seek potential directions for positive change (e.g. use of new carriers, new routes, new model combinations and/or different term of trade). Regardless of the understandings of trade and transport terminologies, roles and liabilities of MTO and contracts are to be carefully considered to prevent problems or to resolve conflicts.

The second contribution made in this study was the attempt to operationalise the concept of Multimodal Transport Service in a holistic manner and to test it against Logistics Service Value, Relationship Quality and Business Performance through Structural Equation Modeling (SEM) approach. Combining academic journals and white papers, the Multimodal Transport Service construct was empirically developed and rigorously tested. As the current study is considered as one of the pioneer research, which incorporated SEM technique to examine the phenomena in between shippers and MTO, the Multimodal Transport Service construct can be taken into account when investigating future Multimodal Transport-related research.

REFERENCES


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THE AFFECTIVE FACTORS OF ORCHID EXPORT FROM THAILAND TO CHINA

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by

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ABSTRACT

This research is study affective factors of orchid export from Thailand to China. China was the biggest importer of Thai orchid. However, the value is lower than Japan (the top-five orchid importer) as China import only low price orchid because of decoration. Moreover, many competitors such as Malaysia, Taiwan and Singapore develop orchid and transportation that are similar Thai exporter. The methodology is 10 samples that are the top-five orchid exporter from Thailand to China. The data is analyzed from questionnaire and interview. The result combines 3 parts that are general information, Internal and external factors of orchid export and SWOT analysis. Most exporters are located in Bangkok and dedobium is the most export to China as color and price is accepted. The most important internal factors are human resource and marketing. Human resource is related to experience of orchid farm and export because these can support orchid quality and China trend forecasting. The most important affecting external factors are competitors, customer, economic, social and culture, laws and rules and logistics.

KEYWORDS
Orchid, Export, Factors, China, Thailand, SWOT

INTRODUCTION

Thailand is the most orchid farm in the world. In 2007 Thailand has orchid farm at 20,793 rai (2.53 rai = 1 acre) and can produce orchid at 45,973 tons per year (Thai Orchid Exporter Association, 2007). Dendobium is widely cultivated in Bangkok, Nakornpatom, Samutsakorn, Ratchaburi, Nontaburi and Ayuthaya as growers who register in DEP by 2,000 person. The import countries from Thailand are China, Japan, USA, Italy and Korea. The competitors of Thai growers are Malaysia, Singapore and Taiwan (Kasikorn Research Center, 2009). Most countries import Thai orchid because of color and cycle time. Therefore, Thailand has been become the best country in orchid export.

However, orchid export number is growing up. The most countries of orchid export are changed from China to Japan. It can be seen that China always import low cost orchid (high quantity) to use in Chinese cultures and decoration as Japan import high cost orchid (high value) and grow up them for social status. The orchid business should focus on high value increasing in China and reducing orchid cost for competition.

THEORY AND LITERATURE REVIEW

SWOT Analysis and Diagnostics

“The organizational environment is composed of many elements which organizations deal with and form complex cause-and-effect type of relationships with. Environment can also be divided into two categories. The first category implies the external environment which contains all changes that take place outside the organization's boundary such as economic, political, cultural, and technological changes upon which organizations have little impact. The second category has to do with internal factors within an organization in various areas such as management, culture, finance, research and development, staff, operational efficiency and capacity, technical frameworks, and organizational structure (al-Rousan and Qawasmeh, 2009).”
SWOT analysis refers to the process through which decision makers develop their awareness of organizational environments so as to influence performance now and in the future (Naryanan & Nath, 1993: 197).

SWOT analysis can help organizations develop an early alarming system that take into considerations all necessary preparations before possible threats rise, and implement capable strategies to face such threats and minimize their negative consequences. In this regard, Thompson (2005) suggests that strategy makers should consider the following scheme:

- Determining the most important factors and reasons for selecting such factors.
- Forecasting changes that might influence the mentioned factors.
- Aligning of all forecasts.
- Undertaking reality and honesty in assessing competitors' strengths and weaknesses as well as their own organization.

Environmental diagnosis refers to the process of predicting the importance of information we get out from SWOT analysis (Glueck & Jauch, 1988:137). This process is subject to the influence of two factors. First, the characteristics of strategy makers which include their experience, ambition, perception style, and the psychological state during the diagnosing operation. Second, the nature of strategy makers' type of work which includes time pressure and work tension, availability of organizational resources, the importance of decision making, the abundance of time allocated to this function, and whether managers are occupied with other activities or not.

SWOT analysis is an effective method used for strategic planning to identify potential, priorities and creating a common vision of achieving the development strategy for a company. This should answer the question “Where are we?” involving the analysis of the internal and external environment generally and specifically. It used to evaluate the company environment factors. Only by taking into consideration the components of general environment: economic environment, social environment, political environment, legislation and pressure groups, a company will be able to adopt the particular way of action, which will assure its performance and advantages on present and potential competitors (Gasparotti, 2009).

As Balamuralikrishna and Dugger (1997) showed that the SWOT (Strengths, Weaknesses, Opportunities, and Threats) analysis has been a useful tool for industry. This article proposes the application of the SWOT tool for use as a decision-making aid as new vocational programs are planned. The process of utilizing the SWOT approach requires an internal survey of strengths and weaknesses of the program and an external survey of threats and opportunities. Structured internal and external examinations are unique in the world of curriculum planning and development.

Orchid

Thailand is famous for its many beautiful orchids, or Gluay Mhai in Thai. It's surprising to many visitors that these tropical plants can be found flowering during the winter in the north of Thailand, when the weather is cool. January is a great month to see an amazing range of shapes, sizes and vibrant colors of Thailand's orchids. Although the weather is so dry at this time of year, orchids employ many different ways of retaining the moisture necessary for flowering. Some have spongy roots that can absorb water from morning mists, other have bulbs that store the precious liquid of the rains of the previous year, while still others shed their leaves so that none of the moisture needed for blooming is wasted. Orchids naturally grow on the bark of forest trees and collect much of their water and food from rain water running down the trunks, and are classified as epiphytes because of this way of growing. In the wild, these winter-blossoming orchids make a wonderful splash of color at a time when the woods are dull and drab, with many trees having lost their leaves. The orchids will flower again in August, in the middle of the abundant rains, and then collect water and food during September downpours to provide the energy for flowering again the following January.

There are more than 1,000 species of orchids in Thailand, and these come in a bewildering and dazzling range of colors - all the hues of the rainbow. Probably the most beautiful of the north's many orchids are the White, the Bright Yellow Oncidium and the Brick - red orchids. The White orchid is highly prized because of its extreme rarity in the wild. Few have ever been discovered in the wild, and it is only through the efforts of Thai orchid nurserymen to multiply it, that this gorgeous bloom can be seen. Many of the other orchid varieties are easy to grow, and abundant at any time of the year, thanks to the skills of the numerous Thai horticulturists, who have developed their art into a major export industry. Typical of these common orchids is the violet bloom that is often presented to visitors, for example to women passengers travelling on Thai Airways international flights.

The range of habitats of orchids in the wild is as astonishing as their great variety of blossoms. They can be found growing wild in almost all parts of Thailand, from Table 1 shows number of orchid export in Thailand.
### TABLE 1

**NUMBER OF ORCHID EXPORT IN THAILAND**

<table>
<thead>
<tr>
<th>Region</th>
<th>Province</th>
<th>Cultivated areas (Rais)</th>
<th>Production (Tons)</th>
</tr>
</thead>
<tbody>
<tr>
<td>North</td>
<td>Chiangmai</td>
<td>188</td>
<td>416</td>
</tr>
<tr>
<td>Middle</td>
<td>Nakornpatom</td>
<td>12,546</td>
<td>27,789</td>
</tr>
<tr>
<td></td>
<td>Samutsakorn</td>
<td>2,059</td>
<td>4,561</td>
</tr>
<tr>
<td></td>
<td>Bangkok</td>
<td>7,186</td>
<td>15,917</td>
</tr>
<tr>
<td></td>
<td>Nontaburi</td>
<td>3,530</td>
<td>7,819</td>
</tr>
<tr>
<td></td>
<td>Ayudhya</td>
<td>329</td>
<td>729</td>
</tr>
<tr>
<td>Northeast</td>
<td>Nakornrachasrima</td>
<td>430</td>
<td>952</td>
</tr>
<tr>
<td></td>
<td>Sakonakorn</td>
<td>8</td>
<td>18</td>
</tr>
<tr>
<td></td>
<td>Udontani</td>
<td>9</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>Ubonrachatani</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Southern</td>
<td>Suratani</td>
<td>46</td>
<td>102</td>
</tr>
<tr>
<td></td>
<td>Songkla</td>
<td>25</td>
<td>55</td>
</tr>
<tr>
<td>Eastern</td>
<td>Chonburi</td>
<td>135</td>
<td>299</td>
</tr>
<tr>
<td></td>
<td>Rayong</td>
<td>36</td>
<td>80</td>
</tr>
<tr>
<td>Western</td>
<td>Rachaburi</td>
<td>2,638</td>
<td>5,843</td>
</tr>
<tr>
<td></td>
<td>Karnchanaburi</td>
<td>287</td>
<td>363</td>
</tr>
<tr>
<td></td>
<td>Phetburi</td>
<td>12</td>
<td>27</td>
</tr>
<tr>
<td></td>
<td>Pajumkerekun</td>
<td>8</td>
<td>18</td>
</tr>
</tbody>
</table>

Source: Department of Agricultural Extension

Note: Quantity of production average per rai multiply cultivated area: 2.53 rai = 1 acre

In 2009 Thailand exported orchid around 24,601 tons, value at 2,070 million baht was found that exporting quantity was increased but the value was decreased because the Thai Baht value appreciated and high competitors. Top five ranging exporter orchid were China, Japan, United State, Italy and India respectively. When considered about exporting value of orchid in Japan was good price since it was high quality while exporting in China was emphasized the quantity and low price and quality. Thailand was big ten exporter. During three to four years ago China had imported orchid from Thailand more at least seventy percents as a result it become high competition orchid after that the farmer could sell orchid flower higher price. Cutting orchid flower and dendrobium pot was favor in China market; however, distribution channel in China market wanted the middle grade and more quantity same as Pakklong Market in Bangkok. China imported orchid to the central market such as Shianghai and Guangzhou; moreover, China would order orchid from Thailand all the year particular on Nation Day, Chinese New Year, and Chinese Middle Festival this were the period that there were higher demand also the buyer would not rather bargain the price. In the past, the orchid market in China was interesting in many countries such as Malaysia and Singapore also Taiwan invested in cultivated orchid in freezing city in China; still, it was different market of Thai orchid but the problem was price competition between Thais merchant because of this it become loss

### TABLE 2

**THAI FLORICULTURE EXPORT IN 2009**

<table>
<thead>
<tr>
<th>Items</th>
<th>Quantity</th>
<th>Value (US$)</th>
<th>Delta (%)</th>
<th>Value Share (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Orchid Flowers</td>
<td>24,601,173 kg</td>
<td>69,016,782</td>
<td>-4.6</td>
<td>66.3</td>
</tr>
<tr>
<td>Live Plants</td>
<td>28,773,126 Pcs/Pit</td>
<td>13,094,919</td>
<td>-24.7</td>
<td>12.5</td>
</tr>
<tr>
<td>Orchid Plants</td>
<td>30,899,081 Pcs/Pit</td>
<td>10,819,492</td>
<td>-15.5</td>
<td>10.4</td>
</tr>
<tr>
<td>Dried Flowers</td>
<td>2,227,821 kg</td>
<td>5,880,299</td>
<td>31.1</td>
<td>5.6</td>
</tr>
<tr>
<td>Dried foliage</td>
<td>1,921,844 kg</td>
<td>2,013,380</td>
<td>18.2</td>
<td>1.9</td>
</tr>
<tr>
<td>Cut foliage</td>
<td>785,810 kg</td>
<td>865,070</td>
<td>59.5</td>
<td>0.8</td>
</tr>
<tr>
<td>Other cut Flowers</td>
<td>530,071 kg</td>
<td>859,086</td>
<td>31.4</td>
<td>0.8</td>
</tr>
<tr>
<td>Bulbs</td>
<td>3,416,055 Bulbs</td>
<td>847,636</td>
<td>1.8</td>
<td>0.8</td>
</tr>
<tr>
<td>Flower Seeds</td>
<td>48,245 kg</td>
<td>784,478</td>
<td>13.3</td>
<td>0.8</td>
</tr>
<tr>
<td>Moss &amp; Lichen</td>
<td>800,982 kg</td>
<td>12,971</td>
<td>-</td>
<td>0.0</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>104,147,016</strong></td>
<td><strong>-6.5</strong></td>
<td><strong>100.0</strong></td>
</tr>
</tbody>
</table>

Source: Thai Custom Department
Currently, exporting orchid situation become high competition since the world value of orchid was high as this was to activate new comer sharing the orchid market also the economic had small purchasing power parity; nevertheless, the production cost had increased in addition the competitors had beyond potential of technology and utility such as Singapore took Information Technology into all management system at the same time Taiwan had the potential about transportation system and so on as a result researcher group saw that it was important to study about the affecting factors to exporting orchid in order that it was the solution way that we could take to improve Thai exporting orchid processes still keeping the leader and number one of exporting orchid in the world.

**Orchid Standards**

A government agency, the National Bureau of Agricultural Commodity and Food Standards (ACFS) set new standards for Orchids in 2009. The standards were 1) GAP for Dendrobium production, 2) Orchid Inflorescence Standard and 3) GMP for orchid packing house. Now the ACFS is working with the Department of Agriculture and Department of Agricultural Extension to promote the use of the new standards.

**Orchid Cost**

Although orchid is the most important agriculture in Thailand and has high value export, orchid area is still limited because of high cost. In 2000, Office of Agriculture Economic found that dendobium has production costs at 100,000 bath/rai that are shown in Table 3. However, costs have been increased by 200,000 bath/rai as raw material and transportation costs have been fluctuation.

<table>
<thead>
<tr>
<th>Description</th>
<th>Cash</th>
<th>Approximately</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Variable Cost</td>
<td>71,642.84</td>
<td>14,521.87</td>
<td>86,164.71</td>
</tr>
<tr>
<td>Labor</td>
<td>15,476.20</td>
<td>9,234.76</td>
<td>24,710.96</td>
</tr>
<tr>
<td>Seeds</td>
<td>23,882.35</td>
<td>4,595.59</td>
<td>28,477.94</td>
</tr>
<tr>
<td>Fertilizer</td>
<td>7,076.83</td>
<td>-</td>
<td>7,076.33</td>
</tr>
<tr>
<td>Pesticide and Herbicide</td>
<td>10,033.86</td>
<td>-</td>
<td>10,033.86</td>
</tr>
<tr>
<td>Electric and fuel</td>
<td>1,775.82</td>
<td>-</td>
<td>1,775.82</td>
</tr>
<tr>
<td>Tools</td>
<td>1,451.23</td>
<td>-</td>
<td>1,451.23</td>
</tr>
<tr>
<td>Renovation and material</td>
<td>797.99</td>
<td>-</td>
<td>797.99</td>
</tr>
<tr>
<td>Other</td>
<td>4,341.37</td>
<td>-</td>
<td>4,341.37</td>
</tr>
<tr>
<td>Iterate and lost sale</td>
<td>6,807.69</td>
<td>691.52</td>
<td>7,499.21</td>
</tr>
<tr>
<td>2. Fixed Cost</td>
<td>1,008.70</td>
<td>11,789.63</td>
<td>12,798.33</td>
</tr>
<tr>
<td>Taxation and Rent</td>
<td>1,008.70</td>
<td>663.04</td>
<td>1,671.74</td>
</tr>
<tr>
<td>Depreciation</td>
<td>-</td>
<td>8,213.13</td>
<td>8,213.13</td>
</tr>
<tr>
<td>Opportunity cost</td>
<td>-</td>
<td>2,913.00</td>
<td>2,913.00</td>
</tr>
<tr>
<td>3. Total cost</td>
<td>-</td>
<td>-</td>
<td>98,963.04</td>
</tr>
<tr>
<td>4. Quantity/ rai</td>
<td>-</td>
<td>-</td>
<td>61,942.00</td>
</tr>
<tr>
<td>5. Total cost/one bouquet (Baht)</td>
<td>-</td>
<td>-</td>
<td>1.60</td>
</tr>
<tr>
<td>6. Income/Rai (Baht)</td>
<td>-</td>
<td>-</td>
<td>121,733.91</td>
</tr>
</tbody>
</table>

**Export procedure**

Orchid Center (1997) studied orchid export procedure. There are export process, document and registration and government. It can be concluded in figure 1 and figure 2.
FIGURE 1
ORCHID EXPORT REGISTRATION AND DOCUMENTS

Exporter

Orchid exporter Registration
(Department of Agriculture)

Identify details, post sign or sticker
- Name and export number
- Name of products and species
- Number of rack and weight of product
- Country of origin

Asking for Sanitary Certificate
(Department of Agriculture)

Custom clearance
Manual or EDI
(Thai Custom Department)

Export

Export report
(Department of Agriculture)

Source: Department of Export Promotion, 2005
Generally, orchid export uses 24 hours from farm to airport. It show that exporter receive orchid in the morning and send in the evening every day. Orchid should be arrived at the airport at least 3-4 hours before leaving. In case of China export, china policy will select 3 percent of orchid for sanitary and health control. These orchids will be sold in cheap price at least 3-4 boxes or 200-250 bunches as this process will reduce orchid cycle time to 3-5 days only.
Cost and marketing expenditure of orchid export are summarized as follows:

1. Orchid cost or selling price
2. Freight cost
3. Packaging cost
4. Shipping and custom costs
5. Chemical and pesticide cost
6. Procedure expenditure
7. Loss weight cost
8. Profit of wholesaler
9. Export price or selling price

**RESULT**

This research collected information from export companies that export orchid from Thailand to China. The sample was 10 companies. The result can be explained in 3 parts. There are general information, affective factors of orchid export from Thailand to China and SWOT Analysis.

**General information of export companies**

**TABLE 3**

<table>
<thead>
<tr>
<th>General Information of Export Companies in Thailand</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Type of business</td>
</tr>
<tr>
<td>Export</td>
</tr>
<tr>
<td>Export and owned farm</td>
</tr>
<tr>
<td>2. Period of business</td>
</tr>
<tr>
<td>1 month – 5 years</td>
</tr>
<tr>
<td>5 years – 10 years</td>
</tr>
<tr>
<td>10 years – 15 years</td>
</tr>
<tr>
<td>Over 15 years</td>
</tr>
<tr>
<td>3. Capital</td>
</tr>
<tr>
<td>50,000 - 500,000 bath</td>
</tr>
<tr>
<td>500,001 - 1,000,000 bath</td>
</tr>
<tr>
<td>1,000,001 - 5,000,000 bath</td>
</tr>
<tr>
<td>5,000,001 - 10,000,000 bath</td>
</tr>
<tr>
<td>Over 10,000,001 bath</td>
</tr>
<tr>
<td>4. Net export value</td>
</tr>
<tr>
<td>1,000,000 - 5,000,000 บาท</td>
</tr>
<tr>
<td>10,000,001 - 15,000,000 บาท</td>
</tr>
<tr>
<td>15,000,001 - 20,000,000 บาท</td>
</tr>
<tr>
<td>20,000,001 บาท นับไป</td>
</tr>
<tr>
<td>5. Location</td>
</tr>
<tr>
<td>Bangkok</td>
</tr>
<tr>
<td>Nakornpamom</td>
</tr>
<tr>
<td>Ratchaburi</td>
</tr>
<tr>
<td>Samutsakorn</td>
</tr>
<tr>
<td>6. Orchid Export</td>
</tr>
<tr>
<td>Dendobuim</td>
</tr>
<tr>
<td>Other</td>
</tr>
<tr>
<td>7. Distribution Channel</td>
</tr>
<tr>
<td>Thai Agents</td>
</tr>
<tr>
<td>Chinese Agents</td>
</tr>
<tr>
<td>Chinese Wholesalers in Thailand</td>
</tr>
</tbody>
</table>
According to the table 3, this research concluded that most samples have own farms and export companies at 70 percent. They set up orchid export for 10 years over as flora business used time and customers’ trust. Capital and asset of business was approximately 1,000,001 – 5,000,000 bath or over 10,000,000 bath and orchid net export value was 1,000,000 – 5,000,000 bath and more than 10,000,000 bath. Most sample that were the top-five export were located in Bangkok as export facility was comfortable such as transportation, custom and re-package. It is possible that provinces that were far from Bangkok were not good location for orchid export. Moreover, Dendobium were the most orchid export value at 80 percent because of colorful, long life cycle, low price and various. Other were Vanda, Cattarya, Ocidium, Mikara and Aranda. Thai agents or Thai exporter were the best distribution channel in Thailand by 70 percent. Chinese customers believed experience and long relationship between Thai and Chinese.

Affective factors of orchid export from Thailand to China

The affective factors of orchid export from Thailand to China can be concluded in internal and external factors:

Internal Factors are marketing, export and production, human resource, finance, and business image and brand name.

The most important affective factors of orchid export were marketing and human resource. Marketing factors were the most important of orchid export. There are product, price, place and promotion. Products: Samples considered fresh of flora first. Size and number of orchid in one bouquet were considered as the second times. Price: Most samples suggested that price were related to orchid size, grower, various species and fresh. These causes were affected to export costs. Distribution Channel: Transportation security was the most important of orchid export. Correct times and available cold rooms were the most second important factor. Promotion: sale and giving extra were the most favorite promotion of orchid export as they increased orchid sale.

Human resource factor were experience and skill. Experience or Background: Most samples recruited employees from orchid experiences and export because perishable products had high risk and loss. Education, age, personal and behavior were not the first impression of recruitment. Language skills were preferred for export business especially Chinese and English. However, negotiation skill were focused and considered in employees’ resumes.

External Factors are competitors, new entrants, suppliers, customers, stakeholder, substitutes, economy, social/cultures, politic/ government, laws and rules, technology and logistics.

The most important affective factors of orchid export were competitors, customer, economic, social and culture, laws and rules and logistics. In case of competitors and customers: they were related to trend, behavior, income and quantity. Most exporters had to study real demand and marketing trend every year. Hence, forecasting will be correct and efficiency operation. Economic: samples should considered GDP, NI, economic grow rates, net export value, Chinese economic and exchange rate. They were caused of low export. Social and culture: Chinese fair and festival was the most important for example the Chinese New Year, exporters understood color and decoration design that were related to Chinese culture. Moreover, many colors in one bouquet were the most popular in Chinese trend and behavior. Laws and rules: they studied step by step of Thai and Chinese rules. They included agriculture import-export rules and custom. The last factor was logistics. Facility was developed as logistics costs were reduced. There are cold room rental, transportation cost, packaging cost and pesticide cost.

SWOT Analysis of orchid export from Thailand to China

The analysis was made based on information concerning orchid exporters in Thailand.

Strength Analysis

S1 = Exporter has high orchid quality and the most famous in the world. These species are various, colorful and long life cycle.
S2 = Exporter has orchid farms that are the biggest farm in the world. Atmosphere and geography is suitable for many orchids.
S3 = Exporters and growers have long experience that are more than 10 years. They support GMP and orchid species development.
S4 = They have collaboration with farmers and partners for orchid development and solution.
S5 = Exporter has a long relationship and reliable for Chinese customers.
Weakness Analysis

W1 = As orchid is perishable export, quality of transportation and packaging are problems of loss, poor fertilizers and raw materials are caused of different standard suppliers.

W2 = Orchid farms encounter pollution flood problems so size and number of orchid are not similar in one bouquet.

W3 = Exporters cut off prices as they can reach the high sale and seasonal trends.

W4 = Inefficiency in farm operation and growers, they do not have standard of cultivation for example Methlbromide process.

W5 = Poor marketing, promotion and public relation.

W6 = Exporter lacks of negotiation and Chinese languages.

W7 = Lack of funds and SME support.

Opportunities Analysis

O1 = High Technology in orchid laboratory and Thailand has many organization to support such as Department of Agriculture, Universities and Organizations. They have been research, quality control and laboratory.

O2 = Orchid trend in China is increasing as result of Chinese festivals and decoration.

O3 = Orchid research and development use technology to species development. They have long life cycles and colorful.

O4 = Thailand collaborates many countries to set up Free Trade Zone.

Treat Analysis

T1 = Government and orchid organizations do not distribute new information to growers and SME.

T2 = It does not have the head organization to manage orchid and export standard.

T3 = Shipping costs and logistics costs are high and poor facility.

T4 = Rules of perishable products are strict and waste time.

T5 = Logistics facilities are poor and stakeholders are not collaborated each other.

T6 = Complex in orchid copyright.

T7 = Competitors, Singapore and Taiwan have high technology and have good logistics facilities.

T8 = Substitutes are various and cheap for example roses and Lilly.

T9 = Chinese economy is down in several years.

T10 = Exchange rate is fluctuation.

RECOMMENDATION

From the research of affective factors of orchid export from Thailand to china, it is found that weakness of orchid export should be solved first. The growers and export companies focus on quality of orchid production for example farm, packaging and transportation. These can support quality and long life cycles of orchid. The growers and stakeholders (governments) should be collaborated and study pollution and flood solution, poor fertilizer, orchid standard control, orchid international fair. As export companies and growers should be considered in term of orchid species development, price competition decreasing for bargain power in the export market. Logistics stakeholders (customs, transportation, freeze container service) should support orchid export and reduce complex.

REFERENCES


ANALYZING THE DISTRIBUTION PATTERN OF LYCHEE FOR REDUCING LOGISTICS COSTS IN AMPHUR AMPHAWA AT SAMUT SONGKHRAM PROVINCE

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ANALYZING THE DISTRIBUTION PATTERN OF LYCHEE FOR REDUCING LOGISTICS COSTS IN AMPHUR AMPHAWA AT SAMUT SONGKHRAM PROVINCE

by

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ABSTRACT

The research of the “Analyzing the distribution pattern of lychee for reducing logistics costs in Amphur Amphawa at Samut Songkhram Province” has the purpose to study the suitable distribution pattern for the lychee in Amphawa District at Samut Songkhram Province. The samples that are used in this study were the growers who grow the lychee in Amphur Amphawa such as Tambol Suan Luang, Tambol Bang Chang, Tambol Nang Lee, Tambol Bang Kae, Tambol Muang Mai, Tambol Wat Pra Du, Tambol Khaew Om, and Tambol Amphawa at Samut Songkhram Province by using simple random sampling method. The result can concluded that overall factors focused on the product distribution activities in the middle level were transportation, packaging, and warehousing, respectively.

KEYWORDS
Distribution, Samut Songkram, Lychee

INTRODUCTION

According to Faculty of Management Science and Innovation Management College developed the research project to develop the competency market in community for sufficient and sustainable by specify the area target in Ampur Amphawa to develop the potential of businessperson in Samut Songkhram about management and marketing in order to meet customer’s demand. In this area had many tourists coming as the result Ampur Amphawa was the conservative community and still the traditional life style additional adhered to Buddhism, culture, attraction area. Doing tourism business in attraction area was created many career and spread income in to community more also this related the policy and strategy of government which were encouraged and developed the creating social community and local strong, developed Thai’s wisdom to universal, and monitor and care about the health of people and community included tourism campaign tourism to certify demand of business and industry of country

Vision of Samut Songkharm province was “It is the city of food and pesticide residue free of fruit, central of relax, conservative tourism on canal of nation, land of people love birth place, preserving environment and beautiful culture” The land in Samut Songkharm was connected other provinces as East reached Mea Klong bay (Thai bay), South reached Phetchaburi province, West reached Ratchaburi province and North reached Ratchaburi and Samut Sakorn province. It had population at 206,452, income average of 57,817 Baht also it was province had more potential in many kind of key agricultural products included fishery and conservative tourism. Beside, the most people run agriculture and fishery in term of industry the most was small like fish sauce, food, fish processing and agricultural production processing industry

Advantages of Samut Songkharm were richness place several seafood by doing fishery in the sea and culturing, selling fresh food and seafood processing. The fishery was the career which was created the highest income of province another part was from agriculture particular fruit planting this was the second income of this province for example the key of fruit in this province as lychee, pomelo, mango, coconut and palmyra especially lychee, the unique product, was famous and created reputation and worthiness of local people in Samut Songkharm for example the test of lychee as luscious, crispy, delicious so who had test must be fascinated to tell something that “It is the lead lychee in Samut SongKharm”
Lychee in Samut Songkharm was growth by a few cold weathers and there were many kind of lychee such as Bantan, Kalok, Sumpaokeaw, and Sumpaotong. Lychee was ripened in April. The land of Samut Songkharm was called Sam Nam as salt, brackish and freshwater; moreover, it had three district were two area had lychee plants reached to 8,600 rais, getting production around 4,000 tons a year. The soil in Samut Songkharam was been worthiness as the result it was made good test of lychee particular Bantan when it was become rip. The characteristic of lychee was strong red color, crust, blister quite shapely, inside shell was pink color, goo smell, sift dry seed, meat of fruit to be white or soft white when it was been split wide the body look like heart, rich flavor, sweet and a bit sour, good mellow enough also it was the queen of Thai fruit

Growing lychee was required experience of professional grower enough starting from selection the cutting, pitting, and taking care till we got the production taken time during 4-5 years then we got them once a year therefore grower had to monitor as to manure, disinfecting and monitoring until lychee was become fully ripen in fact that it was mixed red and pink color then we could get the productions which were distributed through customer

In short this study the researcher saw that the important product distribution. The lychee of Ampur Ampawa in Samut Songkharm was been help grower able to find opportunity to create competitive advantage and to know the real cost in making decision, to select about distribution channel correctly by improve or adjust the working process to be efficient more

**OBJECTIVE OF THIS RESEARCH**

To study the product distribution model which is suitable with lychee at Ampur Ampawa in Samut Songkarn

**SCOPE OF RESEARCH**

Studying distribution lychee of Ampure Anpawa in Samut Songkharm province focus on studying about distribution activity this was continue process of finished product then they were delivered to middleperson and facilitate the market representative to customer so the achievement of transportation product must be passed all activities effectively.

**RESEARCH METHOD**

This research the researcher specified the population and sampling group in this study as follow;
1. Population in this study was grower who grow lychee in Ampur Ampawa area which were eight Tambol such as Tambol Suan Luang, Tambol Bang Chang, Tambol Bang Nang Lee, Tambol Bang Kea, Tambol Muang Mai, Tambol Wat Pra Du, Tambol Khaew Om and Tampol Amphawa in Samut Songkharm province studied during 2009
2. Sampling in this research was grower who grow lychee in eight Tambon in Ampur Amphawa Samut Songkharm province for 1,178 growers by simple random sampling followed random method from table of random numbers after that calculated the size of sampling group by Taro Yamane formula at 90% of creditability level, 10% of error, while had sampling group at 95 persons (Sankasem, 2002) indentified the proportion of collection data were

**TABLE1**

**SHOWING NUMBER OF GROWER WHO GROW LYCHEE AT AMPUR AMPHAWA**

<table>
<thead>
<tr>
<th>Sub-District</th>
<th>Number of lychee grower (Household)</th>
<th>Proportion</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Suanluang</td>
<td>219</td>
<td>18</td>
</tr>
<tr>
<td>2. Bangchang</td>
<td>128</td>
<td>10</td>
</tr>
<tr>
<td>3. Bangnalee</td>
<td>45</td>
<td>3</td>
</tr>
<tr>
<td>4. Bangkea</td>
<td>82</td>
<td>7</td>
</tr>
<tr>
<td>5. Muangmai</td>
<td>281</td>
<td>23</td>
</tr>
<tr>
<td>6. Watpradoo</td>
<td>87</td>
<td>7</td>
</tr>
<tr>
<td>7. Keawaom</td>
<td>286</td>
<td>23</td>
</tr>
<tr>
<td>8. Ampawa</td>
<td>50</td>
<td>4</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>1,178</strong></td>
<td><strong>95</strong></td>
</tr>
</tbody>
</table>

Source: Lychee information from Amphawa agricultural office Samut Songkharm, 2009
RESEARCH PROCEDURE

Guidance of research procedures had 4 steps;
Step 1. Studying the problem and collecting an analysis data. In this step the researcher collecting data from grower and then those data were analyzed to find the real problem
Step 2. Studying the distribution channel of lychee from the original production to customer to meet their demand
Step 3. Taking the result from step 2 to analyze of lychee distribution pattern in fact and suitable then conclusion next
Step 4. Taking the recommendation conclusion result and applying result which got from community in Ampur Amphawa Samut Songkharm province to create competitive advantage and to achieve in lychee production management of Ampur Amphawa

RESEARCH TOOL

Research tool in this research was questionnaire created by studying and the related research and setting the question in questionnaire were
Section 1 was general information of respondents which was the open-end question such as name, address, experience, areas average a year, and income a month
Section 2 was information of distribution channel of lychee grower which were 2 open-end questions such as direct-sale by grower or through middleperson
Section 3 was information of distribution activity had 5 open-end questions i.e. first was Warehouse, second was transportation, third was packaging, forth was labor and fifth was production management, they were questionnaire of rating scale type which were composited by 5 levels sorted from most, more, middle, small and less followed by Likert’s model.
Section 4 was information about problem and barrier of distribution product questions which were open-end question

DATA ANALYSIS

Data analysis the researcher took data to analyze by computer and used finished program as statistic which was the data analysis as descriptive analysis to find frequency, percentage, average, and standard deviation then presented the analysis result in the table and translated result by priority of significant level average interpreting principle of lychee distribution activity as follow;
Average at 4.51-5.00 means the most important level
Average at 3.51-4.50 means more important level
Average at 2.51-3.50 means middle important level
Average at 1.51-2.50 means little important level
Average at 1.00-1.50 means less important level

RESEARCH RESULTS

1. Research result of general agriculture information; agricultural sampling group was male and female. They had experience of lychee growing for 5-10 years, highest 11-20 years, the most of them had growing areas around 1-10 rais, production average at 1-3 tons a years and income average of 50,000-100,000 Baht

Section 2 Research result of lychee distribution that most of the sampling grower, themselves, sold the lychee in their own Tambol, almost of all lychee were sold through middleperson who come to buy to source of lychee

Section 3 Research result of lychee distribution activity, in the view of many factors were important to lychee distribution activity most i.e. transportation, packaging and warehouse respectively
1. The sampling groups were male agriculturists and female agriculturists who had the experience in planting the lychee about 5-10 years and 11-20 years respectively. Most agriculturists had the area for cultivation about 1-10 Rai that could get the average yields about 1-3 tons per year and the average revenue per year was about 50,000-100,000 baht.

2. Most of the sampling agriculturists, themselves, sold the lychee in their own district. Besides, they sold their lychee by passing the middle men who came to buy the lychee in the district.

3. The overall factors focused on the product distribution activities in the middle level. In addition, it found that the most important activities were transportation, packaging, and warehousing, respectively.

4. Transportation was found which was the most important to lychee distribution activity such as safety, then, pointing transportation position, delivery period, quality of transportation, convenient of the route and schedule time correspondingly.

5. Warehouse was found that the most important were getting product management, storing, delivering to Tha Nam, receiving and displace to store respectively.

6. Packaging was found that the most important were public relation (PR), storing product, prolong storage life of product, safety, fasting, saving time in storage and delivery and convenient movement and storage and delivery respectively.

7. Transportation The most sampling agricultural group shipped lychee highest weight at 1-3 tons transportation period at 1-3 hours, transportation expense at 500-1,000 Baht per trip, the qualification of the truck drivers should be second education level, experience of driving at least 1 year also holding driver license of private car in additional the most vehicle were four-wheel trucks and transport distance less than 10 kilometers

8. Labor The most sampling grower group had used 1-3 labors or around 68.42 % when researcher analyzed the typed of labor as permanent labor found that the most number of labor were not permanent labor. Whey they were specified the permanent labor was 1-3 persons and temporary labor found that almost all labors were temporary labor during 1-3 persons

9. Production management More sampling growers group managed the non-quality lychee by discount to low price, then, transformed lychee at most and there was the management method of lychee surplus from own sale to be transformed lychee into dried and composted

**CONCLUSION AND DISCUSSION**

Transportation from research result was found that grower, who gave information, saw that transportation was the most important to lychee distribution activity i.e. safety, transportation period, and transportation quality. Lychee was easily perishable and bruise fruit so the transportation had to been safety and suitable correctly process, shortly period to keep lychee quality.

Warehouse from research result was found that grower, who gave information, saw that the warehouse was the most important i.e. storing, delivery to Tha Nam, receiving and displace lychee related with Associate Professor Doctor Karnchana Setnan and her group (2552, abstract) was identified factors effecting the inbound-logistic system e.g. storing raw material, quality of material, material quality measure tool and transporting from source material to factory another factory effected the outbound logistic system i.e. storing lychee in market, lychee distribution and selling wholesale/retailer.

Packaging from research result was found that grower, who gave information, saw that the lychee distribution activity was the most important such as packaging been the public relation (PR) of lychee, storing lychee, helping prolong storage life of lychee related with Karoonsatitchai (2004) had done studying research about agricultural logistic had be identified by strong packaging to prevent the damage from overlap and bump during transport to destination such as 10 kilos box able to overlap at 5 floors while the 5 kilos box able to overlap at 10 floors. If it was over the weight specified, the lychee in the box might be damaged.
Transportation from research result was found that grower, who gave information, saw that delivery method was the most important to lychee distribution activity. There was the weight to transport lychee for 1-3 tons, delivery period for 1-3 hours, expenditure during 500-1,000 Baht per trip, experience of driver, who has hold the driver license, less than 1 year. The most cars were four-wheel trucks related with Pichpipoon and Keawtamchai (2007). Studying about which transportation method was suitable with two-round delivery lychee was specified selection the transportation method had many other environment factors related such as capacity of each truck, the number of time to delivery, the weighting to deliver per time and transportation distance during distribution unit.

Labor from research result was found that grower, who gave information, saw that labor was the most important to lychee distribution activity. The most grower had used 1-3 labors, permanent at 1-3 labors, temporary for 1-3 labors related with Chewhakarn (1995, p18) found that the labor who had more or less experience were different to satisfy the composition of job related with the result of Warin (1996, p47) specified who should be mention of training for labor in order to those labor had experience more

Recommendations from the study are described as follows:

1. To forecast the need of lychee of Amphur Amphawa in each year in order to plan of planting the lychee in enough quantities for the consumers’ need. Moreover, the growers could distribute their lychee by using the logistics system to support in increasing the better agricultural standard.

2. To create the overall standard system of agricultural products and manage in the other parts from the selection and packaging plant, GMP and HACCP in order to increase the value added of the products such as lychee in syrup, lychee Yogurt, lychee jam, etc.

3. The current problem is a group of spoofing who take the lychee especially the unquality lychee of the other areas to sell in Samut Songkram province. That it destroys the reputation of the genuine lychee of Amphur Amphawa.

4. To collect the growers who planted the lychee in Amphawa. Besides, the government agencies as an intermediary in driving on setting the price or target price and looked after the movement of price including to issue the certification of quality and productivity standard of the lychee in Amphur Amphawa in order to ensure the consumers.

5. The campaign of planting the genuine lychee, “lychee sam nam”, of Ampur Amphawa. From the field survey, the researcher found that some growers cut off the genuine lychee because there were not the yields to harvest. So, the agricultural experts should go to the fields in order to publish the growers to plant the other crops that they could harvest the crops and sell them all a year round. In the same time, the agricultural experts should advise the growers to preserve the genuine lychee of Ampur Amphawa.

REFERENCES


INTELLIGENT SYSTEM FOR TRANSPORTATION MODE SELECTION:
A LITERATURE REVIEW

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ABSTRACT

There are a large number of transportation trade operations at the present time in which many operations made via three major mode of transportation Air Sea and Truck currently and are expected more in the future. A volume of trade among the countries in ASEAN that consist of Myanmar, Laos, Thailand, Vietnam, Cambodia, Malaysia, Singapore, Indonesia, Philippines and Brunei is always increasing, thereby transportation performance across these countries is important in particular and becomes highly interested. ASEAN Transportation Network the major notes of transportation road, sea and air links to ultimately form ASEAN transportation network. This included the Singapore-Malaysia-Thailand-Laos-Vietnam-Cambodia Land Bridge in land transportation and the regional. In the areas of Civil Aviation, the existing inter-ASEAN air links between capital points related to the multimodal transport and the application of electronic data interchange in the process. The successful implementation of this project would enable the carriage of goods through more than one mode of transportation using a paperless document. The obvious outcome would be the further competitive of ASEAN trade and ASEAN's capability to stay in the mainstream of technological advancement in the transport sector. The existed problems of transportation among these three modes in ASEAN are: 1) a higher transportation cost of airfreight, 2) monopoly of land transportation in Laos due to a lack of other modes of transportation, 3) handling materials or goods needs man power rather than automatic system, and 4) being unable to fully utilize the high demand of vegetables exported from Thailand. This paper reviews the literature detailing ASEAN Economic Community, Transportation Network, Transportation Mode Selection, and Intelligent System.

KEYWORDS
ASEAN Economic Community, Transportation Network, Transportation Mode Selection, Intelligent System, Expert System

INTRODUCTION

Recently, many transportation trade operations have run their transportation business via three major mode of transportation Air Sea and Truck currently and are expected more in the future. A volume of trade among the countries in ASEAN that consist of Myanmar, Laos, Thailand, Vietnam, Cambodia, Malaysia, Singapore, Indonesia, Philippines and Brunei is always increasing, thereby transportation performance across these countries is important in particular and becomes highly interested. Indeed, physical supply and physical distribution have been the foremost challenges of operations between the countries in ASEAN because they are one of the large business units in the world market. Also,
the Association of South East Asian Nations (ASEAN) as well as the linked ASEAN Free Trade Area (AFTA) to negotiations on free trade agreements (FTAs) being conducted by ASEAN, such as talks with the European Union, China, Australia and New Zealand that possibility to be major cause to effect to the volume of business part to increase among these FTA members.

Figure 1 Association of Southeast Asian Nations

ASEAN Transportation Network the major notes of transportation road, sea and air links to ultimately form ASEAN transportation network. This included the Singapore-Malaysia-Thailand-Laos-Vietnam-Cambodia Land Bridge in land transportation and the regional. In the areas of Civil Aviation, the existing inter-ASEAN air links between capital points related to the multimodal transport and the application of electronic data interchange in the process. The successful implementation of this project would enable the carriage of goods through more than one mode of transportation using a paperless document. The obvious outcome would be the further competitive of ASEAN trade and ASEAN's capability to stay in the mainstream of technological advancement in the transport sector.

Figure 2 The three major modes of transportation in ASEAN
The existing problems of transportation among these three modes in ASEAN are: 1) a higher transportation cost of airfreight, 2) monopoly of land transportation in Laos due to a lack of other modes of transportation, 3) handling materials or goods needs man power rather than automatic system, and 4) being unable to fully utilize the high demand of vegetables exported from Thailand. For the problems existed of Thai products as an exemplary case study, it may include: 1) high risk of sea transportation due to insufficient cranes at Bangkok port and long lead time of transportation of seafreight, 2) overflow production waited for export resulting in over stock that needs more space to store, 3) the company at final destination in Hanoi needs high inventory to support production planning, 4) production cannot meet demand resulting in stock out, 5) customer procedure needs to be completed at the starting point and each destination, and 6) different product, value, lead time require in each country.

A highly transportation reliable system has been identified as a successful Just-in-Time (JIT) logistics channel. The role of transportation in JIT is especially critical in long line of logistics and supply chain channels. Especially, scheduling in international transportation that is found to become challenge of reliable transportation and additional complexities exist. The delay in transportation, uncertainty to transit time of customs clearance, traffic congestion, and other operating procedures are often highly variable with respect to time. Transportation service qualities are differences between the trading countries too.

<table>
<thead>
<tr>
<th>Airfreight</th>
<th>Truckfreight</th>
<th>Seafreight</th>
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<tbody>
<tr>
<td>- High Cost</td>
<td>- High risk</td>
<td>- Long lead time</td>
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<tr>
<td>- Limited space</td>
<td>- Customs at each border</td>
<td>- Limited space</td>
</tr>
<tr>
<td>- Cargoes restriction</td>
<td>- Truck size different</td>
<td>- Cargoes restrict</td>
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<tr>
<td>- Limited packaging size</td>
<td>- Traffic rule different</td>
<td>- Package size</td>
</tr>
<tr>
<td>- Fixed schedule</td>
<td>- Extra cost</td>
<td>- Fixed schedule</td>
</tr>
<tr>
<td>- Linked major city only</td>
<td>- Road congestion</td>
<td>- Port to Port only</td>
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</tbody>
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Figure 3 The constrain among three major modes of transportation in ASEAN

This paper, therefore, reviews the literature detailing ASEAN Economic Community, Transportation Network, Transportation Mode Selection, and Intelligent System.

ASEAN ECONOMIC COMMUNITY

Background

The Association of Southeast Asian Nations, commonly abbreviated ASEAN is a geo-political and economic organization of ten countries located in Southeast Asia, which was formed on 8 August 1967 by Indonesia, Malaysia, the Philippines, Singapore and Thailand. Since then, membership has expanded to include Brunei, Burma (Myanmar), Cambodia, Laos, and Vietnam. Its aims include the acceleration of economic growth, social progress, cultural development among its members, the protection of regional peace and stability, and to provide opportunities for member countries to discuss differences peacefully. ASEAN covers an area of 4.46 million km², 3% of the total land area of Earth, with a population of approximately 600 million people, 8.8% of the world population. In 2010, its combined nominal GDP had grown to US$1.8 trillion. If ASEAN was a single entity, it would rank as the ninth largest economy in the world (Wikipedia, 2011).

The ASEAN Community is based on three intertwined and mutually reinforcing pillars: ASEAN Security Community (ASC), ASEAN Economic Community (AEC) and ASEAN Socio-Cultural Community (ASCC). The ASC is expected to maintain and strengthen peace, security and stability and enhance ASEAN’s capacity for self-management of regional security. It includes maritime cooperation and fight against terrorism, but no plan for a regional military bloc or defense pact. Besides, member countries are free to pursue their own foreign policies and defense arrangements. Meanwhile, the mission of the AEC is to develop a single market and production base that is stable, prosperous, highly competitive and economically integrated with effective facilitation for trade and investment in which there is free flow of goods, services investment, skilled labors, and freer flow of capital. But it will not adopt a common currency like the European Union. And last but not least, the ASCC is for a Southeast Asia bonded together in partnership as “a community of caring and sharing societies”. The ASCC Plan of Action contains four core elements: Building a community of caring societies, Managing the social impact of economic integration, Enhancing environmental sustainability, and Strengthening the foundations of regional social cohesion towards an ASEAN Community. In 2005,
member countries agreed to establish an ASEAN Charter, which would serve as the legal and institutional framework for the regional organization and the ASEAN Community. Although it will not take on any supranational functions, with its ambitious goals, the ASEAN Community is believed to have far-reaching and important impacts on the lives of the people in Southeast Asia (Wikipedia, 2011).

ASEAN has emphasized regional cooperation in the “three pillars” of security, sociocultural and economic integration. The regional grouping has made the most progress in economic integration, aiming to create an ASEAN Economic Community (AEC) by 2015. The average of economic growth of ASEAN-5 during 1989–2009 were Singapore with 6.73 percent, Malaysia 6.15 percent, Indonesia 5.16 percent, Thailand 5.02 percent and the Philippines 3.79 percent. It were better than average APEC economic growth with 2.83 percent which all of ASEAN countries were included. The next step is ASEAN Economic Community (AEC) with main objectives are to create a:

1. Single market and production base
2. Highly competitive economic region
3. Region of equitable economic development
4. Region fully integrated into the global economy

Since 2007, the ASEAN countries gradually lower their import duties among them and targeted will be zero for most of the import duties at 2015. Since 2011, AEC has agreed to strengthen the position and increase the competitive edges of small and medium enterprises (SME) in the ASEAN region (Wikipedia, 2011).

Previous Research on ASEAN Economic Community

Plummer (2002) mentioned that the Association of Southeast Asian Nations (ASEAN) committed itself to the creation of an ASEAN Economic Community (AEC), in which goods, services, capital, and skilled labor would flow freely by the year 2020, or possibly even 2015. Hence, the AEC will guide the ASEAN integration agenda for at least the medium-term. The object of this paper is to analyze the lessons (both positive and negative) for the AEC that might be gleaned from the European Union (EU) economic integration experience. The paper notes that while there is much that the EU experience can teach ASEAN, the region should not underestimate the substantive differences between the two regions or their differing historical contexts. Based on this analysis, the paper also suggests various approaches to the creation of the AEC that ASEAN might consider as it concretizes the AEC program. While, Soesastro (2005) said that progress and realisation of the ASEAN Economic Community (AEC) can only be achieved if there is a clear blueprint, which identifies the end goal, the process to reach the end goal and a framework for proper assessment of the costs and benefits of an ASEAN Economic Community. AEC should not be based on the AFTA in which an agreement was reached first and the details negotiated afterwards earning it the nickname of "Agree First Talk After". A "new ASEAN way" will have to be developed and accepted as the rule of the game before the AEC has any serious chance of fulfilling the role of making ASEAN more competitive and attractive for world business.

On the other hand, Balboa et al. (2010) found that ASEAN member countries are moving toward achieving the ASEAN Economic Community (AEC) with the timeline set at 2015. It is therefore important for policymakers in the region to sustain the momentum—or perhaps even accelerate the pace—toward establishing the AEC. Policy measures are being implemented based on the AEC Blueprint agreed upon in 2007. However, progress among the ASEAN member countries in meeting their commitments has been uneven. This paper reviews the progress of the Philippines in meeting its commitments on the AEC and comparing it with achievements of other ASEAN countries. The paper also discusses some of the problems and constraints that may prevent the Philippines from benefiting from the AEC. Also, Petri et al. (2010) stated that The ASEAN Economic Community (AEC) is the largest integration effort attempted in the developing world; if realized, it will create a single market with the free movement of goods, services, foreign direct investment and skilled labor, and freer movement of capital encompassing nearly 600 million people. The study finds that the AEC could yield benefits similar to those of the European Union, amounting to 5.3% of the region’s GDP and more than twice that if, as expected, the AEC leads to free trade agreements with key external partners. Every ASEAN member will share in these benefits. There will be mild trade and investment diversion effects, but the world as a whole will benefit from the AEC. Nevertheless, the AEC poses political challenges: the study finds that the project will imply significant structural adjustment in several ASEAN economies.

Furthermore, Kagami (2010) further mentioned that de facto integration is taking place because Free Trade Agreements (FTAs) and Economic Partnership Agreements (EPAs) are flourishing in the region. ASEAN aims to form an ASEAN Economic Community (AEC) by 2015 with the completion of the ASEAN Free Trade Area (AFTA). Surrounding countries have been competing with each other to forge FTAs or EPAs with ASEAN, including China, Japan, Korea, Australia and New Zealand, and India. As a result, ASEAN has become a trading hub in East Asia. Bilateral FTAs/EPAs are also partly in place among 16 countries (ASEAN + 6). These economic ties in trade, services
and investment are accelerating this regional development as the world’s largest production base and biggest consumption market, helping to turn around the global recession in the aftermath of the so-called Lehman Shock. However, some problems also need to be pointed out in the East Asian integration such as the spaghetti bowl effect, severe competition, labor issues, environmental destruction and power struggles. However, in 2010, Lee and Plummer conducted a study on consequences of the ASEAN Economic Community (AEC) are investigated using a dynamic computable general equilibrium (CGE) model. Quantitative assessments of the effects on economic welfare, trade flows and sectoral output are offered. When the removal of trade barriers are combined with reductions in administrative and technical barriers and lowering the trade and transport margins under the assumption of endogenously determined productivity, the estimated welfare gains for the year 2015 range from 1.1% in Indonesia to 9.4% in Thailand. The results suggest that streamlining customs procedures and other reductions in administrative and technical barriers, as well as increased competition and improvements in infrastructure, are significant in enlarging the benefits of the AEC.

TRANSPORTATION NETWORK

Definitions

A transport network, or transportation network is typically a network of roads, streets, pipes, aqueducts, power lines, or nearly any structure which permits either vehicular movement or flow of some commodity. A transport network is used for transport network analysis to determine the flow of vehicles (or people) through it within the field of transport engineering, typically using mathematical graph theory. It may combine different modes of transport, for example, walking and car to model multi-modal journeys (Wikipedia, 2011).

Previous Research on Transportation Network

Levinson (2006) argued that transportation network planning decisions made at one point of time can have profound impacts in the future. However, transportation networks are usually assumed to be static in models of land use. A better understanding of the natural growth pattern of roads will provide valuable guidance to planners who try to shape the future network. This paper analyzes the relationships between network supply and travel demand, and describes a road development and degeneration mechanism microscopically at the link level. A simulation model of transportation network dynamics is developed, involving iterative evolution of travel demand patterns, network revenue policies, cost estimation, and investment rules. The model is applied to a real-world congesting network – the Twin Cities transportation network which comprises nearly 8,000 nodes and more than 20,000 links, using network data collected since year 1978. Four experiments are carried out with different initial conditions and constraints, the results from which allow us to explore model properties such as computational feasibility, qualitative implications, potential calibration procedures, and predictive value. The hypothesis that road hierarchies are emergent properties of transportation networks is confirmed, and the underlying reasons discovered. Spatial distribution of capacity, traffic flow, and congestion in the transportation network is tracked over time. Potential improvements to the model in particular and future research directions in transportation network dynamics in general are also discussed. On the other hand, Ham, et al. (2002) estimated and evaluates the economic impacts from a catastrophic earthquake within regional and national contexts, emphasising the inter-industry relationship in conjunction with regional commodity flows and the assessment of seismic damages on a transportation network. The analytical methods employed are twofold: a multi-regional input-output model and a regional commodity flow model. Using the above analytical framework, the economic impacts from a catastrophic earthquake are estimated and evaluated based on hypothetical scenarios of the event, by analysing the magnitude and extent of direct and indirect impacts. Furthermore, as possible extensions, the models developed here can be used as tools for strategic management of the recovery and reconstruction efforts after the event.

In 2007, Levinson and Yerra investigated the self-organization of surface transportation networks. Using a travel demand model coupled with revenue, cost, and investment models, experiments are run under a variety of parameters on a grid network. It is found that roads, contiguous sections of multiple links operating with similar characteristics, and hierarchies of roads emerge under a broad range of assumptions from networks with neither defined roads nor clearly organized hierarchies. The factors which drive this are the (dis)economies of scale, the presence of boundaries, and any initial asymmetry in the network. This research thus finds that roads and hierarchies, which are often thought to be the product of conscious design, can also arise without such intention. While, Kale et al. mentioned that the establishment of private communities on Internet-based transportation networks is a relatively new trend that has met with mixed success. Within industry, there has been uncertainty over the costs and benefits of these communities to shippers and carriers. Through a theoretical model based on assumptions derived from industry executives, this paper suggests that shippers may indeed benefit by establishing private communities. Further, the results show that in high-trust relationships carriers may be no worse off by cooperating with shippers in their private communities.
Additionally, Chen and Levinson (2007) stated that computer simulation plays an increasingly important role in engineering education as a tool for enhancing classroom learning. This research investigates the efficacy of using simulation in teaching the topic of transportation network growth through an experiment conducted at the Civil Engineering Department of the University of Minnesota. In the experiment, a network growth simulator program (SONG) was incorporated into a senior/graduate class in transportation system analysis. Results of the experiment show that the use of SONG effectively enhanced students’ learning in terms of helping students develop in-depth understanding about the development process of network patterns, and helped them develop some aspects of judgment, problem-solving, and decision-making skills. However the use of SONG may have been more effective had some other barriers to learning been overcome.

TRANSPORTATION MODE SELECTION

Definitions

Mode of transport (or means of transport or transport mode or transport modality or form of transport) is a term used to distinguish substantially different ways to perform transport. The most dominant modes of transport are aviation, land transport, which includes rail, road and off-road transport, and ship transport. Other modes also exist, including pipelines, cable transport, and space transport. Human-powered transport and animal-powered transport are sometimes regarded as their own mode, but these normally also fall into the other categories. Each mode of transport has a fundamentally different technological solution, and some require a separate environment. Each mode has its own infrastructure, vehicles, and operations, and often has unique regulations. Each mode also has separate subsystems. A subsystem is a group of many parts that make up one part. All modes of transportation have 6 subsystems. They are: Propulsion, Suspension, Control, Guidance, Structural, and Support. Transport using more than one mode is described as intermodal. Transportation that carries around many people and can be used by the public is known as Mass Transportation (Wikipedia, 2011).

1) A fixed-wing aircraft, typically airplane, is a heavier-than-air craft where the movement of the lift surfaces relative to the air generates lift. A gyroplane is both a fixed-wing and rotary-wing. Fixed-wing aircraft range from small trainers and recreational aircraft to large airliners and military cargo aircraft. The shape of the wing causes air to travel faster over its upper surface. This reduces air pressure above the wing. It also helps increase the pressure on the wing’s lower surface, pushing it upward and creating lift.

2) Rail transport is a means of conveyance of passengers and goods by way of wheeled vehicles running on rail tracks, known as a railway or railroad. The rails are anchored perpendicular to railroad train consists of one or more connected vehicles that run on the rails. Propulsion is commonly provided by a locomotive, that hauls a series of unpowered cars, which can carry passengers or freight. The locomotive can be powered by steam, diesel or by electricity supplied by trackside systems. Alternatively, some or all the cars can be powered, known as a multiple unit. Also, a train can be powered by horses, cables, gravity, pneumatics and gas turbines. Railed vehicles move with much less friction than rubber tires on paved roads, making trains more energy efficient, though not as efficient as ships.

3) A road is an identifiable route, through a city or village and be named as streets, serving a dual function as urban space easement and route. The most common road vehicle is the automobile; a wheeled passenger vehicle that carries its own motor. Other users of roads include buses, trucks, motorcycles, bicycles and pedestrians. As of 2002, there were 590 million automobiles worldwide.

4) Water transport is the process of transport that a watercraft, such as a large, boat, ship or sailboat, makes over a body of water, such as a sea, ocean, lake, canal or river. If a boat or other vessel can successfully pass through a waterway it is known as a navigable waterway. The need for buoyancy unites watercraft, and makes the hull a dominant aspect of its construction, maintenance and appearance. When a boat is floating on the water the hull of the boat is pushing aside water where the hull now is, this is known as displacement.

5) Pipeline transport sends goods through a pipe, most commonly liquid and gases are sent, but pneumatic tubes can also send solid capsules using compressed air. For liquids/gases, any chemically stable liquid or gas can be sent through a pipeline. Short-distance systems exist for sewage, slurry, water and beer, while long-distance networks are used for petroleum and natural gas.
Previous Research on Transportation Mode Selection

Monahan and Berger (1977) presented a transportation mode selection model for a consolidation warehouse system. It determines the transportation mode to be used by each plant or warehouse (point of origin) to ship its order to the company's consolidation point or its central warehouse. The model considers the tradeoff between the total cost of transporting items and the maximum time until a complete order has reached the consolidation point. It brings to bare the effect of each possible mode on (1) buyer transportation cost, and (2) related buyer inventory costs. An algorithm is provided to determine the most preferable shipping plan. A prototypical example is presented to illustrate the use of the algorithm. Whereas, Qu et al. (2008) stated that multimodal transportation is a complex network, in which all the components should be seamlessly linked and efficiently coordinated. Considered many noncommensurable, nonlinear even conflicting criteria simultaneously, the transport mode selection in multimodal transportation is studied within the framework of multicriteria decision making (MCDM). The theoretical basis for feedforward artificial neural network (FANN) to solve this MCDM problem is presented. With the initial topology predetermined by fuzzy analysis hierarchy process (AHP), an adaptive ANN system is proposed, in which the number of ANN input nodes adapts the decision makers’ preference threshold and the initial input weights are determined by fuzzy AHP. Empirical results evidently show this MCDM method is an accurate, flexible and efficient transport mode selection model.

In addition, Liberatore et al. (1995) emphasized the significance of considering both total network logistics costs and inventory investment costs in making both transport mode and carrier decisions. For virtually all major business logistics decisions, however, there are important qualitative factors that one must also consider in making this decision. For example, does a particular transport mode or individual carrier provide particularly good or bad customer service? And for that matter, what does customer service really mean to an individual shipper or transport carrier customer (i.e., how does an individual shipper define customer service)? Such factors should be evaluated systematically in the mode and carrier selection process. Without a suitable and proven evaluation framework, attempting to weigh quantitative and qualitative factors can become a rather clouded process subject to considerable speculation and inconsistency. Here we demonstrate that the Analytic Hierarchy Process (AHP) can incorporate the previously developed cost methodology and a set of well-defined qualitative factors into a unified, quantitative evaluation system. We show how the sensitivity of the final decision is influenced by the weights assigned to the key evaluation factors. Similarly, Engebrethsen (2009) proposed that selecting the right product and service supplier can reduce the costs and improve the corporate competitiveness. The same is valid for selecting the right transportation mode and carrier selection process. This thesis examines the transportation mode selection decision in quantitative supply chain planning models. The proposed model is further extended by considering multiple stocking locations that order from the same supplier and by introduction of lateral transshipments. This study is motivated by a real-life decision problem faced by a logistics company responsible for distribution of beverages in Scandinavian countries. Novel ways for potential cost reduction have been identified when introducing lateral transshipments, namely through usage of transportation cost discounts and availability of multiple modes. The model has been tested on several examples, considering various transshipment policies, which define the locations that can send and receive transshipments, as well as different transportation strategies, which specify number of modes that can be used in each period. The test results show that the size of the potential savings depends on the problem parameters, and the transshipment policies and transportation strategies applied.

Nevertheless, Meixell and Norbis (2008) categorized transportation choice research (mode choice and carrier selection) leading to insight on themes in the literature and directions for future research. The proposed transportation choice research categorization framework is based on a comprehensive literature review of the peer-reviewed journal papers published over the past 20 years, supplemented with a review of practitioner articles to identify current challenges in the logistics field. The academic papers are analyzed in terms of research purpose/question, methodology, findings, and challenges addressed. The review reveals that several important themes are under-represented in the transportation choice literature: environmental and energy use concerns; security in the supply chain; supply chain integration; international growth; and the role of the internet and emerging information technologies. This review also found that simulation, case study, and interview methodologies are under-represented, and that normative modeling research is only lightly represented in this research. The contributions of this research are three-fold: the development of a classification scheme for transportation choice research, a structured review that provides a guide to earlier research on the subject of transportation choice, and the identification of research issues for future investigation. Moreover, Tuna and Silan (2002) mentioned that freight transportation selection is of critical importance to the shippers in terms of achieving high customer service level, cost savings and efficiency in the overall supply chain. On the other hand, providers of freight transportation services have been interested in finding out the salient freight transport selection factors of shippers in order to be competitive within freight transport market. These facts have directed the attention of transport and logistics researchers towards the problem of freight transportation selection since the beginning of 1970 and as a result of this many empirical researches and reviews have been realised. When such evidences as Turkey’s land bridge position both in East-West and South-North axes, economic developments in CIS, Central Asia and Caucasian, productivity increase in Turkey in parallel with Southeastern Anatolia Project (GAP) and acceleration in the relations with the EU are considered,
Turkey has a great potential within the freight transport and logistics activities. The volume of the logistics market in Turkey was estimated to be 1.5 billion USD in 2000. Although the importance of freight transport and logistics services has been increasing among companies in Turkey due to the accelerating international trade, the number of comprehensive studies within the freight transportation selection is negligible. This paper attempts to investigate the liner transportation selection criteria of Turkish Shippers. A field research was conducted within the framework of the study. After reviewing the attributes used in mode and carrier selection criteria researches, a 24 item importance scale was developed in order to measure the perception of the Turkish liner transport shippers. Questionnaires were mailed with a cover letter to the shippers. In addition to the descriptive statistics, factor analysis was applied to define the salient liner transportation selection criteria. Reliability and competence was found as the most important factor.

**INTELLIGENT SYSTEM**

**Definitions**

A system is part of the universe, with a limited extension in space and time. What is outside the frontier of the system, we call its environment. Stronger or more correlations exist between one part of the system and another, than between this part of the system and parts in the environment. An intelligent system learns how to act so it can reach its objectives. The main processes occurring within the intelligent systems are the following: The Intelligent System has a temporary objective, which it has derived from its main objective. It senses its environment, although we have to realize that it has only a few senses and that these can only capture, for instance, light and sound of an object, but can not capture or know the object itself. The system then stores these sense impressions as elementary concepts. Concepts are a material way of storing information. Working on concepts it creates new ones and stores relationships to other total, part, abstract and concrete concepts. In the following we explain this in more detail.

The concept the system uses for its internal processing and the word it uses to communicate about the concept. With all the information, expressed as concepts, the system builds up the present situation. Now it looks into its memory and finds applicable response rules. It chooses one of the best it has found and performs the corresponding action. Response rules are a field of storage that includes the present situation to which the rule is applicable and the corresponding action. The intelligent system continually records the present situation and the action that followed as a response rule. The very first response rules are due to chance actions and to teaching.

When the system is externally inactive, that is it sleeps, it reviews the response rules stored in its memory and performs some generalizations. It makes abstractions of concepts and creates the corresponding response rules, including these abstractions. Further comparisons are between the situation and action of a series or recently learned response rules as well as comparisons between situations of different response rules and between actions of different response rules. By all these activities, starting with very concrete response rules, it creates response rules that are applicable to several different but similar situations (Fritz, 2006).

**Previous Research on Intelligent System**

Duda and Shortliffe (1983) identified few areas of the Expert Systems research that have been as exciting, promising, or bewildering as artificial intelligence (AI). AI is now being applied to problems of scientific, technical, and commercial interest. Some consultation programs, although limited in versatility, have achieved levels of performance rivaling those of human experts. A collateral benefit of this work is the systematization of previously unformalized knowledge in areas such as medical diagnosis and geology. AI has been applied in the field of medicine (SCRIBD, 2010). It was mentioned that it was thought to be a challenge to develop such an expert system about a decade ago which will assist doctors and those working in medical field to help diagnose a patient’s disease correctly. However, thanks to recent day advancement in technology this has been made possible by scientists who have developed such systems. In the beginning, artificial intelligence was considered to be used only for military based operations but nowadays it is being widely used in all sorts of applications. This has been made possible by the use of computers that think and lean by themselves in order to provide assistance to the doctors to diagnose a patient’s disease correctly. Although these systems are still in testing phase and are only limited to one particular disease, this can be overcome with more research and passage of time. This research paper shows an expert system for diagnosing the disease of depression.

While Lemer (2007) described research conducted to develop a knowledge-based expert system decision-support tool for recommending speed limits in speed zones on highways and local roads, which are considered credible and enforceable. The tool is intended to assist responsible authorities in setting speed zone limits to enhance traffic safety and operating efficiency. The system has been designed to be useful for all types of primary roadways, from rural two-lane segments to urban freeway segments. The expert system is designed to be implemented as a web-based software
application. However, Belle (1991) looked at the application of Expert Systems (ES) in financial investment decision making. Firstly ES are positioned within the other computer-based decision-aiding technologies. Then a closer investigation is made as to whether ES are in fact a suitable and appropriate technology in the area of investment. Thirdly, a survey is made to what extent ES are already implemented; although this is restricted to US financial institutions. Some successful applications are looked at in more detail and the paper closes with some thoughts on expected future developments.

Furthermore, Najjaran et al. (2004), furthermore, presented the framework of a proposed expert system that is used to predict the deterioration rate of buried metallic pipes, based on surrounding soil properties. The knowledge base of the expert system is developed using two sources of information available for evaluating the deterioration of pipes: expert knowledge and field data. The novelty of the proposed approach lies in the modeling process and the framework of the expert system, complying with the nature of the information available. The knowledge base is composed of a subjective and an objective model. The former is based upon fuzzy IF-THEN rules representing the expert knowledge obtained from published work and an expert survey. It determines the soil corrosively potential (CoP). The objective model is a single-input-single-output (SISO) model that relates the deterioration rate (DR) to. The objective CoP model may be developed using either fuzzy modeling or a regression analysis of field data. The result of the latter based on a set of available field data (used in a previous study) is presented.

Table 1 illustrates a summary of research papers on the intelligent system for transportation mode selection.

<table>
<thead>
<tr>
<th>Researcher</th>
<th>Theme and Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plummer (2002)</td>
<td>Analyzing the lessons (both positive and negative) for the ASEAN Economic Community (AEC) that might be gleaned from the European Union (EU)Â’s economic integration experience.</td>
</tr>
<tr>
<td>Soesastro (2005)</td>
<td>Progress and realisation of the ASEAN Economic Community (AEC) can only be achieved if there is a clear blueprint, which identifies the end goal.</td>
</tr>
<tr>
<td>Balboa et al. (2010)</td>
<td>ASEAN member countries are moving toward achieving the ASEAN Economic Community (AEC) with the timeline set at 2015.</td>
</tr>
<tr>
<td>Petri et al. (2010)</td>
<td>The ASEAN Economic Community (AEC) is the largest integration effort attempted in the developing world.</td>
</tr>
<tr>
<td>Kagami (2010)</td>
<td>De facto integration is taking place because Free Trade Agreements (FTAs) and Economic Partnership Agreements (EPAs) are flourishing in the region. ASEAN aims to form an ASEAN Economic Community (AEC) by 2015.</td>
</tr>
<tr>
<td>Lee and Plummer (2010)</td>
<td>Consequences of the ASEAN Economic Community (AEC) are investigated using a dynamic computable general equilibrium (CGE) model.</td>
</tr>
</tbody>
</table>

Transportation Network

| Levinson (2006)    | Transportation network planning decisions made at one point of time can have profound impacts in the future.                                   |
| Levinson and Yerra (2007) | Investigating the self-organization of surface transportation networks. Using a travel demand model coupled with revenue, cost, and investment models, experiments are run under a variety of parameters on a grid network. |
| Ham, et al. (2002) | Estimated and evaluates the economic impacts from a catastrophic earthquake within regional and national contexts.                          |
| Kale et al. (2007)  | The establishment of private communities on Internet-based transportation networks is a relatively new trend that has met with mixed success. |
| Chen and Levinson (2007) | Investigating the efficacy of using simulation in teaching the topic of transportation network growth through an experiment |

Table 1 SUMMARY OF RESEARCH PAPERS ON INTELLIGENT SYSTEM FOR TRANSPORTATION MODE SELECTION
**Transportation Mode Selection**

<table>
<thead>
<tr>
<th>Author(s)</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monahan and Berger (1977)</td>
<td>Transportation mode selection model for a consolidation warehouse system.</td>
</tr>
<tr>
<td>Qu et al. (2008)</td>
<td>Multimodal transportation is a complex network, in which all the components should be seamlessly linked and efficiently coordinated.</td>
</tr>
<tr>
<td>Liberatore et al. (1995)</td>
<td>Considering both total network logistics costs and inventory investment costs in making both transport mode and carrier decisions.</td>
</tr>
<tr>
<td>Engebretson (2009)</td>
<td>Considering multiple stocking locations that order from the same supplier and by introduction of lateral transshipments.</td>
</tr>
<tr>
<td>Meixell and Norbis (2008)</td>
<td>Categorizing transportation choice research (mode choice and carrier selection) leading to insight on themes in the literature and directions for future research.</td>
</tr>
<tr>
<td>Tuna and Silan (2002)</td>
<td>Freight transportation selection is of critical importance to the shippers in terms of achieving high customer service level, cost savings and efficiency in the overall supply chain.</td>
</tr>
</tbody>
</table>

**Intelligent System**

<table>
<thead>
<tr>
<th>Author(s)</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Duda and Shortliffe (1983)</td>
<td>Expert systems as artificial intelligence (AI) research. AI is applied to problems of scientific, technical, and commercial interest.</td>
</tr>
<tr>
<td>SCRIBD (2010)</td>
<td>Expert system for diagnosing the disease of depression. This research paper shows an expert system for diagnosing the disease of depression.</td>
</tr>
<tr>
<td>Belle (1991)</td>
<td>Application of Expert Systems (ES) in financial investment decision making. ES are positioned within the other computer-based decision-aiding technologies.</td>
</tr>
</tbody>
</table>

**CONCLUSION**

The appropriate mode of transportation has been an important economical source for industries on ASEAN area. However, this economical region may be jeopardized due to continuing transportation debacles. Hence, it is necessary to examine the problem and determine possible solutions before the repercussions of delays hinder industrial performance. For the future research, the objectives are to be as follows: 1) to assess and compare the transportation performance of Airfreight, Seafreight and Truckfreight between ASEAN countries; 2) to investigate the difference constrains between Airfreight, Seafreight and Truckfreight the influence that may determine key individual affecting firms' perceptions on transportation mode selection; 3) to assess and compare the perceived impact of transportation mode on the operations of firms; and 4) to create intelligent system for transportation mode selection.
REFERENCES


INTEGRATING THE INFORMATION TECHNOLOGY AND FORECASTING TECHNIQUE FOR PLANNING OFF-SEASON LONGAN

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INTEGRATING THE INFORMATION TECHNOLOGY AND FORECASTING TECHNIQUE FOR PLANNING OFF-SEASON LONGAN

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ABSTRACT

Longan is one of the important fruit in the northern part of Thailand. Longan also has a problem with matching supply with demand almost every year. The production of longan during the season is normally greater than demand. In order to delay the seeding of fresh longan, some farming technology has been used. Then, during the off-season, the seeding process can be activated. The problem of this system is when many farmers activate the seeding process at the same time; tons of fresh longan will enter to the market at the market price for this fresh longan is very low. To overcome this problem, this paper focused on the implementation of the information technology in the production of off-season longan. Mobile phone and Internet can be used to send the information from farmers to the computer server “Longan prediction system; LPS”, including date and section of farm that the farmers activated their longan trees. The LPS can predict the production of the off-season longan for this group of farmer based on collected database and forecasting application. Farmers and traders who are the member of this group can see the forecast result and then can manage the next activation process and trading plan for the future market. This system can help both farmers and traders in matching supply with demand and finally, farmer can receive higher price from trader.

KEYWORDS
Artificial Neural Network (ANN), Forecasting, Information Technology, Longan

INTRODUCTION

Longan is one of Thailand’s major export fruits. In year 2010 alone, Thailand produced more than 265,000 tons of fresh longan and more than 80% of this amount was exported and worth more than 120 million USD, while only 45,000 tons are consumed domestically (Customs Department, 2011). Longan major production base is in the northern region of Thailand, which currently accounts for more than 85% of gross production. Chiang Mai and Lamphun are among the top cultivation areas suitable for longan production. More than 230,000 acres are related to the longan industry.

Longan products can be produced and distributed in many forms such as fresh, dehydrated, canned or frozen. Generally, longan is harvested during July to August, which is Thailand’s rainy season. Almost every year, Thailand also has an over supply problem. From the report of the supply chain of fresh longan in Thailand (Sopadang et al., 2008), two of main reasons to over supply crisis are off-season planting. Some farmers in Thailand have knowledge and can choose to stimulate the trees to force them to bear fruits during off-season. This is usually implemented when the farmers want to strategically avoid the high harvest season that lowers the price of fresh longan. A report indicated that only 30% of off-season longan farms successfully produce expected merchandise (Maejo Longan Research and Development Center & Agricultural Promotion and Development Region 6, 2009). Chemicals such as KClO3 can expand the harvesting period from seasonal longan in June to August to the more satisfied period such as Chinese New Year period during December and January, or Qing Ming Festival during March and April. This can increase the opportunity to sell according to the market demand.

The study by Yangyuen (2000) concluded that the economic impact of the industry as the off-season longan production is more efficient than the seasonal longan production. Hence, the off-season longan farmer would have more product surplus than those during the season. The price of off-season longan is 2-5 times higher than the in-season (Manochai, 2004). Beside the sophisticated techniques, off-season longan also requires an understanding of good information for success in this industry.
The supply chain of the off-season longan (illustrated in Figure 1) is comprised of farmers, middle-man (as most of the time, exporters or trader) and the distribution overseas. Middle-men mainly collect the product from the farmer and sell it directly to the buyer from oversea. Within the country, longan products were transported via small size and when exporting and moving over countries, it mostly uses ship, truck or container, depending on the destination.

![FIGURE 1 TYPICAL SUPPLY CHAIN OF AN OFF-SEASON LONGAN IN THAILAND](image)

Famers cultivated the off-season longan based on their potential and experience by trial-error without the supply forecasting. When the off-season longan cultivation came, they also reap their product in the same time without the harvest priority in the area because they also start to cultivate in the same period. Most of the time, farmers do not understand the requirement of the end consumer in both domestic and overseas. When the off-season longan cultivation came, they also reap their product in the same time without the harvest priority in the area because they also start to cultivate in the same period. The demands of the market are also unreachable by the farmers and many times lead to the over supply problem as mentioned before. This is a serious problem within this industry’s supply chain.

To overcome this problem, this paper offers the implementation of the information technology and forecasting technique in the production of off-season longan.

**THE FORECASTING OF THE OFF-SEASON LONGAN PRODUCTION**

In forecasting the off-season longan product, five main aspects need to be considered included:
1) General profile of agriculturalists to off-season longan comprised of their gender, cultivation’s experience, educational level.
2) General profile of longan garden including density of garden, longan type, height of longan trees, longan diameter of the canopy and longan cultivation period.
3) Technical longan cultivation information about the care of longan for instance, shape pruning after harvest, the frequency of longan garden treatment, early recovery period after harvest before pouring fluid catalytic productivity, the continuity of the catalytic productivity fluid, irrigation system to garden, volume of potassium chlorate and other chemicals usage in the treatment of leaf, flower, the other chemicals used to eliminate diseases and insects and how to add substance.
4) Longan garden environment information such as garden’s soil characteristics, the sunlight, temperature, humidity, rainfall on soil nutrients, moisture in the soil, diseases and insect pests of longan.
5) Productivity information for example, harvests date, the average harvest yield per day, ratio of good grade longan, the percentage of blooming flower, inflorescence characteristics of longan and longan color.

From the previous aspects, 40 factors are summarized into 4 groups; (1) general information (14 factors), e.g., age, experience in the production, education of the farmers, production area, density and distance of plants, age of plants, height and diameter of plants, (2) production technique (12 factors), e.g., chemical application volume, continuity, and date, irrigation system, convalesce period, (3) farm environment (10 factors), e.g., soil, temperature, air and soil humidity and (4) product (6 factors), e.g., harvesting date, average production capacity per plant, longan size (grade), efflorescence rate and type. Artificial Neural Network (ANN) is widely used in a variety of application. Golmohammadi (2006) demonstrated the use of ANN to learn the relation among criteria and alternatives. Wang (2007) confirmed the success of ANN to have an ability to learn and respond in producing cost estimates for manufacturing processes and also seek to find new patterns. In this study, the ANN was presented. The artificial neural network model as presented in Figure 2 can be used to forecast the amount of the off-season longan. The network composed of 3 layers, which are 40 nodes in input,
layer, 20 nodes in hidden layer and 1 node in output layer. According to 40 nodes input, it means we have 40 factors affected to the amount of longan supply.

**FIGURE 2**
ARCHITECTURE OF THE PROPOSED ARTIFICIAL NEURAL NETWORK

Three distinguish groups of longan farmers with 57 data sets were obtained. After that, the 1,710 data sets were created based on the Monte Carlo simulation for the computation purpose. Then, all data sets were separated into 3 groups, 80% of data sets will be used for training, 10% of data sets will be used for validation and other 10 % will be used for testing as shown in figure 3.

**FIGURE 3**
THE RELATIONSHIP AMONG TRAINING, VALIDATION, AND TESTING IN THE ARTIFICIAL NEURAL NETWORK (ANN)

THE APPLICATION OF INFORMATION TECHNOLOGY IN OFF-SEASON LONGAN PRODUCTION

The information technology system has four main modules in the computer server; (1) database module, (2) general information module, (3) forecasting module, and (4) report module. The database module contains three main databases, i.e. farmer database, farm database and middleman database. The general information module covers knowledge on off-season longan which are exhibited in web document and video formats. The forecasting module has the engine that link to the forecasting information for each farmer from the artificial neural network (Longan prediction
system; LPS). The report module involves statistics on longan farm and productivity, as well as location mapping. These contents help assisting longan stakeholders in planning, making decision and forecasting. An example of screen capture of the information system is illustrated in Figure 4.

Beside the computer access via Internet to the computer server, an easy way to communicate with farmers is the SMS technology. Based on the text messaging service, it allows the system to exchange information such as chemical application input from farmers; including date and section of farm that the farmers activated their longan trees, news, longan price and other related information from the system.

**FIGURE 4**
**MAP AND STATUS OF LONGAN TREES FOR EACH FARMER**

RESULT OF INTEGRATING THE INFORMATION TECHNOLOGY AND FORECASTING TECHNIQUE

Mobile phone and Internet can be used to send the information from farmers to the computer server “Longan prediction system; LPS”. The LPS can predict the production of the off-season longan based on collected database and artificial neural network forecasting technique. Farmers and traders who are the member of this group can see the forecast result and then can manage the next activation process and trading plan as shown in figure 5.

**FIGURE 4**
**FORECASTING RESULT**
CONCLUSION AND REMARK

The common problem within the off-season longan industry is the problem with matching supply with demand can be solved using information sharing and forecasting technique. In this work, integrating the information technology and forecasting technique “Longan prediction system; LPS” has been developed and used as a tool for information sharing. This integrated system can solve the matching supply with demand problem. As a result, this system can help farmer to receive higher price from trader.

ACKNOWLEDGEMENTS

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DEFINING COMMUNICATION FLEXIBILITY FOR SMART LOGISTICS

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ABSTRACT

The paper articulates the concept of communication flexibility, in the form of dimensions, by which operations managers may judge the ability of the logistics chain to configure / reconfigure information linkages in responding to the changing environment. The research method is mainly a conceptual work. Three levels of communication flexibility are identified, namely, transactional, operational and strategic. Each level consists of a number of dimensions and sub-dimensions that together define communication flexibility in logistics operations. The proposed conceptual work needs further verification and validation via both case study and large scale survey which will be conducted at the later stage of this research. The analytical definition of communication flexibility provides the basis for managers to more fully assess the flexibility capabilities of their logistics operations. Until now the term ‘communication flexibility’ has been loosely used in the literature. This paper establishes a more analytical definition that forms the foundation for more comprehensive empirical quantitative and qualitative research in the field of flexible operations.

KEYWORDS
Conceptual Model, Inter-Organisational, ICT

INTRODUCTION

The provision of logistics services relies heavily on effective intra- and inter-organisational information exchange and communication, for which Information and Communication Technology (ICT) is seen as a key enabler (Phillips and Wright 2009). Effective communication among shippers (consignors), carriers and customers (consignees) helps to foster collaborative relationships and to reduce uncertainties and performance-related errors, thereby enhancing operational efficiency and customer responsiveness (Premkumar et al., 2005). Innovative logistics practices that are based on the use of such state-of-art technologies are often referred to as ‘smart logistics’, i.e. flexible and able to cope with uncertainties.

The aim of this paper is to develop the concept of communication flexibility enabled by ICT in the context of logistics. This paper will focus on the inter-organisational perspective where there are a variety of emerging technologies that have not been adequately researched in the literature. Inter-organisational communication flexibility is not well defined in the literature, but as a basis for further articulation it is defined as the extent to which the firms are able to configure and reconfigure their information linkages in responding to a changing environment.

LITERATURE REVIEW

Early inter-organisational systems (IOSs), such as Electronic Data Interchange (EDI), are often criticised for their adverse effects in facilitating flexible information connectivity between organisations because they utilise rigid and complex interfaces and are costly to deploy (Badii and Sharif 2003). However, the recent advances in ICTs, particularly web-based technologies, have dramatically changed the way information flows are managed and structured. Rather than the costly and complex point-to-point integration of separate systems, web-based systems are designed for participants to share a single platform (Christiaanse et al. 2004). Such technological advances have made inter-organisational information connectivity more flexible and less costly, allowing increased visibility and opening up opportunities for better decision making and collaborative initiatives such as joint delivery for both cost and carbon emission reduction.

Yet it seems too simplistic to assume that such flexible connectivity automatically leads to increased communication flexibility and effectiveness. Much of the literature related to flexibility concentrates on manufacturing
operations, including the early notable work of Slack (1987) and Gerwin (1987). More recently, the study of flexibility has extended from a manufacturing systems level to a supply chain level (Sanchez and Perez 2005).

Within the literature, there is limited evidence in explicitly defining and measuring ICT-enabled communication flexibility. The discussion of communication flexibility in the context of logistics is even scarcer. Only two works have been identified which explicitly address communication flexibility in a logistics context. The first work is of Naim et al. (2006) who defines transport flexibility into two types: Internal flexibilities which describe system behaviour and external flexibilities which determine the actual or perceived performance of the system. They argue that communication flexibility is one of the internal flexibilities and briefly define it as “the ability to manage a range of different information types”. Zhang et al. (2006) used another term “spanning flexibility” to describe the ability of a firm to provide information across the supply chain. In addition, they also propose a definition of ‘supply chain information dissemination flexibility’ as the ability of a firm to collect and disseminate quickly the various data needed along a supply chain to respond resourcefully to the customer needs. Both works have a loose definition of communication flexibility, with no real attempt to characterise or develop it from an ICT perspective. This paper therefore intends to fill the gap in adequately defining communication flexibility by answering the following research question;

*RQ: What are the key dimensions of communication flexibility?*

### INTER-ORGANISATIONAL COMMUNICATION FLEXIBILITIES

We propose a three-layer model for inter-organisational communication flexibility as shown in Figure 1. This conceptual model builds mainly on the work of Ward and Peppard (2002) and Klein and Rai (2009) who argue that the impact of ICT to supply chain management could be classified into three levels:

- Strategic: emphasis on planning and development of information provisions for strategic gains and competitive advantages
- Operational: emphasis on the improvement of information flows between companies to unlock potential efficiency gains.
- Transactional: emphasis on automating data processing and enabling reliable data exchange

The constructs associated with each layer are developed along the discussions in the following sections as presented in Table 1.
**TABLE 1**

**KEY PROPERTIES OF COMMUNICATION FLEXIBILITY (SOURCE: AUTHORS)**

<table>
<thead>
<tr>
<th>LCF</th>
<th>DCF</th>
<th>Sub-D</th>
<th>Degree of flexibilities</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Low</td>
</tr>
<tr>
<td><strong>Transitional</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ICT infrastructure</td>
<td>Hardware</td>
<td>All hardware owned in house</td>
<td>Mostly rent from a technology provider; some advanced features</td>
</tr>
<tr>
<td></td>
<td>Software</td>
<td>Traditional software licensing; in-house applications</td>
<td>On-demand or free to use</td>
</tr>
<tr>
<td></td>
<td>Networks</td>
<td>In-house client-server architecture</td>
<td>Web-based</td>
</tr>
<tr>
<td>Systems access &amp; security</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Linkages</td>
<td>Rigid EDI links</td>
<td>Connect with a limited number of partners</td>
<td>Web-based connection with a wide range of audience</td>
</tr>
<tr>
<td>Interoperability</td>
<td>Restricted information exchange between systems</td>
<td>Seamless information exchange between systems, no required changes for users</td>
<td>Information exchange based on certain standards, users need to agree to use the same standard for data transaction</td>
</tr>
<tr>
<td><strong>Operational</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quality/integrity</td>
<td>Manual data input</td>
<td>Automatic data generation capturing and generation</td>
<td>Hybrid; manual and automatic data input</td>
</tr>
<tr>
<td>Visibility</td>
<td>Limited visibility</td>
<td>Total pipeline visibility</td>
<td>Moderate visibility</td>
</tr>
<tr>
<td>Speed</td>
<td>Within days or even weeks/months</td>
<td>Within hours</td>
<td>Within minutes</td>
</tr>
<tr>
<td><strong>Strategic</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Optimisation</td>
<td>Focusing purely on execution</td>
<td>Facilitate highly intelligent analysis for decision making</td>
<td>Some degree of intelligent analysis facilitated</td>
</tr>
<tr>
<td></td>
<td>With existing partners</td>
<td>Technically difficult and costly to facilitate the collaboration between partners</td>
<td>Easy and low cost for inter-organisational collaboration</td>
</tr>
<tr>
<td></td>
<td>With changing partners</td>
<td>High switching cost</td>
<td>Low switching cost</td>
</tr>
<tr>
<td>Improved services or products</td>
<td>Limited functionality supported</td>
<td>Support end-to-end supply chain planning and execution</td>
<td>Support some offerings</td>
</tr>
<tr>
<td>New services or products</td>
<td>Rigid standard software packages offering little room for added functionality of services or otherwise costly</td>
<td>Offering choice of modules, users able to ‘cherry pick’</td>
<td>Able to facilitate a certain degree of added functions based on requirement</td>
</tr>
</tbody>
</table>

**Transactional layer**

The bottom level focuses on enabling transactions and is composed of two elements: **ICT infrastructure** and **Connectivity**. ICT infrastructure here refers to hardware, software and networks. The decisions from companies on how to use their ICT infrastructures have a profound impact on productivity and achieving competitive advantages, as ICT is an effective means of organisational productivity, enterprise innovation, network communication and service delivery (Paulraj et al. 2008). The recent innovations in infrastructure utilisation have provided alternative ways in reducing the total cost of investment in infrastructures. For instance, cloud computing allows companies to avoid the cost of investment on an ICT infrastructure and staff by renting the computing and storage capacity that they need and pay a charge only based on usage. Such approaches highly reduces the rigidity and high fixed cost associated with the planning, purchasing and maintaining of traditional hardware and thus increases the ease of deployment.

The second element under the transactional layer is **Connectivity**. Connectivity here emphasises the ability of inter-organisational systems to gain access to information resources and support data exchange between organisations. Companies and individual users have to have quick access to the systems in responding to changes. Prior to the advent of the Internet, many logistics information systems were in-house systems which can only be accessed in certain fixed geographical locations. With the pervasiveness of web technologies and wireless communication, people can communicate with each other almost from anywhere in the world if there is an Internet connection. Many systems now have got a secure web-based interface that can be accessed remotely. For instance many organisations will grant their customers the online entry to their Customer Relationship Management (CRM) module (normally as part of an ERP package).

Linkages under Connectivity deals with the level of reach (i.e. e-connection with a wide audience) and range (share information across a variety of technological platforms). Linkages and interoperability are often discussed together, as one affects another. To ensure the seamless flow of information across company boundaries, interoperability is a fundamental requirement. Interoperability at the network level refers to “the ability of an enterprise to receive and
send data from and to another enterprise using its hardware, applications, or operating systems via an established network connection” (Mouzakitis et al. 2009). Currently technology providers’ solutions to interoperability mainly base on the use of some standards and also middleware in order to integrate across systems. However, semantic web services based solution has become more promising and is being actively researched (Chituc et al. 2008). In a logistics collaborative network, it is a common practice for the technology provider to translate different formats of EDI data into an agreed standard form so as to ensure effective communication between various participating parties.

**Operational layer**

This second layer deals with two major issues: information sharing and process improvement.

We define information sharing as the extent to which data is exchanged in real time and information asymmetries reduced. Much of the research under information sharing focuses on information distortion and related costs and benefits (Lee et al. 1997; Samaddar et al. 2006). According to Donk (2008), there has been few investigations about what is needed for information systems to provide seamless information flows. This paper proposes that three constructs: data quality, information visibility and speed of transactions, need to be considered to ensure information sharing.

Data quality is often a concern for businesses, as the accuracy, consistency and completeness of data is the foundation for managers to make the right decisions. In the past many data errors occurred due to the fact that they had to be keyed into the system by operators. Now the use of automatic identification and data capture technologies has largely reduced data errors. For instance bar codes and Radio Frequency Identification (RFID) are frequently used for inventory management in a variety of sectors (Jones et al. 2005). The use of real time satellite tracking of containers and trucks also provides timely and factual data for monitoring the delivery performance.

The increased complexity of supply chain and globalisation has led to longer lead times, increased landed cost (the total cost of a product) and more goods-in-transit inventory. It requires expanded data exchange and higher levels of connectivity to suppliers, carriers, customers and other parties like government bodies across multiple countries. This in turn has posed significant challenges to companies in obtaining the total pipeline visibility in order to respond quickly to disruptions as well as find ways to cut cost. One can only control and improve the current processes if adequate visibility is provided.

Many ICT visibility tools have been developed in practice in recent years to address the multi-enterprise visibility issue. For instance, Microsoft, IBM, JDA, Info and GT Nexus, to name only a few, have all developed supply chain visibility solutions. There are visibility modules in ERP and supply chain management suites, visibility systems from carriers or freight forwarders and hosted commercial platforms. In a multimodal transport chain, a growing willingness from shippers is observed to utilise hosted commercial platforms, in order to reduce the cost and complexity of maintaining such a system (Heaney and Sadlowska 2009).

Speed is concerned with how quickly visibility can be gained. It could be within minutes, hours, days or even months. For instance, Tesco uses satellite tracking system monitoring deliveries to stores. The status of each individual delivery is fed into the system every five minutes (Isotrack.com 2011). The stores will receive an automatic alert (geo-fence notification) when the delivery comes close to the store. Automation, integration and synchronisation are ways to achieve speedy data transactions and visibility. This then leads us to examine the second subcategory under Operational layer: Process Improvement.

Most ICT tools are designed and developed for process improvement, particularly in terms of streamlining business processes such as order management, inventory management, transport and distribution (Turban and Volonino 2010). Some will also aid for optimisation by enabling ‘what-if?’ scenario analysis and dynamic re-routing of deliveries. The use of ICT in logistics originated in the 1960s, when traditional applications like inventory management systems, scheduling and billing systems were developed. These enterprise systems were stand-alone hence just aiming to automate a single process. Material Requirements Planning (MRP), Manufacturing Resource Planning (MRP II) Enterprise Resource Planning (ERP) are the typical packages widely used nowadays. The development of IOSs has paralleled the development of enterprise systems. EDI is one of the earliest IOSs developed to streamline business processes like order transmission, delivery note communication, and financial settlements. Due to the use of open technologies like web/XML based applications, there has also been Electronic Marketplace (EM) in aiding procurement for both buyers and suppliers in the early 2000s.
Strategic layer

Many organisations utilise the developments of ICT for strategic gains. The third layer of communication flexibility deals with partnering and offering. Partnering means the ability to build and alter linkages to partner with different supply chain players in response to changes in the business environment. This is to allow companies to be able to configure and reconfigure their supply chain structures in order to be responsive to the customers’ changing needs and increasing uncertainties.

Prior to the creation of web technologies in the late 1990s, e-business integration between organisations was usually achieved through building dedicated linkages, for example, using EDI, or sophisticated Enterprise Application Integration (EAI) techniques. Such connectivity involved large capital investment, long deployment time, and high switching costs and has been seen as too rigid to meet such requirement (Edwards et al. 2001).

It is the development of web-based systems which makes flexible B2B integration possible. Rather than the costly and complex point-to-point integration of separate systems, web-based systems are designed for participants to share a single system. More recently, the rapid development of web technologies has also led to the emergence of the relatively new concept of ‘cloud computing’ (Weber 2010). Unlike traditional applications that are paid for with an up-front licence fee and installed on a company’s own premises, cloud computing systems are hosted by the vendor and typically paid for on a subscription basis. Offering greater flexibility for B2B collaboration, such systems also enable not only large companies but also small and medium sized companies to be able to use web-based technologies.

Adapted from Gosain et al. (Gosain et al. 2004), offering here refers to the ability of inter-organisational linkages to support changes in product or service offerings to customers. The limited lifecycle of products and the variability of customer demands are the driving forces for this attribute of flexibility. For example, Dell allows its customers to build their PCs with their own specifications by providing modular choices via a web based interfaces and linking the online order capturing system with their in-house ERP system. This approach increases Dell’s offering in terms of variety and customisation but without a corresponding increase in cost. This concept of mass customisation will simply not be feasible without the supporting technologies.

DISCUSSION AND CONCLUSION

Even though much attention has been focused on the logistics flexibility concept in recent years, one critical dimension is missing - namely, communication flexibility. While the profound effect of ICT in supporting flexible operations, be it at supply chain level or manufacturing level, is well recognised, academic researchers need a more rigorous approach in assessing inter-organisational communication within the logistics context. This is the major driver and novelty of this research.

In order to fill this void, this research sets out to define and measure inter-organisational communication flexibility in the logistics context. A conceptual model has been proposed aiming to capture the key attributes of communication flexibility. This paper provides valuable insights to the logistics and operations management as well as ICT research communities regarding the role of emerging ICT in aiding inter-organisational communications. Consequently it extends the literature on agility, flexibility and resilience, allowing other academic researchers to scrutinise or build on the research findings and explore further this important, yet under-developed subject.

This research is also timely as it investigates and consolidates the key emerging technologies in the logistics field, for instance real time tracking and tracing technologies using Global Positioning System (GPS) and electronic logistics marketplaces based on cloud computing solutions. Used separately or in combination, they will facilitate inter-organisational communication at different levels. Such technologies only emerged recently and therefore, by incorporating them, this study advances and updates our knowledge towards the use of ICT in the logistics field as well as provides guidance for the management and use of existing and future information technologies.

One limitation of our research is that it is conceptual. Future work should use more detailed case studies and/or large-scale survey to validate the proposed model. It would also be interesting using longitudinal data to examine the dynamics between the time when the information linkages are built and the time when the economic and environmental impact are materialised.
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BUILDING THE SUPPLY CHAIN DATABASE SYSTEM

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ABSTRACT

The lack of data management on ornamental fishes supply chain for export from up-stream to down-stream effected to related agents. It was about as it needed to make decision for the related agents. Private sectors required the data before their decision – making for business, as well as the administrators needed the data for making policy. The lack of the data management caused of competitive capabilities in ornamental fishes industry in Thailand resulted in less capabilities than competitors in international market. The data management on the ornamental fish supply chain for export could be done by collect all data on productive processes, suppliers, producers, consolidators/wholesalers, exporters, logistics service providers, international competitors and all concerned government bureaus. All data then was managed to be database in easily accessing via web page, web board and it should be linked to the network main information. The development of database on ornamental fish supply chain for export found that it should be related agents who responded directly in the process to control, improve and update the data system. This was for increase the capabilities on international marketing competition. The concerned organizations had to check update, inform and cooperate with other related agents for the data development. The database on ornamental fishes supply chain for export had been informed at http://msc.npru.ac.th/fish/index.php. The data was last updated in the 30th September 2011 of all 843 lists.

KEYWORDS
Database System, Supply Chain, Ornamental Fish, Exporting

INTRODUCTION AND OBJECTIVE

Currently, the ornamental fish for export was another part of business had been grown not only had higher export value but also it was the source of nation income. The ornamental fish was related to other organization on network in order to cooperate and work together in term of management and improvement as the product flow, the information flow and finances flow from culturist to end-user called “supply chain”. The ornamental fish supply chain had compose from up-stream to down-stream as the part of purchaser for ornamental fish farm/ supplier, culturist/ farm, collector/ middleman, exporter/ export cooperative agency and logistic enterprise such as packing business forwarder agent, airline, international market trade partner, government officer and specialist and related organization.

The barrier of ornamental fish for export from up-stream to down-stream was production of culturist/ farm, lack of continuous factual improvement, and production system not related to market demand. Most of profit from ornamental fish distribution was collector/ middleman. Exporter/ export cooperative agency had not the export information resource and the logistic system barrier while the potential of competition partner had management system better in addition legal restriction and regulation from nation trade partner and further lack of ornamental fish supply chain system from up-stream to down-stream; therefore, researcher team saw supply chain management significantly so this research objectives were to study and to create ornamental fish for export supply chain database.

METHODOLOGY

Ornamental fish for export supply chain study research framework was to planning the infrastructure ornamental fish for export supply chain database as supplier, culturist/ farm, collector/ middleman, exporter cooperative agency, international market trade partner data, and logistic business for instance packing, shipping agency, airline, officer and specialist from related government office as the picture below.
To study the demand of data user as breeding/aquaculture, logistic and international market trade partner export when we got the accuracy data and met the user demand to develop the database. The research procedure was studied about primary data status related to ornamental fish supply chain for exporter. By collecting and studying those data distributed widely both parts as academic and statistic was related to breeding/aquaculture, market, export, logistic and ornamental fish supply chain for export under collecting each of ministry then these data were divided by grouping in order to user to search easily.

**RESEARCH RESULT**

Research team provided the ornamental fish for export supply chain had the details as below;
- First, to open the internet explorer in the top box of address typing the system name as [http://msc.npru.ac.th/fish](http://msc.npru.ac.th/fish) then the screen display shown as below picture.

The first page was consisted many parts as follows;
1. Menu bar was composed sub menu such as profile, web link to related organizations, contact us, site map

2. Main menu was composed sub menu for instance aquaculture supplier data, ornamental fish, breeding/aquaculture, exported ornamental fish procedure, logistic enterprise data and research history map

Menu bar was tool tap appeared on the top program divided by main menu group as follow;

1. How profile menu work, it was shown the project history

2. Link with related organizations
   2.1. Click “link” menu connected with related organization
   2.2. Screen display directly “Link” related organization. In this part showing the related organization detail for example ornamental fish data, URL which was linked to other organization web site
   2.3. Click “web link” that you need to see other organization
   2.4. The web site display system was opened as below picture

3. Contact us
   3.1. Click “contact us” menu
   3.2. Screen display system of “contact us” shown organization name, address and map

4. Site map
   4.1. Click “site map” menu
   4.2. Screen display system as site map shown all main menus structure of this web site

Main menu was the tool tap on the left site of program by grouping as follows

1. Click “supplier data”
   1.1. Screen display system in this part shown their name and address

2. How ornamental fish data worked as follow;
   2.1. Starting from click “ornamental fish” menu
   2.2. Screen display system shown ornamental fish both fresh-water and salt-water fish
3. How aquaculture/farm data worked, it had procedure as

3.1. Starting from click “aquaculture/farm data”
3.2. Screen display system shown aquaculture/farm data in each province

![Aquaculture Farm Data Display](image)

4. How collector/middleman data worked, it had procedure as;

4.1. Starting click “collector/middleman data”
4.2. Screen display system shown collector/middleman data as below picture

![Collector Middleman Data Display](image)

5. How international market trade partner data worked, it had procedure as

5.1. Starting from click “international market trade partner data” menu

![International Market Trade Partner Data Display](image)

5.2. Screen display system of “international market trade partner data” appeared as below picture

![International Market Trade Partner Data Display](image)
6. How exporter data menu worked, it had procedure as follows;

6.1. Starting from click “exporter data” menu
6.2. Screen display shown exporter data appeared as below

7. How exporting data worked, it had procedure as follows;

7.1. Starting from click “exporting data” menu
7.2. Screen display system exporting data appeared as below picture
8. How ornamental fish for export worked, it had procedure as follows;

8.1. Starting from click “ornamental fish for export procedure” menu
8.2. Screen display system of ornamental fish procedure data appeared as below picture

CONCLUSION

Developing the ornamental fish for export supply chain database found we should have organization to in-charge directly such as handle, solution, improvement and always updated in order to increase the international competitive capabilities at the same time reduce redundancy. Related organization whose data to be improved own data have been updated also accuracy at the same time should have public relation (PR) and cooperate with other related organization which had use the same data to join and develop data to update. Ornamental fish for export supply chain database system has been collected data as aquaculture, market export, logistic system, and trade partner market to be connected computer to network also able searching easily for the user group such as agriculturist, student, researcher/specialist, and businessperson included specified policy person, those persons cloud search wherever had computer connected to internet network. Those system always has be developed to modern data this is to increase ornamental fish for export potential, to sustainable develop competitive capability, to develop as system to connect related organizations, it was to be highest benefit all parts and Thailand is the number one of ornamental fish exporter in the world

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Inventory and Warehouse Management
SIMULATION STUDY OF INVENTORY POLICY
IN LATERAL COLLABORATIVE SUPPLY CHAIN

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ABSTRACT

Due to global competition, firms are seeking more effective supply chain collaboration in order to provide quality products with less cost, at the right time and in the right quantity. The present study examines manufacturing supply chain collaboration: vertical, horizontal and lateral. This research emphasizes lateral collaboration in showing the impact of inventory policies ((s, S) and (s, Q) inventory policies) on supply chain performance. For better understanding, a conceptual model is provided which is supported by numerical example. As the study of supply chains is complex in nature, a simulation approach has been employed to show the impact of lateral collaboration on performance measures, such as the total cost which is the sum of several cost components like inventory holding cost, backorder cost and ordering cost. The research work is based on two manufacturing supply chains where the manufacturer is taken as the collaborative node. The laterally collaborative supply chain has been simulated on ARENA 9.0, a simulation package. The results show that the efficacy of lateral collaboration outperforms the horizontal collaboration due to having the individual supply chain members more liberty to make decisions.

KEYWORDS
Supply Chain, Collaboration, Inventory Policy, Simulation

INTRODUCTION

Enterprises are now competing globally and traditional barriers between industries are breaking down. Thus the main goals for enterprises are maximizing the added value and reducing the total cost across the entire trading process by means of focusing on speed and certainty of response to the market. Due to abovementioned market pressures, all the supply chain players need to collaborate towards the same goals to be more profitable in the market and in providing a quality product in less lead time.

Collaboration is defined as: “A long-term partnership process where supply chain partners with common goals work closely together to achieve mutual advantages that are greater than the firms would achieve individually” (Sheu et al. 2006). In general, two types of collaboration can be distinguished, namely vertical and horizontal collaboration. Vertical collaboration can be defined as collaboration between parties performing complementary activities or services while the latter indicates collaboration between parties performing the same type of activities and/or services (Cruissens et al., 2007; Naesens et al., 2009). To overcome of both types of collaboration difficulties, a new paradigm of lateral collaboration has been developed in this study.
In the present paper, an attempt has been made to show the impact of inventory policies on the supply chain cost, and also with collaboration. To show the impact of inventory policies, two linear supply chains have been considered where one follows (s, S) and the other follows (s, Q) inventory policy. Initially both supply chains have vertical collaboration to achieve the same goal. In horizontal collaboration, only the manufacturer can decide on sending an order to the other manufacturer and it will take more time and more cost will be incurred. To overcome this deficiency, lateral collaboration has been explored and this will glean ideas from both types of collaboration. The main performance measure in this study is the total cost which is the sum of the inventory holding cost, the backorder cost and the ordering cost. As the present supply chain context is very complex, it has been simulated in ARENA 9.0, a simulation package.

The remainder of the paper has been organized in the following manner: section 2 provides the literature review whereas section 3 provides the collaboration in supply chains. Section 4 describes the conceptual model of supply chain collaboration. Section 5 gives the results from the simulation study, discussed in detail, and the paper is concluded in section 6.

LITERATURE REVIEW

Collaboration is based on mutual trust, openness, shared risk and shared rewards that yield a competitive advantage, for better performance (Horvath, 2001). Supply chain collaboration seems to have great potential, but further investigation is needed to recognize its value (Goffin et al., 2006).

A significant amount of research has focused on the development of supply chain collaboration models to make this new research area more understandable (Flynn et al., 2010). Previous definitions of supply chain collaboration put more emphasis on process integration and less on the components of relational communication and knowledge creation (Simatupang and Sridharan, 2005). Further, collaboration between supply chain partners is not merely a pure transaction, but leverages information sharing and market knowledge creation for sustainable competitive advantage (Malhotra et al., 2005). Soonhong et al. (2005) revealed that sharing periodical information, either formally or informally, is regarded as the essential ingredient for collaborative partners to ease the flow of products, services and feedback from customers.

Some researchers such as Mentzer et al. (2000), Sheu et al. (2006) have worked on supply chain collaboration and viewed it as a business process. Whereas other researchers, such as Bahinpati et al. (2009), Naesens et al., (2009), have worked on the type of collaboration and especially on horizontal collaboration. Cannella and Ciancimino (2010) have studied bullwhip effect avoidance in supply chain collaboration.

From literature review, it can be concluded that lateral collaboration is still an unexplored research area. Due to abovementioned research gaps in the literature, the motivation of the present research is to work on lateral collaboration.

COLLABORATION IN SUPPLY CHAIN

Collaborative relationships can help firms share risks, reduce transaction costs, and enhance profit performance and competitive advantage over time. Collaboration in supply chains can be classified into three types: vertical, horizontal, and lateral collaboration, which are defined below:

Vertical Collaboration

The vertical collaboration can be defined as the collaboration when two or more organizations such as the manufacturer, the distributor, the carrier and the retailer, share their responsibilities, resources, and performance information to serve relatively similar end customers.

Horizontal Collaboration

Horizontal collaboration is a business agreement between two or more companies at the same level in the supply chain (SC) or network in order to allow greater ease of work and cooperation towards achieving a common objective.
**Lateral Collaboration**

Lateral collaboration combines the benefits and sharing capabilities of both vertical and horizontal integration. Integrated logistics and inter-modal transport are examples of the application of lateral integration that aim at synchronizing carriers and shippers of multi firms in a seamless effective freight transport network.

**CONCEPTUAL MODEL**

For the conceptualization of vertical collaboration, two linear supply chains have been taken into consideration. In the first supply chain, there are four members: Supplier (S1), Manufacturer (M1), Distributor (D1) and Retailer (R1). This supply chain follows the (s, S) inventory policy i.e. the maximum inventory level is ‘S’ and minimum inventory level or reorder point is ‘s’. The supply chain (SC1) has been depicted in Figure 1. In SC1, three types of flow are shown: material, information and cash flow.

**FIGURE 1**

**STRUCTURE OF SUPPLY CHAIN (SC1) WORKS ON (S, S)**

![Supply Chain Diagram](image)

In lateral collaboration, the distributor also has control in handling backorders and will help to reduce the backorder cost of the distributor as well as the retailer. The lateral collaborative supply chain has is shown in Figure 2. From the figure, it is clear that after checking the status of inventory, the distributor can also send the order to another collaborative manufacturer.
RESULTS AND DISCUSSION

In the present study, the effect of collaboration has been shown by the evaluation of two supply chains and both these supply chains have four players: supplier, manufacturer, distributor and retailer. One of the supply chains has adopted the (s, S) inventory policy and the other one has followed the (s, Q) inventory policy.

The main objective of this study is the total cost of the supply chain which is the sum of the inventory holding cost, backorder cost and ordering cost. The result is shown in Figure 3. From the figure, it is observed that the total cost of SC1, which follows the (s, S) inventory policy, is less than for SC2. From this study, it can also be visualized that when the reorder point quantity is increased, the total cost for lateral collaboration is slightly less than for horizontal collaboration. From the results, it is also seen that at $s=100$ units, the percentage profit for lateral collaboration over horizontal collaboration is $12.22\%$ whereas at $s=500$ units, the difference is only $2.91\%$. Therefore it can be said that if the reorder point quantity increases, the impact of collaboration will be lower.

![FIGURE 2 STRUCTURE OF LATERAL COLLABORATED SUPPLY CHAIN](image-url)
FIGURE 3
THE VARIATION OF TOTAL SUPPLY CHAIN COST VS. MANUFACTURER INVENTORY LEVEL

CONCLUSION AND FUTURE SCOPE

The main contribution of this research is in showing the impact of collaboration on inventory holding cost, backorder cost and ordering cost. This study shows that collaboration plays a crucial role on the performance of a supply chain. From the study, it can be concluded that lateral collaboration can reduce the overall cost of a supply chain and the enterprises involved can improve the real time decision making process by adopting a suitable inventory policy.

For future studies, a few more components such as transportation cost, lead time, and transportation time can be considered. Some important but intangible aspects like trust, senior management commitment, flexibility, teamwork, and patience should also be taken into account.

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LEAN TOOL DEVELOPMENT AND REGRESSION MODEL FORMULATION IN WAREHOUSES OPERATION: A LITERATURE REVIEW

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ABSTRACT

Lean manufacturing or lean production is a production practice that considers the expenditure of resources for any goal other than the creation of value for the end customer to be wasteful, and thus a target for elimination. Basically, lean is centered on preserving value with less work. Lean manufacturing is a management philosophy derived mostly from the Toyota Production System (TPS) (hence the term Toyotism is also prevalent) and identified as "Lean" only in the 1990s (Womack, 1990; Holweb, 2006). It is renowned for its focus on reduction of the original Toyota seven wastes to improve overall customer value, but there are varying perspectives on how this is best achieved. To apply lean concepts in the context of warehouses, this research study focuses on applying the concepts for a general warehouse and refrigerated warehouse operation. Normally, a warehouse is a commercial building for storage of goods. Warehouses are used by manufacturers, importers, exporters, wholesalers, transport businesses, customs, etc. Generally, a cold storage company may provide service for keeping import and export chilled/frozen cargo, freezing, re-packing, and container vanning. A cold storage facility is not only essential for increased production capacity and larger profits, but also important in order to achieve maximum efficiency with minimum non-value added waste. This paper reviews the literature detailing lean manufacturing, general warehouse and refrigerated warehouse, and applying lean concepts in warehouses.

KEYWORDS
Leán, Manufacturing, Regression Model, Value Stream Mapping, Warehouse, Refrigerated Warehouse

INTRODUCTION

Lean manufacturing or lean production is a production practice that considers the expenditure of resources for any goal other than the creation of value for the end customer to be wasteful, and thus a target for elimination. Working from the perspective of the customer who consumes a product or service, "value" is defined as any action or process that a customer would be willing to pay for. Basically, lean is centered on preserving value with less work. Lean manufacturing is a management philosophy derived mostly from the Toyota Production System (TPS) (hence the term Toyotism is also prevalent) and identified as "Lean" only in the 1990s (Womack, 1990; Holweb, 2006). It is renowned for its focus on reduction of the original Toyota seven wastes to improve overall customer value, but there are varying perspectives on how this is best achieved. The steady growth of Toyota, from a small company to the world's largest
automaker, (Bailey, 2008) has focused attention on how it has achieved this. Lean manufacturing is a variation on the theme of efficiency based on optimizing flow; it is a present-day instance of the recurring theme in human history toward increasing efficiency, decreasing waste, and using empirical methods to decide what matters, rather than uncritically accepting pre-existing ideas.

To apply lean concepts in the context of warehouses, this research study focuses on applying the concepts for a general warehouse and refrigerated warehouse operation. Normally, a warehouse is a commercial building for storage of goods. Warehouses are used by manufacturers, importers, exporters, wholesalers, transport businesses, customs, etc. They are usually large plain buildings in industrial areas of cities and towns. They usually have loading docks to load and unload goods from trucks. Sometimes warehouses are designed for the loading and unloading of goods directly from railways, airports, or seaports. They often have cranes and forklifts for moving goods, which are usually placed on ISO standard pallets loaded into pallet racks. Stored goods can include any raw materials, packing materials, spare parts, components, or finished goods associated with agriculture, manufacturing, or commerce (Wikipedia, 2011). For the specific refrigerated warehouse, there is a need for more efficient cold storage facilities in order to serve with the food consumption industries. Generally, a cold storage company may provide service for keeping import and export chilled/frozen cargo, freezing, re-packing, and container vaning. A cold storage facility is not only essential for increased production capacity and larger profits, but also important in order to achieve maximum efficiency with minimum non-value added waste. This paper reviews the literature detailing lean manufacturing, general warehouse and refrigerated warehouse, and applying lean concepts in warehouses.

**WHAT IS LEAN MANUFACTURING?**

**Definitions**

Lean manufacturing or lean production, which is often known simply as "Lean", is a production practice that considers the expenditure of resources for any goal other than the creation of value for the end customer to be wasteful, and thus a target for elimination. In a more basic term, more value with less work. Lean manufacturing is a generic process management philosophy derived mostly from the Toyota Production System (TPS) (hence the term Toyotism is also prevalent) and identified as "Lean" only in the 1990s. It is renowned for its focus on reduction of the original Toyota seven wastes in order to improve overall customer value, but there are varying perspectives on how this is best achieved. The steady growth of Toyota, from a small company to the world's largest automaker, has focused attention on how it has achieved this.

Lean principles come from the Japanese manufacturing industry. The term was first coined by John Krafcik in a Fall 1988 article, "Triumph of the Lean Production System," published in the Sloan Management Review and based on his master's thesis at the MIT Sloan School of Management. Krafcik had been a quality engineer in the Toyota-GM NUMMI joint venture in California before coming to MIT for MBA studies. Krafcik's research was continued by the International Motor Vehicle Program at MIT, which produced the international best-seller book co-authored by James Womack, Daniel Jones, and Daniel Roos called The Machine That Changed the World (1990). For many, Lean is the set of "tools" that assist in the identification and steady elimination of waste (muda). As waste is eliminated quality improves while production time and cost are reduced. Examples of such "tools" are Value Stream Mapping, Five S, Kanban (pull systems), and poka-yoke (error-proofing).

There is a second approach to Lean Manufacturing, which is promoted by Toyota, in which the focus is upon improving the "flow" or smoothness of work, thereby steadily eliminating mura ("unevenness") through the system and not upon waste reduction per se. Techniques improve flow include production leveling, "pull" production (by means of kanban) and the Heijunka box. This is a fundamentally different approach to most improvement methodologies which may partially account for its lack of popularity. The difference between these two approaches is not the goal but the prime approach to achieving it. The implementation of smooth flow exposes quality problems which already existed and thus waste reduction naturally happens as a consequence. The advantage claimed for this approach is that it naturally takes a system-wide perspective whereas a waste focus has this perspective, sometimes wrongly, assumed. Some Toyota staff have expressed some surprise at the tool-based approach as they see the tools as work-around made necessary where flow could not be fully implemented and not as aims in themselves.

Both Lean and TPS can be seen as a loosely connected set of potentially competing principles whose goal is cost reduction by the elimination of waste. These principles include: Pull processing, Perfect first-time quality, Waste minimization, Continuous improvement, Flexibility, Building and maintaining a long term relationship with suppliers, Autonomation, Load leveling and Production flow and Visual control. The disconnected nature of some of these principles perhaps springs from the fact that the TPS has grown pragmatically since 1948 as it responded to the problems...
it saw within its own production facilities. Thus what one sees today is the result of a 'need' driven learning to improve where each step has built on previous ideas and not something based upon a theoretical framework. Toyota’s view is that the main method of Lean is not the tools, but the reduction of three types of waste: muda ("non-value-adding work"), muri ("overburden"), and mura ("unevenness"), to expose problems systematically and to use the tools where the ideal cannot be achieved. Thus the tools are, in their view, workarounds adapted to different situations, which explains any apparent incoherence of the principles above.

**Previous Research on Lean Manufacturing**

Ohno (1988)’s concept recognized the scheduling of work should not be driven by sales or production targets but by actual sales. Given the financial situation during this period, over-production had to be avoided and thus the notion of Pull (build to order rather than target driven Push) came to underpin production scheduling. Ohno at Toyota mentioned the concept of Toyota Production System (TPS). It is principally from the TPS, but now including many other sources, that Lean production has developed. While, Womack et al. (1990) published their groundbreaking book on lean production, “The Machine That Changed the World.” Initially, lean initiatives focused on examining existing manufacturing processes, then re-working such processes to increase efficiencies. Similarly, Abdullah (2003) addresses the application of lean manufacturing concepts to the continuous production/ process sector with a focus on the steel industry. The goal of this research is to investigate how lean manufacturing tools can be adapted from the discrete to the continuous manufacturing environment, and to evaluate their benefits on a specific application instance. Although the process and discrete industry share several common characteristics, there are areas where they are very different. Both manufacturing settings have overlap, but at the extreme, each has its unique characteristics. This research attempts to identify commonalities between discrete and continuous manufacturing where lean techniques from the discrete side are directly applicable. The ideas are tested on a large steel manufacturing company (referred to as ABS). Value stream mapping is used to first map the current state and then used to identify sources of waste and to identify lean tools to try to eliminate this waste. The future state map is then developed for a system with lean tools applied to it. To quantify the benefits gained from using lean tools and techniques in the value stream mapping, a detailed simulation model is developed for ABS and a designed experiment is used to analyze the outputs of the simulation model for different lean configurations. Generalizations of the results are also provided.

Furthermore, Sriariyawat and Zunder (2007) describe the impact of lean production to supply chain. There are some issues that might be considered for suppliers who are going to join or be the partner with Lean manufacturer. Also, the summarizer effect of Lean production will be conducted a first round Delphi survey. The future study will gather information of the impacts of Lean production from Delphi expert panel from different regions (Thailand and European countries). Shahin and Janatyan (2010) stated that while Group Technology (GT) has considerable effects on important dimensions of lean production such as production wastes, set up time, quality and inventory management, the relationship between the two subjects has not been sufficiently addressed in the literature. In this paper, a conceptual model has been proposed for enhancing productivity through the application of Group Technology (GT) in lean production systems. The model includes dimensions of GT and its relationship with lean production goals. Statistical analysis has been conducted and the links in the proposed model have been examined based on a questionnaire. The statistical population included managers of two industrial companies. The results confirm the high correlation between the elements of the proposed model in both companies. Also, the results of the variance analysis imply that except two items of the questionnaire, there is no difference in other items between the two companies.

Moreover, Ross (2003) stated that lean manufacturing has been re-discovered' by many UK manufacturing companies over the past two years. Announcements of its 'death' in the late 1990s as companies' focus moved into topical areas such as enterprise resource replacement (ERP), e-business, supply-chain management and product data management were undoubtedly premature. In a study completed by Codexx earlier this year into 25 medium-sized manufacturing companies based in the UK, 10 of them had an active lean manufacturing programme. A survey of 100 UK manufacturing executives in 2002 for The Manufacturer magazine showed that 45% were seeking to implement lean manufacturing within 12-24 months. Adopt a lean manufacturing strategy but make sure innovation plays a key part. On the other hand, Brown (2005) presented lean manufacturing, which establishes small production "cells," or teams of workers, who complete an entire product from raw material processing through final assembly and shipment, increases health and safety hazards by mixing previously separated exposures to various chemicals (with possible additive and cumulative effects) and noise. The intensification of work leads to greater ergonomic and stress-related adverse health effects, as well as increased safety hazards. The standard industrial hygiene approach of anticipation, recognition, evaluation, and hazard control is applicable to lean operations. A focus on worker participation in identifying and solving problems is critical for reducing negative impacts. A key to worker safety in lean production operations is the development of informed, empowered, and active workers with the knowledge, skills, and opportunity to act in the workplace to eliminate or reduce hazards.
WAREHOUSES

Definitions

General Warehouse

A warehouse is a commercial building for storage of goods. Warehouses are used by manufacturers, importers, exporters, wholesalers, transport businesses, customs, etc. They are usually large plain buildings in industrial areas of cities and towns. They usually have loading docs to load and unload goods from trucks. Sometimes warehouses load and unload goods directly from railways, airports, or seaports. They often have cranes and forklifts for moving goods, which are usually placed on ISO standard pallets loaded into pallet racks.

Stored goods can include any raw materials, packing materials, spareparts, components, or finished goods associated with agriculture, manufacturing, or commerce. Some of the most common warehouse storage systems are:

- Pallet rack including selective, drive-in, drive-thru, double-deep, pushback, and gravity flow
- Mezzanine including structural, roll formed, rack supported, and shelf supported
- Cantilever Rack including structural and roll formed
- Industrial Shelving including metal, steel, wire, and catwalk
- Automated Storage and Retrieval System (ASRS) including vertical carousels, vertical lift modules, horizontal carousels, robotics, mini loads, and compact 3D

Traditional warehousing has declined since the last decades of the 20th century, with the gradual introduction of Just In Time (JIT) techniques. The JIT system promotes product delivery directly from suppliers to consumer without the use of warehouses. However, with the gradual implementation of offshore outsourcing and offshoring in about the same time period, the distance between the manufacturer and the retailer (or the parts manufacturer and the industrial plant) grew considerably in many domains, necessitating at least one warehouse per country or per region in any typical supply chain for a given range of products. Recent retailing trends have led to the development of warehouse-style retail stores. These high-ceiling buildings display retail goods on tall, heavy duty industrial racks rather than conventional retail shelving. Typically, items ready for sale are on the bottom of the racks, and crated or palletized inventory is in the upper rack. Essentially, the same building serves as both warehouse and retail store.

Another trend relates to Vendor Managed Inventory (VMI). This gives the vendor the control to maintain the level of stock in the store. This method has its own issue that the vendor gains access to the warehouse. Large exporters/manufacturers use warehouses as distribution points for developing retail outlets in a particular region or country. This concept reduces end cost to the consumer and enhances the production sale ratio.

Refrigerated Warehouse

Cold storage may refer to a form of refrigerated storage. The cold storage company may provide service for keeping import and export chilled/frozen cargo, freezing, re-packing, and container vanning. A cold storage facility is not only essential for increased production capacity and larger profits, but also important in order to achieve maximum efficiency with minimum non-value added waste.

Previous Research on General and Refrigerated Warehouse

Duiven and Binard (2002) conducted the research on cold stores or refrigerated warehouses that are facilities where perishable foodstuffs are handled and stored under controlled temperatures with the aim of maintaining quality. Preservation of food can occur under chilled (above zero) or frozen (below zero) temperatures. For some products, other conditions besides temperature control might be required: for living products (e.g. fruit) the moisture content and/or the composition of the surrounding atmosphere has to be changed as well. Controlled-Atmosphere storage of Ultra-Low-Oxygen storage are some of the techniques available. In a later year, Nitin Magoo (2003) stated that refrigerated warehouses play an important link in the storage of food products throughout the year under conditions specially suited to prevent their decay. In doing so, refrigerated warehouses serve as an indispensable link in maintaining the availability of otherwise seasonal food products all year round. A proper humidity and temperature level has to be maintained in the warehouse at all times to make this possible. The operation of the warehouse is an energy intensive process; however, under many electricity pricing tariffs, there are no cost benefits of adopting operating strategies that shift electrical usage to lower price (off-peak) periods, i.e., a demand-shifting strategy. But, with the deregulation of utility rate structures, there has been a gradual shift towards RealTime Pricing (RTP), whereby the electricity price varies every hour. The RTP rate is a typical example of the demand-supply interaction. The RTP structure offers consumers the incentive of reducing their electricity bill if they can shift their loads from high price to low price periods. The benefit to the end-user is
reduced utility operating costs (even with equal or slightly higher energy usage). The utilities benefit by being able to reduce their cost of electricity generation by stimulating stability in their aggregate demand of electricity through pricing signals.

Nonetheless, Gottlieb (2006) stated that refrigerated warehouse facilities operate in different fashions, depending upon whether they offer public or private refrigerated space. Public general storage facilities typically store food for clients at a stated unit rate. Private general storage facilities exist to facilitate an operator’s role- often that of a producer, processor or manufacturer of refrigerated food products. Semi-private facilities store an operator’s products in addition to offering storage space to outside clients. All facilities attempt to turn product over quickly, aiming for “just-in-time” delivery. Most refrigerated warehouse facilities have loading docks, and nearly all have interiors divided into cooler space and freezer space. Cooler space temperatures may range from 0 to 50 degrees Fahrenheit, while freezer space temperatures range from -5 degrees Fahrenheit to -30 degrees Fahrenheit. Among all operators, freezer space occupies 78 percent of total warehouse area; cooler space fills the remaining 22 percent. CEC (2007) mentioned that refrigerated warehouses have long been the target of energy efficiency programs run by the IOUs. These programs have generally targeted shell and refrigeration equipment specifications. Shell requirements address wall and ceiling U-values, interior wall U-values, floor U-values for frozen food warehouses, and door U-values. Refrigeration systems requirements address condenser sizing, condenser fan and pump power, condenser fan controls, compressor motor efficiency, compressor capacity control, evaporator sizing, evaporator fan control, and evaporator fan motor efficiency. Refrigerant piping and storage vessels, when located outside, have maximum U-value requirements. Lighting generally defaults to Title 24 requirements for warehouse and/or C&I work area categories. As part of this CASE Study, we carried out secondary research on refrigerated warehouse energy efficiency, conducted interviews with contractors and designers, and conducted detailed energy modeling and economic analysis on a series of potential measures that could be addressed within Title 24. Based on the results of these activities, we propose a set of changes to the Standards.

Pacific Gas and Electric Company (2007) carried out secondary research on refrigerated warehouse energy efficiency, conducted interviews with contractors and designers, and conducted detailed energy modeling and economic analysis on a series of potential measures that could be addressed within Title 24. Based on the results of these activities, we propose a set of changes to the Standards. The proposed changes to Title 24 affect the building shell insulation levels, evaporator fan controls, condenser fan power and control strategies, compressor plant controls and interior lighting levels for refrigerated warehouses. The equipment-related changes deal only with the storage part of the facility; standards for pre-coolers or other clearly process related equipment was not addressed. Whereas, Bledso (2009) proposed the action plan of cold chain and storage. Warehousing and cold storage are the central elements in the food harvest, preservation and distribution system and should not be considered in isolation, but rather as a part of a primary sector commonly referred to as the “Cold Chain.” Constraints in the cold storage and warehousing sector in Azerbaijan go beyond a basic lack of capacity. Where cold storage exists, they also include a knowledge gap in how to build, run, and maintain a storage facility. Preventative maintenance schedules are lacking and rudimentary activities such as daily recording of cold chamber temperatures and humidity controls also seem to be missing. There are also problems of management and marketing of existing warehouse and cold storage facilities, which are often empty due to mismanagement. Finally, the fruit and vegetable sector as a hole lacks fundamental expertise in regards to post harvest handling of their crops. Given the importance of cold storage to many of the fruit and vegetable value chains, this is a sector where PSCEP could have a major impact.

Agricultural Statistics Board (2010) General refrigerated storage capacity in the United States totaled 3.79 billion gross cubic feet on October 1, 2009, an increase of 14 percent since the previous survey was conducted two years ago. While most of the increase from the previous survey was due to increased survey coverage of existing warehouses, some was due to new construction. This was the 46th biennial survey of refrigerated warehouses. The five States with the largest gross general warehouse capacity (million cubic feet) were: California with 495; Florida, 274; Pennsylvania, 227; Georgia, 218; and Texas, 198. In 2011, California Utilities Statewide Codes and Standards Team proposed changes to the Mandatory Requirements for Refrigerated Warehouses, Section 126 of the 2008 California Building Energy Efficiency Standards (the 2008 Standards). Refrigerated warehouses are extremely energy intensive and are fertile ground for additional energy savings and demand reductions. While, Cole (2011) mentioned about two process freezing techniques - contact freezing and air blast freezing. Contact freezers typically have lower operating costs, particularly from the standpoint of the amount of refrigeration required to accomplish the freezing and the cost of the associated energy required to do the freezing. This consideration will define the need for ice production and handling, special cutting, portioning, or other processing and/or cooking machinery. However, Jim Thompson (2011) mentioned that energy use in a cold storage facility is affected by the amount of heat the refrigeration equipment must remove and the efficiency of the equipment. The main sources of heat in a facility for long-term storage are transmission through walls, evaporator coil fans, lights, air leakage, and respiration of the stored commodity. Refrigeration system design has a great effect on energy use. The temperature of the refrigerant fluid after it is cooled in the condenser should be as low as
possible. For example, a facility maintaining 32°F (0°C) and a condensing temperature of 125°F (52°C) requires 50 percent more power than one that operates at a condensing temperature of 95°F (35°C).

McMullan (2011) detailed the procedures of non-destructive infrared evaluation on two commercial refrigeration facilities and report the findings of these inspections. The use of non-destructive testing methods to examine the thermal envelope of low and medium temperature refrigerated facilities is the subject of this paper. Commercial refrigeration is similar to the refrigeration that occurs in your household refrigerator. Simply, it is the process of removing heat from an area and transferring that heat to a place where it makes little or no difference. Furthermore, the use of non-destructive infrared imaging of the refrigerated box provides an invaluable dialogistic tool. The presence of any type of breach in the box can create havoc with the refrigeration system. As the system works to remove latent and sensible heat from the cooler, the uncontrolled addition of ambient air can cause a number of problems including additional energy consumption, product loss and thermal envelope damage. Besides, Pineda and Diaz (2011) proposed that liquid-desiccant systems have been extensively studied as a way of reducing the latent load on air conditioning systems. Most of the studies have targeted the removal of moisture from air at ambient conditions. The literature about the use of liquid desiccants in low temperature applications is scarce. In this study, a small-scale liquid-desiccant absorber is installed inside a commercial refrigerated warehouse. Its performance under realistic operating conditions inside a pre-cooling room is analyzed. The results show that the dew point temperature of the air downstream of the absorber is comparable to the evaporator surface temperature suggesting the potential to delay the formation of ice on the cooling coil. An internal heat exchanger is used to lower the temperature of the inlet liquid desiccant flow to the absorber and the regeneration process is performed using only ambient air. The analysis of the reduction in water and energy consumption for a scale dup system is also performed. Nonetheless, Reindl and Mitchell (2011) investigated the possibility to utilize product stored in a refrigerated warehouse as a thermal energy storage media to minimize energy costs under real-time pricing rate structures. Demand shifting, i.e. precooling the warehouse during hours of low electricity prices to a lower temperature and shutting down the refrigeration equipment during high price hours, can yield operating cost savings. The increase in product temperature during equipment shutdown limits the possible floating duration. A computer model of a representative refrigerated warehouse was developed. The model includes the building envelope, the refrigeration systems and a model of the stored product. A thermally massive and a lightweight wall construction were investigated.

LEAN WAREHOUSE

Definitions

The underlying theme of “lean” thinking is to produce more or do more with fewer resources and less waste. Lean manufacturing is a recognized discipline — but the concept is just beginning to take hold in the distribution center. For applying lean concepts in warehousing, it can be applied to the distribution center to cut waste, improve productivity, increase space utilization and meet increasing customer demands. Lean principles can be applied key warehousing functions such as receiving, put-away/storing, replenishment, picking, packing and shipping. Each section concludes with a list of action items which guides the reader from theory to practical steps that can be implemented in the warehouse. It’s a practical approach that will help any warehouses reduce the waste from the operations.

Previous Research on Lean Warehouse

Wanitwattanakosol and Sopadang (2010) proposed a conceptual framework to apply many techniques for implementing lean in the high-variety low-volume (HVLV) environment is presented. Lean production has increasingly being implemented as a potential solution for many organizations. Anyway, the lean formula is applicable directly only to the make-to-stock business, but the make-to-order (MTO) product environment has to adapt lean manufacturing principle. The objective of this paper is to develop a suitable lean manufacturing system for SMEs. This modeling framework is also used to study the performance of the system for improving effectiveness. This paper addresses how to combine lean concept with simulation optimization, the step of this framework to obtain the optimization solution. On the other hand, Womack and Jones (2003) stated that achieving lean warehousing requires a certain mind set. A can-do attitude is the starting point. If you and your staff don’t believe that “the perfect order” is attainable, normal error rates will persist. Lean thinking will require a conversion from top-down leadership to bottom-up initiatives. In a lean operation, every worker is an inspector, and everyone is expected to help the company achieve continuous improvement. Lean thinking will not occur in a hierarchical environment. Managers must become coaches rather than tyrants. Employees must be rewarded for being proactive.
According to logistics’ viewpoint, Zylstra (2005) conducted a study applying lean concepts to distribution and logistics. The challenges facing Profit-Chain Company were higher total logistics costs subject to financial budget pressures. There are a number of barriers to improve distribution and logistics operations such as freight cost or reliability, customer requirements, forecast accuracy, labor costs, quality, or planning processes that needed to be solved. The results indicated that forecasts are only accurate in the aggregate and over longer periods of time, re-planning as forecasts change takes time and effort, re-planning tends to induce snowball effect, customer service policies are not well documented or formalized, minimizing transportation in isolation can be a faulty objective, and high inventories may not equal responsiveness. Sezen and Erdogan (2009) conducted a study aimed at introducing the lean philosophy in the strategic supply chain management and its process. The lean tools are used to reduce wasteful activities across the supply chain. The approach of lean brings the enterprises a value stream, which is called a business model. To reach high quality and customer satisfaction; the whole supply chain and each every chain implements the lean principles to have a competitive advantage and to reduce costs. So, the lean production can give the lower costs through eliminating waste.

Garcia (2007) conducted a case study of the ongoing application of pork producer by investigating lean concepts in normal warehouse operation. He assessed the operation using a value stream mapping (VSM) and product families and warehouse data, and identified lean improvements and continuous improvements. The result indicated that by proposing the future state using VSM, it was needed to expand warehouse to provide staging areas, most pallets are staged on floor, revise order picking methods, upgrade robotic palletizing systems, schedule and plan improved production, and increase turns of new markets for frozen products. Similarly, Calderone (2008) mentioned that a recent study involving a large HME supplier revealed that their overall order processing cycle time was grossly inefficient. Orders were being worked on less than 40 percent of the time within the total cycle time. Nearly nine percent of the total cycle time was spent on wasteful activities such as removing items from blocked aisles, waiting for a lift truck, searching for products, dealing with backorders, or staff having to deal with interruptions not directly related to picking and shipping. Many orders sat waiting or idle nearly 50 percent of the total cycle time. Sobanski (2009) conducted the research undertaken to fill a gap in the academic literature and in practice by developing a comprehensive lean implementation assessment tool for warehousing operations implementing lean manufacturing principles and techniques. The lean implementation assessment tool developed provides specific, actionable items that can be used in practice to further implement lean production and provide useful information to monitor the initiative’s progress and make better resource decisions. Furthermore, the results from the application of the lean implementation assessment tool are analyzed to better understand the practical implementation and underlying factors of lean warehousing. Consequently, the research outcomes are two-fold, both filling the gap in the development of a comprehensive warehousing lean implementation assessment tool and providing insight into the actual implementation of lean warehousing.

In 2011, Dharmapriya and Kulatunga mentioned that according to Lean thinking it can be decided that the efficiency of warehouse operations depends on the layout arrangement, material handling techniques and media of transportation. Therefore, this study attempts to optimize warehouse layout: by allocating an economical place to each type of item while minimizing the honeycombing. However, due to the computational complexity of finding an optimal allocation within reasonable time frame, this is mathematically termed as NP-hard type problems. It has been found in the literature that the heuristic approaches are highly attractive than the traditional approaches for this instances. The Simulated Annealing heuristic was used to determine the optimal allocation of each category once the initial solution is generated by greedy approach. Generating a shortest route to collect all the items of a respective order is also an objective of this study. The route was decided based on the item’s rank in the delivery route, distance in between two consecutive types of items and the weight. The improved layout was tested on several case studies and simulation results show that improved layout is beneficial in terms of travel distance (reduced by 30%) and resource utilization. Whereas, Fledderjohann (2011) stated that with a modernization project going on upstream from the warehouse, it was clear the Goodyear plant would require more than a retrofit for the current manual processes used for tire distribution. With the high number of SKUs, manual sorting capabilities had reached capacity, and Goodyear wanted to protect its workforce from the risk of injuries. It was also essential to have a Supply Chain Deployment strategy that offered real advantages to customers. It was also mentioned that in today’s lean manufacturing and warehousing environment, it’s a competitive advantage to have automation that can sort, temporarily stage, then ship tires directly to customers on demand. It not only reduces labor costs, it also keeps inventory levels low and customer response high.

In the same year, Martichenko and Luery stated that the lean thinker believes in standard work as it produces the baseline from which we will improve. Visibility of material flow, inbound logistics, internal warehouse flow, and outbound logistics are critical to the lean warehouse. It is needed to understand the flow of material and be able to determine if we are supporting the “perfect order”; the right quantity, at the right place, at the right time in the right quality. The lean concept of “visual management” allows us to understand the score of the game (operation) so we can make decisions in real time that impact the overall flow of material to the customer. This is counter intuitive to many warehousing operations where the operation simply reacts to what trucks (or orders) show up at the facility on any given day. While, Venkateswaran et al (2011) conducted the research that implements, documents and evaluates the impact of
implementing a hybrid 5S strategy versus two traditional 5S on hospital warehouses’ operations by using Hybrid 5S that is an integration of inventory management techniques and process improvement tools. The results indicated that Hybrid 5S had the greatest impact compared to the traditional methods. Further measurement is required to maintain a steady increase in inventory turnover. Employee training and top-management involvement needs to be exercised in order to sustain the improvements for long term.

**TABLE 1**

**SUMMARY OF RESEARCH PAPERS ON LEAN IN WAREHOUSE/DISTRIBUTION/LOGISTICS**

<table>
<thead>
<tr>
<th>Researcher</th>
<th>Theme and Description</th>
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<tbody>
<tr>
<td><strong>Lean Manufacturing</strong></td>
<td></td>
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<tr>
<td>Ohno (1988)</td>
<td>A concept of Toyota Production System (TPS) Beyond Large-Scale Production and Lean production</td>
</tr>
<tr>
<td>Krafcik (1988)</td>
<td>Lean principles come from the Japanese manufacturing industry in the article, &quot;Triumph of the Lean Production System&quot;</td>
</tr>
<tr>
<td>Womack (1990)</td>
<td>Lean production in automotive industry. Lean initiatives focused on examining existing manufacturing processes</td>
</tr>
<tr>
<td>Zylstra (2005)</td>
<td>Lean concepts to distribution and logistics. Its aims at improving distribution and logistics operations such as freight cost or reliability, customer requirements, forecast accuracy, labor costs, quality, or planning processes</td>
</tr>
<tr>
<td>Sriariyawat and Zunder (2007)</td>
<td>Lean production to supply chain. The study is conducted to investigate the impacts of Lean production from Delphi expert panel from different regions</td>
</tr>
<tr>
<td>Pettersen (2009)</td>
<td>Lean production with conceptual and practical issues. He reviewed the literature to delineate what is Lean finds little evidence that the removal of waste is central to Lean yet Taichi Ohno</td>
</tr>
<tr>
<td>Sezen and Erdogan (2009)</td>
<td>Lean philosophy in strategic supply chain management and value creating. The approach of lean brings the enterprises a value stream, which is called a business model</td>
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<tr>
<td>Wanitwattanakosol and Sopadang (2010)</td>
<td>Lean in the high-variety low-volume (HVLV) environment. The objective of this paper is to develop a suitable lean manufacturing system for SMEs</td>
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<td><strong>General and Refrigerated Warehouse</strong></td>
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<td>Duiven and Binard (2002)</td>
<td>Cold stores or refrigerated warehouses that are facilities where perishable foodstuffs are handled and stored under controlled temperatures with the aim of maintaining quality</td>
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<tr>
<td>Nitin Magoo (2003)</td>
<td>Refrigerated warehouses play an important link in the storage of food products and serve as an indispensable link in maintaining the availability of otherwise seasonal food products all year round</td>
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<tr>
<td>Gottlieb (2006)</td>
<td>Refrigerated warehouse facilities that operate in different fashions, depending upon whether they offer public or private refrigerated space</td>
</tr>
<tr>
<td>CEC (2007)</td>
<td>Refrigerated warehouses with energy efficiency programs run</td>
</tr>
<tr>
<td>Pacific Gas and Electric Company (2007)</td>
<td>Secondary research on refrigerated warehouse energy efficiency, conducted interviews with contractors and designers, and conducted detailed energy modeling and economic analysis on a series of potential measures that could be addressed within Title 24</td>
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<tr>
<td>Bledso (2009)</td>
<td>Warehousing and cold storage are the central elements in the food harvest, preservation and distribution system and should not be considered in isolation, but rather as a part of a primary sector commonly referred to as the “Cold Chain”</td>
</tr>
<tr>
<td>Agricultural Statistics Board (2010)</td>
<td>General refrigerated storage capacity in the United States totaled</td>
</tr>
<tr>
<td>California Utilities Statewide Codes and Standards Team (2011)</td>
<td>The proposed changes to the Mandatory Requirements for Refrigerated Warehouses</td>
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<tr>
<td>Author</td>
<td>Title</td>
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<td>------------------------</td>
<td>----------------------------------------------------------------------</td>
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<tr>
<td>Cole (2011)</td>
<td>Two process freezing techniques - contact freezing and air blast freezing</td>
</tr>
<tr>
<td>Dharmapriya and Kulatunga (2011)</td>
<td>Investigating new strategy for warehouse optimization by the use of lean warehousing. They studied the efficiency of warehouse operations that depends on the layout arrangement, material handling techniques and media of transportation</td>
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<td>Jim Thompson (2011)</td>
<td>Energy use in a cold storage facility is affected by the amount of heat the refrigeration equipment</td>
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<tr>
<td>McMullan (2011)</td>
<td>The procedures of non-destructive infrared evaluation on two commercial refrigeration facilities and report the findings of these inspections with the use of non-destructive testing methods and non-destructive infrared imaging of the refrigerated box</td>
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<tr>
<td>Reindl and Mitchell (2011)</td>
<td>Investigating the possibility to utilize product stored in a refrigerated warehouse as a thermal energy storage media to minimize energy costs under real-time pricing rate structures</td>
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<td><strong>Lean Warehouse</strong></td>
<td></td>
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<tr>
<td>Womack and Jones (2003)</td>
<td>Lean thinking in the warehouse and existing manufacturing processes. In a lean operation, it is expected to help in achieving continuous improvement</td>
</tr>
<tr>
<td>Garcia (2004)</td>
<td>Showing how a warehouse operation can be improved using lean concepts and techniques. Warehouse improvement requires optimizing material flow, order picking, replenishment, and dock operations. Although many traditional lean techniques maybe difficult to apply, the concepts of improving material flow and eliminating waste can be used to make significant improvement in warehouse lead time.</td>
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<td>Calderone (2008)</td>
<td>Involving a large HME supplier that revealed the overall order processing cycle time was grossly inefficient and wasteful activities of handling materials equipment</td>
</tr>
<tr>
<td>Sobanski (2009)</td>
<td>Developing a comprehensive lean implementation assessment tool for warehousing operations implementing lean manufacturing principles and techniques</td>
</tr>
<tr>
<td>Martichenko and Luery (2011)</td>
<td>Visibility of material flow, inbound logistics, internal warehouse flow, and outbound logistics are critical to the lean warehouse</td>
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<td>Venkateswaran et al (2011)</td>
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</table>

**CONCLUSION**

The literature review presented here identifies detailed information of lean manufacturing, general warehouse and refrigerated warehouse, and applying lean concepts in warehouses that can be used for developing a proposed model of lean in warehouse operation. Nonetheless, this study also proposes lean tool development and regression model formulation in the warehouses operation in a later stage. It is hypothesized that creating a lean warehouse operation may understand cycle time and identify non-value added activities that are important requirements in order to identify lean improvement opportunities. Implementing lean tools and concepts into warehouse operations has produced impressive results in many different industries. Logistics service providers can have benefits by gradually transforming existing operations through the application of lean tools and concepts. Formulating the multiple regression model of the lean warehouses operation may identify what type of parameters can have a direct impact of the non-value added and necessary non-value added activities.
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HOW VENDOR-MANAGED INVENTORY AFFECTS THE SUPPLY CHAIN?

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HOW VENDOR-MANAGED INVENTORY AFFECTS THE SUPPLY CHAIN?

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ABSTRACT

This paper focuses on the single-vendor-single-retailer supply chain under a vendor-managed inventory (VMI) policy. We propose mathematical models after discussing the inventory and replenishment patterns. We evaluate how VMI affects the supply chain by investigating the optimal decisions include supply chain costs, order quantities and replenishment frequencies before and after implementing VMI. The analysis yields several key insights. A numerical study is also performed to illustrate the analysis.

KEYWORDS
Supply Chain Integration, Vendor-Managed Inventory, Information Sharing

INTRODUCTION

Vendor-managed inventory (VMI) is a kind of cooperative mechanism whereby a vendor is authorized to manage the inventory for a retailer using advanced online messaging and data-retrieval system. Reviewing the retailer’s inventory levels, the vendor makes decisions regarding the quantity and timing of replenishment. The VMI model as an extension of the classic economic order quantity model has been widely studied. In this problem, the vendor makes decisions of the system’s inventory and delivery to get a better integration of the channel. Our goal aims to find the optimal order quantity and frequency so as to minimize the supply chain total costs, and make a further understanding by implementing VMI.

Recently, implementing VMI becomes easier with the development of information technique. The successful instance in using VMI includes Wal-Mart, P&G, Lucent Technologies, Dell and HP (Buzzell et al., 1995). VMI plays a positive role in information sharing (Cetinkaya et al., 2000; Chen et al., 2000), and it may alleviate the bullwhip effect and improve customer service. Dong et al. (2002) show that VMI always leads to a higher profit for the retailer, but the supplier’s profit varies. While reducing the total inventory cost, VMI decreases the order quantity for the retailer but increases the replenishment frequency (e.g., Achabal et al., 2000; Yao et al., 2007).

Relatively, few studies get a different conclusion about the optimal decisions under VMI. For example, Vilist et al. (2008) shows that the vendor will replenish more quantity and less frequency for the buyer after implementing VMI.
Some authors have studied integrated inventory strategies for vendor-retailer systems (e.g., Woo et al., 2001; Li et al., 2010). The replenishment policy in Yao et al. (2007) is not optimal which means there is a higher average inventory level at the vendor. Vilist et al. (2008) give a comment on their replenishment policy but based on some special assumptions. Moreover, they only applied an optimal replenishment policy in the situation with VMI, but ignored it without VMI.

Therefore, this study proposes a vendor-retailer supply chain integration strategy to show how VMI affects the supply chain. Our main findings suggest that VMI has significant impacts on the cost savings and optimal order decisions. Specifically, our results indicate that the optimal replenishment quantity increases, but the optimal replenishment frequency decreases after implementing VMI.

**PROBLEM DEFINITION AND REPLENISHMENT PATTERNS**

**Assumptions**

The mathematical model in this paper is developed on the basis of the following assumptions:
- The planning horizon is infinite.
- The considered supply chain with single item consists of a single vendor and a single retailer.
- The demand rate is constant and deterministic.
- Deliveries of orders are assumed to be instantaneous, i.e., the lead time is negligible.
- Shortages are not allowed for both the vendor and the retailer.

**Notation**

1) *Parameters*
   - $D$: Demand per year.
   - $C$: Vendor’s fixed order cost.
   - $c$: Retailer’s fixed order cost.
   - $K$: Vendor’s fixed cost of processing retailer’s order.
   - $H$: Vendor’s inventory holding cost per unit per year.
   - $h$: Retailer’s inventory holding cost per unit per year.
   - $f$: Fixed delivery cost from the vendor to the retailer.
   - $v$: Variable delivery cost from the vendor to the retailer.

2) *Decision variables*
   - $q$: Retailer’s order quantity or replenishment quantity from the vendor to the retailer.
   - $n$: Replenishment frequency.

**Discussion of the inventory and replenishment patterns**

Yao et al. (2007) present a vendor managed inventory strategy to explore the effects of collaborative supply-chain initiatives. From Fig. 1, we can see after implementing VMI, the vendor orders a quantity $nq$ while a quantity $q$ still keeps as the retailer’s inventory. Therefore, the vendor’s average inventory, $(n + 1)q/2$, is not optimal.

**FIGURE 1**

THE INVENTORY AND REPLENISHMENT PATTERNS OF YAO ET AL.
About the vendor’s replenishment policy, Vilist et al. (2008) gives an optimal replenishment policy under VMI: when the retailer’s inventory is reduced to zero, the vendor will place an order \( nq \), and deliver a shipment \( q \) to the retailer, instantaneously. The vendor’s average inventory level with VMI is \((n-1)q/2\). However, their model is not optimal before implementing VMI.

Fig. 2 shows the vendor’s inventory pattern before implementing VMI in Vilist et al. (2008): when the retailer’s inventory is reduced to zero, the vendor does place an order \( nq \), but does not deliver a shipment \( q \) to the retailer, instantaneously. Therefore, the vendor’s average inventory level before implementing VMI is \(nq/2\). This made the two models with VMI and without VMI lose comparability (Wang et al., 2010).

**FIGURE 2**

**VLIST ET AL. ’S THE INVENTORY AND REPLENISHMENT PATTERNS BEFORE IMPLEMENTING VMI**

The optimal models

This paper proposes an optimal replenishment policy. Its replenishment and inventory patterns are shown in Fig. 3.

**FIGURE 3**

**THE INVENTORY AND REPLENISHMENT PATTERNS IN THIS STUDY**

In this study, the vendor’s average inventory levels both before and after implementing VMI are \((n-1)q/2\), and both the retailer’s average inventory levels are equal to \(q/2\).

The annual inventory total cost at the retailer which consists of the ordering, inventory holding, and delivery costs, can be expressed as

\[
TC_r = \frac{2}{q} h + \frac{D}{q} c + \frac{D}{q} f + vq \]

For the vendor, the annual inventory total cost can be written as

\[
TC_v = \frac{(n-1)}{2} qH + \frac{D}{nq} C + \frac{D}{q} K
\]

Therefore, the system’s annual inventory cost can be calculated by

\[
TC_s = \frac{(n-1)}{2} qH + \frac{D}{nq} C + \frac{D}{q} K + \frac{q}{2} h + \frac{D}{q} c + \frac{D}{q} f + vq + q
\]
MODEL WITHOUT VMI

Retailer’s ordering decision

Taking the first derivative of (1) with regard to \( q \), we get the optimal order quantity without VMI from the vendor to the retailer,

\[
q^*_{\text{no VMI}} = \sqrt{\frac{2(c+f)D}{h}}.
\]

(4)

Furthermore, the optimal annual inventory cost without VMI at the retailer is

\[
TC^*_{\text{no VMI}} = \sqrt{2D(c+f)K} + \frac{\sqrt{2}}{8}.
\]

Vendor’s ordering decision

Before implementing VMI, the vendor determines his own order quantity \( q^*_{\text{no VMI}} \) according to the retailer’s optimal order quantity, \( q^*_{\text{no VMI}} \). We can rewrite (2) as

\[
TC_{\text{no VMI}}(n) = \left( \frac{n-1}{2} q^*_{\text{no VMI}} \right) H + \frac{D}{n q^*_{\text{no VMI}}} C + \frac{D}{q^*_{\text{no VMI}}} K.
\]

Then, we can compute the optimal replenishment frequency. First, we treat the replenishment frequency \( n \) as a continuous variable. Taking the first derivative of (6) with respect to \( n \), the optimal replenishment frequency is

\[
\hat{n}_{\text{no VMI}} = \frac{Ch}{H(c+f)}.
\]

(7)

Taking the second derivative of (6) with respect to replenishment frequency \( n \), we obtain \( \frac{\partial^2 TC_{\text{no VMI}}}{\partial n^2} > 0 \). \( TC_{\text{no VMI}}(n) \) is a convex function of replenishment frequency \( n \). Thus, the vendor’s optimal annual inventory cost without VMI, which is minimized at \( n^*_{\text{no VMI}} \), can be calculated by

\[
TC^*_{\text{no VMI}} = \sqrt{2CDH} \left( \frac{Ch}{H(c+f)} \right) \cdot \left( \frac{2Dh}{2(c+f)} \right) \cdot \frac{2Dh}{2(c+f)^2}.
\]

However, in practice, the replenishment frequency \( n \) is usually an integer. In the following, we explore situation when the replenishment frequency \( n \) is an integer. Using the double-inequality approach, we can determine the optimal replenishment frequency’s integer-value \( \hat{n}^*_{\text{no VMI}} \) that satisfies

\[
\hat{n}^*_{\text{no VMI}} \left( \hat{n}^*_{\text{no VMI}} - 1 \right) < \left( CH \right) / \left( H(c+f) \right) \leq \hat{n}^*_{\text{no VMI}} \left( \hat{n}^*_{\text{no VMI}} + 1 \right).
\]

Defining \( \left\lfloor x \right\rfloor \) as the largest integer \( \leq x \), a closed form expression for optimal replenishment frequency \( \hat{n}^*_{\text{no VMI}} \) can be obtained as follows:

\[
\hat{n}^*_{\text{no VMI}} = \left\lfloor 1 + \sqrt{1 + \frac{4Ch}{H(c+f)}} \right\rfloor \cdot \frac{1}{2}.
\]

(9)

The system’s annual inventory cost

The system’s optimal annual inventory cost before implementing VMI can be computed by
\[ T_{C_{r, no-VMI}}^* = T_{C_{r, no-VMI}}^* + T_{C_{r, no-VMI}}^* = \sqrt{2CD} \left( \frac{H}{2} \sqrt{\frac{2(c+f)D}{h}} + K \right) + \sqrt{2D}\left(\frac{c+f}{h}\right)^{\frac{1}{2}} \]

**MODEL WITH VMI**

Under VMI, the vendor determines the optimal replenishment quantity and frequency based on actual sales of the retailer to minimize the integrated system’s cost.

The system’s annual inventory cost structure is given by (3). Rewriting (3), we get

\[ TC_{r,VMI}(n,q) = \frac{(a-1)q}{2} H + \frac{D}{mq} C + \frac{D}{q} K + \frac{q}{2} h + \frac{D}{q} c + f + vlq \]

Taking the first derivative of (11) with respect to \( q \) and \( n \), the vendor’s optimal replenishment quantity and frequency after implementing VMI are, respectively,

\[ q_{VMI}^* = \sqrt{\frac{2D(K+c+f)}{h-H}} \]

\[ n_{VMI}^* = \sqrt{\frac{C(h-H)}{H(K+c+f)}} \]

**Proposition 1.** The function of the system’s annual inventory cost \( TC_{r,VMI}(n,q) \) is a convex function.

**Proof.** Taking the second derivative of (11) with regard to \( q \) and \( n \), respectively, we have

\[ \frac{\partial^2 TC_{r,VMI}(n,q)}{\partial q^2} = \frac{D}{q^2} \left( \frac{C}{n} + K + c + f \right) > 0, \]

\[ \frac{\partial^2 TC_{r,VMI}(n,q)}{\partial n^2} = \frac{DC}{qin} > 0. \]

We can see \( TC_{r,VMI}(n,q) \) is a convex function of replenishment quantity \( q \) and replenishment frequency \( n \). Thus, the system’s annual inventory cost is minimized at \( q_{VMI}^* \) and \( n_{VMI}^* \).

Substituting the above equations (12)(13) into (11), we obtain the system’s optimal annual inventory cost with VMI:

\[ TC_{r,VMI} = \sqrt{2D} \left( \frac{CH}{\sqrt{\frac{2D}{h}} + \sqrt{\frac{2D}{h}}} \right) + vD \]

Similarly, we can use the double-inequality approach to determine the optimal replenishment frequency’s integer-valued \( \hat{n}_{VMI} \) that satisfies

\[ \hat{n}_{VMI} \left( \hat{n}_{VMI} - 1 \right) \leq \left( H \left( K+c+f \right) \right) \leq \hat{n}_{VMI} \left( \hat{n}_{VMI} + 1 \right) \]

A closed form expression for the optimal replenishment frequency \( \hat{n}_{VMI} \) can be obtained as follows:

\[ \hat{n}_{VMI} = \left[ \left( 1 + \sqrt{1 + \left( 4C(h-H)/(H(K+c+f)) \right) / 2 } \right) \right] - \left( \sqrt{2D} \left( CH - \sqrt{\frac{2D}{h}} \right) \right) \]
COMPARISON OF THE OPTIMAL POLICIES

We now demonstrate the system’s optimal annual inventory cost savings from VMI, and the changes of optimal replenishment decisions after implementing VMI.

**Proposition 2. VMI decreases the system’s optimal annual inventory cost.**

**Proof.** From (10) and (14), we have

\[
TC_{\text{no-VMI}} - TC'_{\text{VMI}} = \left( \sqrt{2CDH} \cdot \frac{H}{h} + \frac{2DCc}{c} \right) - \left( \sqrt{2DCcH} - \sqrt{2DChc} \right)
\]

Proposition 2 provides an analytical result that supports the conventional wisdom with respect to VMI, i.e., implementing VMI can reduce the system’s inventory cost.

**Proposition 3. VMI increases the optimal replenishment quantity.**

**Proof.** By (4) and (12), we have

\[
\frac{q_{\text{no-VMI}}}{q'_{\text{VMI}}} < 1
\]

**Proposition 4. VMI decreases the optimal replenishment frequency.**

**Proof.** Compare (7) and (13), we obtain

\[
\frac{n_{\text{no-VMI}}}{n'_{\text{VMI}}} > 0
\]

Proposition 3 and Proposition 4 indicate the optimal replenishment quantity tends to be higher, but the optimal replenishment frequency decreases after the implementation of VMI.

**NUMERICAL STUDY**

The benchmark data are obtained from (Woo et al., 2001). The base values of parameters are given as: \(D=1000, C=200, K=5, H=2, c=10, h=4, f=20, v=0.1\).

First, we consider the situation without VMI. In this case, \(q'_{\text{no-VMI}} = 70.42, n'_{\text{no-VMI}} = 3\). The system’s optimal inventory cost is \(TC_{\text{no-VMI}} = 1263.37\). Next, we consider the situation with VMI. In this case, \(q'_{VMI} = 132.12, n'_{VMI} = 2\). The system’s optimal inventory cost is \(TC'_{VMI} = 1121.53\). It is easy to see that the optimal replenishment quantity increased but frequency decreased after implementing VMI. The system’s optimal annual inventory cost is lowered from 1263.37 to 1121.53.

The change can be calculated by \(\Delta q' = q'_{\text{no-VMI}} - q'_{\text{VMI}}\), \(\Delta n' = n'_{\text{no-VMI}} - n'_{\text{VMI}}\), and \(\Delta TC' = TC'_{\text{no-VMI}} - TC'_{\text{VMI}}\). The results from a full factorial experiment using low and high values for some factors considered is summarized in Table 1.

From Table 1, we can see that after implementing VMI, the system’s annual inventory cost decreases (\(\Delta TC' < 0\)). The optimal replenishment quantity increases (\(\Delta q' > 0\)), and the optimal replenishment frequency decreases (\(\Delta n' > 0\)). These are consistent with the propositions shown above. The changes of optimal replenishment quantity \(\Delta q'\) and system’s annual inventory cost \(\Delta TC'\) increase with parameters \(K, c\) and \(f\), additionally, the changes of \(\Delta q'\) and \(\Delta TC'\) are much less sensitive to the vendor’s order cost \(C\).
TABLE 1
SENSITIVITY ANALYSIS OF SOME PARAMETERS

<table>
<thead>
<tr>
<th>Parameters</th>
<th>$K$</th>
<th>$C$</th>
<th>$c$</th>
<th>$H$</th>
</tr>
</thead>
<tbody>
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<td></td>
<td>1</td>
<td>100</td>
<td>300</td>
<td>2</td>
</tr>
<tr>
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<td>-1</td>
<td>-1</td>
<td>-2</td>
</tr>
<tr>
<td>$\Delta q^*$</td>
<td>53</td>
<td>70</td>
<td>61</td>
<td>61</td>
</tr>
<tr>
<td>$\Delta C^*$</td>
<td>-41</td>
<td>-66</td>
<td>-54</td>
<td>-54</td>
</tr>
</tbody>
</table>

CONCLUSIONS

In this study, we have proposed mathematical models to explore how VMI benefits the vendor-retailer system. We compared the supply chain models before and after implementing VMI in terms of replenishment frequency, quantity and the total inventory cost. Our findings indicate that the VMI strategy increases the retailer’s replenishment quantity, but decreases its replenishment frequency. Our results also reveal that a VMI program will be effective in reducing the system’s inventory cost.

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THE IMPACT OF VMI ON BUSINESS PROCESSES OF THE SUPPLY SIDE

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ABSTRACT

Increasing competition and rising customer needs require companies to coordinate business processes with supply chain partners. Existing supply chain concepts like Vendor Managed Inventory (VMI) can lead to a number of benefits like reduced inventory or transaction costs. However, studies showed that the adoption rate of VMI in practice (especially amongst SMEs) is low. One reason for this is the difficulty companies have to estimate the effects of VMI on their business processes in advance. They do not know which process modifications are required, how to implement VMI and how to measure the outcome. To close this gap we developed a process reference model to support planning and implementing VMI. We did this by conducting a multi-staged approach. In a literature review we identified common VMI implementations and best practices. Additionally, an empirical study was realized based on half-standardized questionnaires and interviews with experts and companies. Since the results showed that a lot of business processes are sourced out from the customer to the supplier, this paper focuses on pointing out the required process changes due to VMI. The research resulted in an extended process reference model called LogWIN-P_VMI which includes the whole VMI process from the supplier’s point of view. LogWIN-P_VMI provides best practice processes and points out affected processes by VMI and required processes modifications on the supply side. Therefore it supports estimating the effects of VMI by pointing out necessary internal and external business process adaptations.

KEYWORDS
Vendor Managed Inventory, Business Process, Process Reference Model, Supply Chain Concept, Supply Chain Management

INTRODUCTION

Due to the increasing individualization of products and services on the market and based on the principle of the division of labor Supply Chains are confronted with a higher complexity in planning and controlling material and information flows. To manage this complexity companies collaborate with partners of the supply chain. An effective supply chain concept to plan and coordinate material and information flows is Vendor Managed Inventory (Wildemann, 2005). VMI is a concept where “the supplier, usually the manufacturer but sometimes a reseller or distributor, makes the main inventory replenishment decisions for the consuming organization” (Waller et al., 1999). He therefore has “the obligation to maintain the retail stores they serve with sufficient inventory levels” (Xu et al., 2007).

As the focus of this paper lies on the affected processes on the supply side, the impacts of VMI are described from the supplier’s point of view, who can achieve benefits like (Bowon et al., 2010):

- Increase of sales
- Reduced transportation and transaction costs
- Increase of profit
- Better internal and external planning
- More flexibility

Although the associated benefits of VMI sound promising, a study showed that the adoption rate of VMI is low. (Humpl et al., 2009). However, to plan and implement VMI successfully, processes and organizational structures are required to be modified and companies have difficulties estimating the effects of implementing VMI in advance. Therefore, using process reference models can be recommended to support companies in adapting business processes and organizational
structures. A process reference model is a best practice framework which is based on practical and theoretical knowledge about business processes (Reitner, 2010; Schulte, 2009).

To provide companies a framework for estimating the effects of VMI on business processes the process reference model LogWIN-P_VMI was developed. It is based on the existing reference model LogWIN-P. This intersectional model is applicable for any industrial company and contains six main processes (Order Management, Planning, Procurement, Production, Distribution, Research & Development) with four levels of detail each. We chose LogWIN-P, because of its higher level of detail compared to other models (e.g. SCOR) (Ortner et al., 2005).

METHODOLOGY

To develop the extended process reference model LogWIN-P_VMI a two-staged approach was chosen. In the first stage a comprehensive literature review concerning the topics Vendor Managed Inventory and Process Reference Models was done. We used digital data bases (e.g. Emerald Management Xtra) and bibliographies and chose a total of 26 papers by the titles using these two terms to identify common VMI implementations and best practices. In a second step an empirical study was conducted. Therefore a half-standardized questionnaire was set up to evaluate the practical relevance of VMI. Five VMI experts and eight companies using VMI were interviewed. The results gave an overview of VMI variations in different industries and showed the relevance and appliance of VMI in enterprises.

IMPACTS OF VENDOR MANAGED INVENTORY

Primarily, impacts of VMI concern business processes and are shown as a comparison of conventional activities and activities due to VMI based on LogWIN-P. Therefore, implementing VMI requires modifications of business processes of all partners, which results in new, affected or not affected processes by VMI. Firstly, processes affected by VMI are e.g. processes from the buyer’s (procurement processes) and supplier’s (distribution processes) point of view, i.e. the processes Management of Materials, Order, Production, Transportation, Receipt of Goods, Storage, Payment and Removal of Goods (Figure 1). This paper focuses on the affected processes of the supply side, i.e. the distribution processes (from management of materials to payment) (Figure 1). Obviously, the supplier carries out more activities within the whole VMI process and the overall effort seems higher. However, this process relocation can lead to other benefits for the supplier (see Introduction).

FIGURE 1

COMPARISON OF CONVENTIONAL PROCESS AND PROCESS WITH VMI

The whole distribution process due to VMI is shown in Figure 2, which points out significantly affected (bold) and new processes (italicised) of LogWIN-P_VMI.
In the extended process reference model LogWIN-P_VMI the process “Transportation Distribution” is affected significantly by VMI. The processes “Invoice Processing and Settlement with VMI at Buyer”, “Inventory Management of Supplier” and “Preparation for Cooperation with VMI Buyer” are new and were added as they do not exist in the conventional model LogWIN-P. The following section compares the conventional process and the processes with VMI by describing affected and new processes of LogWIN-P_VMI on the highest level of detail of the process model (fourth level).

**Transportation Distribution**

Implementing VMI the supplier is responsible for managing the buyer’s inventory. The process starts with the removal of goods in the buyer’s warehouse which influences the inventory management of the supplier. After reaching a pre-defined level of inventory the supplier plans the replenishment of the buyer’s warehouse and transfers a confirmation of order to the VMI-buyer. In contrary to the conventional process of LogWIN-P the buyer orders the goods and the supplier confirms the order within the order processing activities (Figure 3).

Furthermore, transportation of goods to the VMI-Buyer is carried out by the supplier or a third party logistics provider. In contrary to the conventional process this is realized by the supplier, a third party logistics provider or the buyer himself. The reason for this change in LogWIN-P_VMI is that the supplier is responsible for managing the inventory of the buyer and for replenishing continuously the buyer’s warehouse (Figure 4).
After loading the goods into the distribution vehicle and the physical transportation of the products to the VMI-Buyer the shipping documents are given to the buyer.

**Invoice Processing and Settlement with VMI at Buyer (new)**

After transporting the goods to the VMI-Buyer the delivery is added to the collective invoice. At the end of each month this collective invoice is given to the buyer, who checks the correctness of the invoice by comparing it with the received shipping notes. If the monthly invoice is correct, the buyer pays the goods, if it is not correct the buyer initiates a claim (Figure 5).

**Inventory Management of Supplier (new)**

Due to the implementation of VMI this process was relocated to the supplier’s area of responsibility. After removing goods from the buyer’s stock combined with a fall below pre-defined inventory levels the supplier receives an automatical demand notification. The supplier is able to request current data like inventory levels or demand forecasts from the buyer’s IT system and can check the availability of the required goods in its own warehouse. If the required goods are available in stock, delivery date and delivery quantity are defined and an order confirmation is sent to the buyer. If the goods are not available at this time, the supplier transmits the quantity of residues (which are currently available in stock), the delayed delivery date and an order confirmation (Figure 6).
After sending the confirmation of order to the buyer the commissioning and transportation of goods is initiated.

**Preparation for Cooperation with VMI Buyer (new)**

A truly partnership and transparency are required for a successful VMI implementation with a suitable partner (Heydt, 1999). Therefore this process was added, which is initiated with the strategic decision for implementing VMI with a supply chain partner. After the agreement of both partners to realize VMI common expectations and aims of the cooperation are defined. The next steps are to define an implementation approach and set up a VMI contract. Therefore for instance inventory range and inventory levels need to be defined with the VMI partner (Figure 7).

**CONCLUSION**

A number of concepts like VMI exist that optimize the processes in Supply Chains. However, studies show, that the adoption rate in practice is low. To support companies to estimate the affects of VMI on business processes and organizational structures we developed the process reference model LogWIN-P.VMI. This paper focused on the processes of the supply side, which are mostly the distribution processes. We showed, that the process “Transportation Distribution” is affected significantly by implementing VMI. Furthermore, the three processes “Invoice Processing and Settlement with VMI at Buyer”, “Inventory Management of Supplier” and “Preparation for Cooperation with VMI Buyer” did not exist in the conventional process reference model LogWIN-P. As a result this extended process reference model provides companies a framework of described VMI processes of the supply side on a very detailed level. It provides a guideline for companies to implement VMI and adapt the effected processes.

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smartSUPPLY: A CONCEPT TO IMPROVE SUPPLY CHAIN TRANSPARENCY WITH THE USE OF SMART PHONES

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ABSTRACT

Supply Chain Transparency is a key success factor for an effective Supply Chain Execution as many companies need to track & trace their individual orders. GPS-based tracking & tracing systems try to cope with this trend in order to improve gained transport information. However, these systems are mostly linked to proprietary IT solutions but cannot provide real time status information of their loads and estimated arrival times. The new smartSUPPLY concept uses proven internet-based technologies, such as Location Based Services (LBS), to overcome given media breaks and addresses existing obstacles, especially in the fields of intermodal transports. With the integration of common smart phone technologies and transformation of social network principles into the professional field of logistics, a state-of-the-art toolkit for complex supply networks has been developed to increase the transparency and foster data exchange. Researched benefits result in a quick and interactive information flow with regards to the transparency of transports and shipped items. Gathered information may be quickly published to all relevant stakeholders in real time (e.g. to the sender, the shipper or the receiver of a load). Researched case examples underline easy to gain operational benefits in Supply Chain Execution such as the optimization of truck fill rates, transport lead time, idle times and capacities. Gained practical findings are a better preparation of loading and unloading processes, more accurate calculation of times of arrival and a higher quality of dispatch processes. A set of performance indicators has been developed and will be presented in this paper.

KEYWORDS
Track and Trace, GPS, Supply Chain Transparency, Supply Chain Agility, Location based Services

INTRODUCTION

Research Background

The backbone of supply networks are delivery transports from the supplier to the demand side. Due to growing globalization, deliveries from manufacturing to trading companies or finally to retailers are often integrated combinations of multi-modal transports by plane, ship, train and/or by truck. Especially express deliveries with unpredictable volumes need the flexibility of road based shipments. However, this paper describes how road based delivery information can theoretically be made transparent to stakeholders, with the joint appliance of LBS (Küpper, 2005) / systems and tracking technologies. LBS play a major role in the transformation process towards a transparent Supply Chain. The strong trend in the telecom market towards smartphones, with permanent internet access and integrated Global Positioning System (GPS) functions, can be smartly used for a solution of existing supply chain management transparency problems.
In addition to the navigation signal reception, smartphones do also have, depending on the coverage, constant connection to a cellular network. Hence, there is a bi-directional communication possible, which leaves the opportunity not only to receive satellite signals, but also to exchange information to and from internet applications. Due to the positioning opportunity by GPS-technology and cellular network, the user permanently can be tracked and served with location related information. Currently available mobile location-based communication services enable their users to consume categorized spatial information containing text, images, sound or video. The categorization of information can be made both passively - a user receives automated and predefined information - and actively - the user requests information individually.

**Supply Chain Transparency**

The information flow is a basic requirement for transparency along a supply chain. The increasing importance for complete transparency can be recognized in the growing number of internet based tracking and tracing platforms provided by all major international mail services. Leading companies like DHL, UPS, TNT or Fedex offer both web-based tracking services for shipment monitoring and automated notification of pickups and deliveries via internet-platforms, email or simple text messages. Thus, the information must reach all participants more or less at the same time, independent of its methodology.

Companies especially in production and transport handling have a high demand in the transparency in the Supply Chain Execution. It is also vital for them to know details of incoming goods, changes in planned processes, forecast information of suppliers, feedback of customers and, if in some way possible, exact details on current status of trucks from their contracted transport service providers. To manage all this information in one system, has led to a disadvantage of all present proprietary IT-Systems. The central problems laid in media breaks that arise when various software solutions should collaborate but are not actually able to do so. Reasons may be their diversity in advancement, structure, licensing agreements with developers, special requirements of the company, and so forth.

In addition, enterprises are therefore encouraged to react flexibly to changes in their environment without reducing the efficiency. How flexible an enterprise can react is shown by its ability to tackle unexpected events. Events are based on status reports, and changes in a process that can be both positive and negative. In addition, they are able to trigger further processes or be recognized as mistakes and signal a deviation in plans.

If enterprises can handle environmental dynamics, they will be successful. If they react inappropriately, it will negatively influence the operating performance (Wallenburg et al., 2005). Beside a high environmental dynamic, the surrounding of Supply Chains is often non-transparent. The problem is a lack of trust between Supply Chain partners that leads to information barriers that hamper the communication and coordination within the Supply Chain, substantially. Due to the insufficient transparency, processes along the Supply Chain and the existing environmental dynamic, are quickly subject to disorders (Heusler et al., 2006).

**SMARTSUPPLY - THE LOGISTIKUM RESEARCH APPROACH**

**Supply Chain Event Management – necessity for all actors/partners in the delivery processes**

Supply chain events can be compiled to qualified status information of shipments and are also a good example for Supply Chain Event Management (SCEM). An IT based SCEM system recognizes an upcoming event and can trigger alternate logistical strategies. The exchanged information is therefore not bound to one supply chain participant but is shared among others in real time. However, it’s an excellent methodology to react quickly in advance to irregularities and makes process disorders visible to all interested partners. Generally speaking, LBS support SCEM to improve the transparency of the supply chain and the controllability of processes, which is finally an enormous contribution to the agility of all participants. The basic idea to apply the LBS technology is to overcome the media break caused by proprietary IT soft- and hardware, as well as transport modalities with a standardised internet based communication and information system. However, the more companies/ Supply Chain partners are working together in delivery networks, the bigger the demand is to keep track of all the individual deliveries and shipments.

**The research outline**

This research paper states that geo-tracking functionalities can be used not only for vehicles, but also for the tracking of their individual loads. In addition, accurate load data can be published in real time to all relevant stakeholders (like the
sender, the shipper or the receiver of a load) via the internet. Forecasts of estimated arriving times can efficiently support the Supply Chain management of all partners and the physical movement of material streams becomes visible at any time. The research shows, with LBS there are new indicators for performance measurable in the material handling process (Bredrup, 1995).

For example, whenever the truck stops for a longer time period, the changed time of arrival can be transmitted to relevant stakeholders. Such events can trigger, for example, a change in the production process, or a re-order in a dynamic delivery time window management system. LBS have a high potential to make a delivery process much more transparent in the future. The central point, is that only the ability of real-time tracking and tracing makes a higher transparency possible.

**Existing transparency lacks in the road transport sector**

Taking the developments in parcel business into account, it was realized that common road based deliveries do not provide a similar Supply Chain transparency. Although there are proprietary fleet management systems, which usually allow forwarders and trucking companies to manage their fleets, the information flow to the sender or to the receiver of consignments is limited and complex.

Similar to the tracking & tracing information services of mentioned mailing companies, in a first step open internet based information handling of full truck loads (FTL shipments) or less-than-full truckloads (LTL deliveries) need to be implemented in a wide manner. In order to gain further SCEM advantages, real time LBS functionality needs to be complemented for the road based transports.

**Research Thesis & Vision:**

Having this demand and these visions in mind, the purpose of the research is to show how current and readily accessible technologies can be nicely combined, to create transparency through continuous information flow in the delivery process. Very quickly smartphones were detected as the most cost efficient mobile device to be used in the near future. The most decisive criteria for a soon commercial use are:

- **smartphones**, as they experience a high acceptance worldwide in the private as well as the business sector and
- **telecom fees for mobile internet**, as they drop steadily all over Europe.

Thus, the very low investment cost of the mobile devices and acceptable roaming fees make a cross boarder employment feasible.

**Requirements for a prototype**

As the theoretical research is to be proved by practical experiences, a LBS prototype named “smartSUPPLY” was jointly developed and tested with a professional partner in the field of automotive industry. With an integration of common smart phone technologies and transformation of social network principles into the professional field of logistics (Graf et al., 2010), a state-of-the-art toolkit was developed for supply networks. The focus of the test-case has been all inbound deliveries, which traditionally caused complications in the management of unloading windows and of the yard traffic.

The research approach states, that

- Supply Chain event recognition (e.g. the notification of loading of a shipment) is important to maintain tracking and tracing functionality not only for involved trucks (like supported in existing fleet management systems) but also for all individual loads.
- with dedicated information sharing, recognized events should be automatically reported to all partners of a delivery process, who are the sender, the shipper and the receiver of a load.
- events should not only be used for documentation of historical facts (= tracking), but also be used to forecast in a best possible way, the subsequent transport steps (e.g. calculation of the estimated time of arrival of an individual shipment) or should be used for the management of related process steps (e.g. the re-scheduling of unloading or production steps).
- a system has to have the ability to not only handle predictable events of a delivery process (e.g. compliance with statutory resting periods) but also to cope with unpredictable situations (e.g. traffic jams or inclement weather) and to influence the forecast.
Taking these conditions into account, Supply Chain transparency opens up new quality dimensions in the management of delivery processes. Real time event management results in a quick and automatic information flow to all relevant stakeholders. Each situation can be detected as it happens, so that alerts can be issued. For example, the presence of rain or snow and the lengthening of journey times could cause a bad weather alert which triggers operational changes. (Sachs et al., 1998)

An additional and important benefit of real time event management in open platforms, is its contribution to dynamic fleet management functionality. Dynamic fleet management focuses on real time management of distribution systems. This means that when an odd event occurs within the distribution chain, action must be taken in real-time (Zeimpekis et al., 2007). Dynamic fleet management functionality integrates routing algorithms and decision support tools for the decision maker in goods dispatching, tracking & tracing, etc.

**Smartsupply Information handling**

In the analysis of standardized delivery operations there are four major actors to be mentioned as process drivers, who cause information needs and high communication demand. These are:

- the sender of supply (= the manufacturer or wholesaler)
- the recipient of a consignment (= the customer and the one who ordered a product)
- the forwarder (= the carrier who organizes the transport)
- the truck driver (= the one who executes the physical road transport)

This reflection seems to be simple but comprises a quite complex network of communication lines. Along the shipment process, specific data is relevant in different process steps and has to be shared with several acting representatives of related stakeholders (e.g. the shipping manager of the sender has to manage the order information, but the loading staff has to issue the bill of loading).

**FIGURE 1**

**COMMON COMMUNICATION LINES BETWEEN SHIPMENT STAKEHOLDERS**

Typical information needs are (sample selection):

- for the sender and for the recipient
  - delivery order
  - type and load capacity of the truck
  - planned and real time of loading
  - real arrival time of trucks
  - confirmation of loading and loading time
  - acknowledgement of shipment (after delivery)
  - ...

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• for the truck driver
  • overview of delivery orders
  • order schedule with timeline
  • route plan, navigation targets
  • information about loading windows and waiting times
  • confirmation of loading and loading time
  • acknowledgement of shipment (after delivery)
  • ...

• for the forwarder
  • overview of delivery orders
  • fleet information (current truck location, capacity, status of transport, ...)
  • vehicle information (consumption, maintenance data, ...)
  • driver information (availabilities, performance, activities, ..)
  • confirmation of loading and loading time
  • acknowledgement of shipment (after delivery)
  • ...

As the italic indicated points show, there is a class of identical information for all or a subset of stakeholders and this very class of information, including its triggers, events and timestamps, is the shared information. Open information sharing for further event management is realised by an open internet based database.

As in this smartSUPPLY concept future internet platforms will act as open information hubs, which will allow stakeholders to access and interpret database information. Authorised stakeholders can find order status information no matter where and in which supply chain partner’s possession the order is. This one-stop inquiry is a contrast to a traditional process in which a customer was referred to other chain partners several times or was called back hours or days later (Lee et al., 2000).

Additional LBS features

Beside the proven quality increase in the decision making process of a supply manager caused by the introduction of the smartSUPPLY system, there will be further features and functions possible in the near future. Practical examples are:
  • Automatic recognition of arriving vehicles at the gatehouse of an enterprise with the effect of faster identification and automatic gate opening.
  • Automatic alarming function in the case of accidents or break downs.
  • Automation of logbooks, track recording and driving data statistics.
  • Easy adding of media for event documentation (including photo/video/audio).
  • Navigation tools not only for cross county but also for company yards.
  • Direct bi directional communication between stakeholders.

All these features will contribute to the strategic goals of supply chain management. Deliveries will not only be traceable, but also accelerated. Unnecessary times for waiting, slow loading or unloading and for administration can be reduced significantly and therefore the cycle times of vehicles improved.
CONCLUSION AND OUTLOOK

The researched findings from the smartSUPPLY prototype verify:

- Existing smart phone technology is technically mature to be professionally used for supply chain event management.
- The prerequisite for effective SCEM is an open internet based database and the acceptance of all parties involved that information sharing is a key success factor for their daily operation.
- A comprehensive implementation of SCEM is rather complex because many systems of various companies have to be consolidated via the open information hub. Moreover, a good data integration quality is necessary.
- Due to improved visibility of transports and individual deliveries, the smartSUPPLY concept has the potential to speed up road transportation, in general, and to increase the efficiency of truck use.

SCEM is a sophisticated instrument not only to improve transport management but also to reduce buffer stock and cost of inventory by the increase of Supply Chain transparency.

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THE IMPACT OF VENDOR MANAGED INVENTORY (VMI) ON INTRALOGISTICS IN SUPPLY CHAINS

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ABSTRACT

Concepts of supply chain collaboration (SCC) are effective tools to improve the quality and effectiveness in supply networks. Although scientific research and practical experiences with SCC is high, the impact on effected in-house logistics technologies (intralogistics) was not researched thoroughly in the past. However, the relation between SCC concepts, like vendor managed inventory (VMI) and intralogistics, is gaining importance. Collaborations, as a part of daily business, have the potential to simplify the in-house material flows. According to increasing changes of customer behaviour, as well as unpredictable demands and forecasts, flexibility and transparency are needed also in the fields of intralogistics to create sustainable collaborations in future supply chains. Following its German roots, intralogistics is defined as the sector responsible for enhancing material flow within companies. It addresses material handling and warehouse equipment, logistics software, services and turnkey systems and its implementation and operation. The identified lack of knowledge, which a SCC has on logistical in-house processes, results in high costs and requires optimization. The purpose of this paper is to identify potentials for all supply chain partners and to create value for future collaboration approaches. This paper presents the results of empirical best practice research. A list of relevant criteria was identified and proven by examples in the spare parts and automotive industry. The paper illustrates how collaboration potentials related to intralogistics can be realized. Three main success drivers of VMI are identified and explained for both, the supply and demand side.

KEYWORDS
Supply Chain Collaboration, Intralogistics, Vendor Managed Inventory, Supply Chain Execution

INTRODUCTION

In today’s dynamic and technology driven economy, satisfaction of customer needs gains in importance and those needs have to be fulfilled individually. Due to globalization, numerous competitors appear on local markets and companies need to improve their unique selling proposition (USP). In this scenario, it is essential to offer excellent products at low prices and high service levels. This cries for an increasing supply chain performance through intensive collaborations with suppliers and customers to improve product availability. In literature, this kind of company co-operations are termed, “supply chain collaborations” (SCC).

Supply chain management (SCM) is the management of material, as well as information flows in and between facilities in the chain, such as vendors, manufacturing plants, and distribution centres. (Shingeki et al., 1998). During the past several years, a number of supply chain management initiatives have been developed. These approaches are highly linked to cross company management methods which have to be supported by cross company information sharing.
Initiatives include collaborative planning, forecasting, and replenishment (CPFR), vendor managed inventory (VMI), continuous replenishment programs (CRP), and efficient consumer response (ECR).

In principle, supply chain collaboration is an efficient tool to improve the quality and effectiveness in supply networks whereby the involvement of suppliers in transportation and inventory management processes is high. Close relationships and trust between suppliers, manufacturers, transporters, distributors and customers are the keys to success. Companies look at their supply chains – the upstream part of the value-chain from the company’s perspective – as a means of focusing on their core competences, of leveraging those of vendors, of lowering their costs, and, thus, becoming more responsive to customers. (Sahay, 2003)

**Vendor Managed Inventory**

Vendor managed inventory enables suppliers to be authorized managing inventories at buyers’ locations and can rationalize inventory in the supply chain. This approach is defined as collaboration between a manufacturer and a retailer, such that the manufacturer is authorized to manage the inventory at retail locations (in addition to information sharing and more frequent replacements). (Yao et al., 2008) VMI is also known as continuous replenishment or supplier-managed inventory and is one of the most widely discussed partnering initiatives for encouraging collaboration and information sharing among trading partners. (Angulo et al., 2004)

**Intralogistics**

In German-speaking areas, the term “intralogistics” refers to all the management, tools and technical equipment for physical material and product flows that take place within the borders of an enterprise. The term was defined in order to create a differentiation from transporting and managing of external material flows. (VDMA (Verband Deutscher Maschinen- und Anlagenbau), press conference CEMAT, 2005) The forum of the Association of German Machine and Plant Engineering defines intralogistics as the internal logistics organisation, management, implementation and optimization of internal goods and material flows, including the related information flows and goods handling methodologies in industrial, commercial or public facilities.

The Steyr department of logistics management at the Upper Austria University of Applied Sciences (LOGISTIKUM) defines intralogistics synonymously for logistics technology as follows:

“Both terms, Logistics Technology and Intralogistics focus on technical systems and services to manage and execute all in-house material flows, as well as the corresponding flow of information.”

The referred in-house material flow includes all material handling, storage and transport within defined areas (e.g. of a company) (Martin, 2009)

In a practical interpretation, the authors describe logistics technology and intralogistics as:

\[
= \left( \sum \text{equipment & information technologies for material management & material handling} \right) \\
+ \left( \sum \text{information management technologies and information handling} \right) \\
+ \left( \sum \text{related process organisation} \right).
\]

**Intralogistical cost criteria of SCC**

SCC helps a company in numerous ways. The potential benefits of VMI, for example, are very compelling and can be summarized as reduced inventory for the suppliers and buyer and improved customer service levels, such as reduced order cycle times and higher fill rates. (Achabal et al., 2000), (Waller et al., 1999) Service levels become more important as an indicator of a supply chain’s performance. Customers are demanding highest availability, be it on the shelf of a retailer or in the distance-shopping segment of an e-commerce-business. (Taylor et al., 2004)

Besides that, companies still have to seek a cost optimum, in which logistical operations have to be contemplated as well. (Robertson et al, 2002) (Stank et al, 2001) Although in academia, VMI has been the centre of different studies and research programs, its impacts on Intralogistics can be seen as an academic void. Knowing and understanding the impacts of a SCC-tool helps a company to determine cost saving opportunities which underlines the importance of this topic for both partners individually and the supply chain, as a whole.

Two examples of cost criteria, influenced by SCC, are as follows. The reduction of total inventory tends to reduce the necessary warehouse space, thus reducing the need for further investments; the space at hand can be used otherwise. (Donath et al., 2002) Another quite important criterion is the choice of the proper handling equipment. By choosing thus correctly, the performance of the in-house material flow can be improved significantly, therefore
contributing to both the demanded service level as well as the cost factors (e.g. due to less handling, storage or picking costs).

The research question: How is Intralogistics influenced by VMI?

As intralogistics is focusing on company internal logistics management, it is dominated by company internal requirements and needs. Nevertheless, the interfaces to external transports along the upstream and downstream partners, influence the intralogistics as well. Within a research project (ILog - Integrated Implementation Logistical Concepts for Collaboration, 2011) executed at the LOGISTIKUM in Steyr, Austria, these influences where analysed and documented.

FIGURE 1
INTRALOGISTICS IN THE FOCUS OF SC COLLABORATION

By expectation considered changes in intralogistics, caused by SCC could result in higher efficiency and lower cost in the long run. The potentials in intralogistical optimization are expected by all partners who participate in a SCC, or in VMI, specifically. These could be reached by streamlining or modernization of re-dimensioned material flows like changes in packaging, materials handling, use of standardised load unit loads (carriers), in-house transport, goods identification and adaption of logistic processes.

THE RESEARCH APPROACH

As the method of research, there was an intensive literature review executed to analyse known and documented impacts of VMI. Furthermore, the literature review was enlarged with an empirical study to confirm results from the literature review.

Literature review

As a result of the literature review, it was found, that partners of VMI-SCC dominantly focus on transportation and inventory processes. (Sahay, 2003) Relevant influencing criteria for changes in intralogistics are reported very rarely. The literature mostly explains expected collaboration effects in principle. An often considered theory generally states, that changes in supply chains towards integrated collaboration can and will result in a higher efficiency and lower costs in the long run.

Concerning management of volumes and inventories, collaboration partners are jointly enabled to gain a better understanding of future product demand and implement more realistic programmes to satisfy that demand. Close collaboration among supply chain partners can align the parties and then enhance the value of the network’s combined activities. Collaborating with suppliers, manufacturers will derive benefits in such key activities as new product development, order fulfilment, and capacity planning. This, in turn, results in improved order fulfilment and increased capacity utilisation. (Lapide, 1999)

The relationship between the partners, instead of being restricted to the coordination only, should transform to a more collaborative one. Failing to collaborate would result in distortion of information (bullwhip effect) as it moves through the supply chain, which, in turn, can lead to costly inefficiencies, excess inventories, a slow response, and lost profits. (Lee et al, 1997) Due to the realization of these collaboration approaches, there have been results in changing industrial structures and improvements in a firm’s performance. Specifically, VMI enables suppliers to be authorized to manage inventories at buyers’ locations and can rationalize inventory in the complete supply chain.

But, in addition, there is still a lot of potential to optimise operations within the enterprises to streamline and modernise the internal information and material flow, as for example, packaging, materials handling, the use of standardised carriers, tanks as load carriers, in-house transport, goods identification and persecution or warehouse structure.


**Qualitative empirical social research**

To create a valued link between literature and practical approaches, a study within the automotive sector and the spare parts industry has been done. For the empiric research, the method “text-interpretation” was applied. (Lamnek, 2005) Based on this integrated research, a framework for intralogistical criteria has been developed.

The framework contains different types of technical criteria, for both the supply and the demand side, which can be separated in primary dependencies (dominantly resulting from product demands) and secondary requirements, which are influenced by the terms and volumes of shipments and related transport organisation.

VMI collaboration only affects the secondary dependencies and it is important to state that there are changes in both partners’ intralogistics.

**FIGURE 2**

**INTRALOGISTICAL CRITERIA FOR SC COLLABORATIONS**

The mentioned definition of the above criteria framework creates a helpful structure for the analysis of changes in intralogistics caused by VMI collaboration. As a result there have been identified three main drivers for intralogistical changes. These changes have been analyzed in the fields of spare parts industry, as well as in the automotive industry.

The first effect is the tendency of reduced quantity per shipment (drop size) because supplies become more frequent when using VMI. This driver can be underlined by the practical analysis in the automotive sector, but, on the contrary, the spare parts business proves that such change is only identified for standard products. The shipment quantity determines the used type of packaging, especially if reusable or not.

The second identified VMI effect is realized in standardization of used carriers and unit loads. In businesses with very small order amounts, resulting from unplanable sporadic demand like in the spare part business, standardization is hardly at hand. This effect underlines that the order size and the frequency of deliveries are the two
core factors for intralogistical criteria. In stable and predictable businesses, VMI-concepts cause a trend to standardisation, but in event driven relations, the effects on intralogistics are very limited. In such a business, a flexible and reliable transport organisation is more relevant.

The third identified driver is the goods identification and tracing, as well as communications technology. Among the whole supply chain, several identification technologies for tracking and tracing are applied, e.g. barcodes using the serial shipment container code. The introduction of optical data carriers or radio frequency identification (RFID) tags is realised when costs can be kept low. This means that RFID is only useful when there is a certain volume and frequency of deliveries.

**FIGURE 3**
FRAMEWORK OF THE VMI IMPACT ON INTRALOGISTICAL CRITERIA OF SUPPLY CHAIN PARTNERS

The researched approach demonstrates the importance of smaller delivery sizes in typical VMI operations. These affect the product carrier (unit load) sizes and conditional warehouse criteria of VMI partners. Due to small unit load carriers, the warehouse structure (racking and handling equipment, conveyors and transport tools) is to be adapted. Concerning the empirical study, the hypothesis was proven, that a certain order volume causes changes in the intralogistics. However, this only applies to a frequent, constant flow of material. In the case of sporadic product demand, like in the spare parts industry, the resulting changes within the intralogistics are not verifiable. In the spare parts industry, standardization is not demonstrable as well, because in this branch of industry, flexibility in packing and delivery transport are the most important aspects.

Furthermore, this empirical study proves that the size of a company is not an influencing factor for impacts on intralogistics. All results are valid for collaborations within bigger industries, as well as for small and medium enterprises (SME).

In all cases, advanced information sharing by information technology is important for VMI. Information about inventory, demand, sales, forecast, production schedules and order status for tracking and tracing is to be exchanged intensively. (Lee, 2000) As partners manage their inventories and material flow beyond the borders of independent companies, extensive coordination among multiple functions becomes necessary. Significant investments are required to allow information to be shared across entities so that the activities and decisions through the supply chain can be coordinated.
CONCLUSION AND FUTURE ANALYSIS

As a result it is proven that the business volume and the constant frequency of shipments are the two essential criteria impact intralogistics directly and most of all. Related changes happen within the companies on the supplier, as well as on the demand side.

Proper implementation of information sharing technologies is a requirement for successful VMI collaborations. Furthermore, a continuous demand is necessary to create extra value in intralogistics. Industrial branches, which do not have this stability - like the spare parts industry with its sporadic, non-predicable demand – do not benefit from VMI driven potentials.

Although there has been a growing awareness of the importance of SCC as a strategic tool, and organisations have already made some progress, a lot of work remains to be done. There has been growing recognition of the need for more qualitative research in this logistics area, especially for SME.

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FRAMEWORK OF HOSPITAL-PHARMACY NETWORK MODEL WITH REBATE CONTRACTS UNDER VMI – A CASE OF THAILAND

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ABSTRACT

While the majority hospitals in developed countries have their out-patients fill their prescriptions at any local pharmacy stores, the out-patients in Thailand still fill their prescriptions with pharmacy department in the hospital. With normally large crowd of the state and teaching hospitals, patients have to wait a long line to get diagnosed and yet another long line to have their prescriptions filled. The pharmacy department not only works tirelessly to serve both in- and out-patients, but also provides drug use related consultation to physicians. Moreover, the department has to keep a massive pharmaceutical inventory in various places in order to effectively distribute medicine to various wards in the hospital. These require enormous amount of work, labour, and expertise which results in a huge hospital budget spending and difficulties in management. In order to ease hospital burden and ensure quality of healthcare, a model of having out-patients filled their prescriptions at local pharmacies, Hospital-Pharmacy Network Model, is proposed. The model will reduce the work loads in hospital and wait time while increase the healthcare quality. The network model was developed by analysing cost-benefit of all parties, and allocated to each party by employing rebate contract to the model. Initially, patients under the universal coverage were selected. Data was obtained from the hospital’s electronic database and 10 local pharmacies. Vendor Managed Inventory (VMI) also needs to be implemented to ensure efficiency. The success of proposed model implementation will be great benefit to healthcare in Thailand.

KEYWORDS
VMI, Supply Chain, Healthcare Management, Dispensing Prescription at Pharmacy, Rebate Contract

INTRODUCTION

The concept of dispensing prescription medicines at the pharmacy (community pharmacist) has been applied in developed countries for many years. To fill their prescriptions, patients bring the prescription from the hospital to local pharmacy and the pharmacist will fill their prescriptions and explain how and when to take each prescription medication. One of the reasons that is to reduce the duplication of the pharmacist for having to management both the out- and in-patient pharmacy department’s (OUT-PATIENTS pharmacy) inventories on top of the drug monitoring and consulting. However, the most important reason is that patients will benefit more from dispensing at pharmacy. (ElTayeb, 2004; Eronen, 2005) Hospital pharmacists are responsible for monitoring the use of drugs that are more complicate and the essential ones of the health professions team to improve the effectiveness and safety of treatment to patients. Concept of hospital-pharmacy network is that it is a network of hospital and qualified community pharmacies which allow patients to fill their prescriptions at qualified local pharmacy. Detail of the proposed network model will be further explained in the following section. Under the hospital-pharmacy network concept, it helps reducing burden of the hospital’s warehouse management which requires a lot of resources, man power, areas, the expense of care and maintenance and the document management. In addition, the hospital-pharmacy network concept is one way to lessen congestion in the hospital which can cause repeated infections and dissatisfaction of the long waiting time for out-patients pharmacy. For the benefit of patient’s care in hospital, hospital pharmacists will have more time to study and improve the skills of rational drug use leads to safety, save and treated effectively. That means the raising of the quality of care for the hospital.

The direct benefit for the patients is that they will not have to wait in a long queue for receiving the drug at the out-patients pharmacy; the patients will have more time to clarify all questions with the community pharmacist. The community pharmacist is not in a rush to explain all side effects and related symptoms to the patient, so the patient will have better understanding on how to take the drug and their affects.

Without appropriate network model, the out-patients in Thailand still have to fill their prescriptions with pharmacy department in the hospital. In order to alleviate hospital burden and ensure quality of healthcare, a model of having out-patients filled their prescriptions at local pharmacies, Hospital-Pharmacy Network Model, is proposed. The model will reduce the work loads in hospital and wait time while increase the healthcare quality. Although, Hospital-
Pharmacy models have been proposed, but none has incorporated rebate contract in the model. The framework of the proposed network model in this study was developed by analysing cost-benefit of all parties, and allocated to each party by employing rebate contract to the model. Initially, patients under the universal coverage were selected. Data was obtained from the hospital’s electronic database and 10 local pharmacies were interviewed. Vendor Managed Inventory (VMI) also needs to be implemented to ensure efficiency. There also is a case study of one of the major teaching hospital in Thailand. The rest of the paper is organized as follows: Literature Review; Proposed Hospital-Pharmacy Network Model, Case Study, and, Conclusions and Recommendations.

LITERATURE REVIEW

Presently, the Thai health insurance system is divided into three major schemes as follows, Civil Servant Medical Benefit Scheme – CSMBS, Social Security Scheme – SSS, and The Universal Coverage Scheme – UC. CSMBS is coverage for officers and employees of government workers or retirees. The family is entitled to reimbursement of medical expenses from this scheme. Comptroller general’s department is responsible for the CSMBS cost. The second system, SSS is for private employees which both employer and employee monthly deposit required money to the Social Security fund. And, the health coverage comes from this fund. The third system, UC is to expand to cover the rest of population whom is not under CSMBS and SSS including uninsured persons (N Ranoong, 2004). The people under the UC do not have to pay for medical expense; the government will pay per capita to the hospital. Therefore, the government are responsible for both CSMBS and UC. The proportion of people under the CSMBS:SSS:UC is 4.96:9.61:47.56 respectively. In 2009, the number of visits of out-patients service under UC is 140.70 million times, or 79.6 percent of the total out patient service. The top three out-patients UC disease is respiratory (27.52 percent), pain (26.45 percent) and chronic (16.23 percent) diseases which can be treated at the primary care level. (Kantamara, 2009) Since UC is the largest health insurance, under the UC patient was studied and proposed as patient model of the hospital pharmacy network.

Wittayasaksitpan (2001) conducted a survey of public opinion on dispensing medicines at the pharmacy under the government’s universal coverage healthcare showing that 76.7 percent respondents agree with this concept expecting reduced the waiting time (83.9 percent), shorter time in hospital (67.4 percent) and received more advice from pharmacist. It was further presented those respondents who do not want to visit pharmacy network because they are concerned about quality of medicine (57.1 percent), standard of the dispensing (52.7 percent) and presence of pharmacist in the open hour (34.1 percent). This survey revealed the public acceptance on dispensing medicines at the pharmacy but it requires pharmacist to provide better quality. This survey established that the waiting time in hospital is still unsatisfactory although hospitals have been trying to improve the time continuously. Moreover, the respondents also gave weight to received advice completed from the pharmacist; this implies that the pharmacy service was not satisfactory in terms of dispensing in hospital. Additional, from a latest survey of health and hygiene of the Thailand’s National Statistical office in year 2007, 25.69 percent of unhealthy Thais decided to consult the community pharmacist. The high percentage of people visiting pharmacy demonstrates the sense of the reliability, convenience or easy to access for Thais. Although they cannot reimburse their medical bills occur at pharmacy with their National Health Insurance coverage, they still choose to visit pharmacy.

Chalongsuk R. (2007) compared the primary care service in chronic disease between pharmacy and primary care unit under the UC scheme in Thailand by select a local pharmacy for experiment. The selected pharmacy is responsible for dispensing the prescription medicines from the study hospital and then interviews the opinion on satisfaction in service of patients and the value of the clinical laboratory when receiving the prescription medicines at pharmacy. The result was 74.3 percent of patients were satisfied and the value of clinical laboratory of the patients did not differ from patients receiving the medicines at the hospital. Tundee, W. (2002) studied pharmaceutical care and prescription refill for Type 2 diabetes mellitus patient in Mahasarakham University’s pharmacy in Thailand. This study showed the significant increasing in physical function, role physical, mental health and vitality in the intervention group. Moreover, the overall of medicine cost is reduced and increasing in convenience to patients as well. (Khumsikiew, 2009)

The concept of dispensing prescription medicines at the pharmacy (community pharmacist) is under the integrating health service system concept. This means the public health service model that includes a variety of services provided by various service agencies with the coordination of relevant agencies, which pharmaceutical service at pharmacy store is an important service-related health services that the people use it regularly (Ratanavichitsilp, 1998). The integration of pharmacy as part of the healthcare system to expand services to cover more people has been studied in a corner of the user or patient’s perspective, the provider's perspective and the payer’s perspective. It was additionally suggested that the cooperation established a network of hospitals and pharmacies will need to consider service, financial, and management arrangements. There are two main issues to consider such a system to organise the network. And, a good system designed so that it provide good practice, flow of service, flow of information, flow of fund and flow of
goods. The network will lead to improvement of pharmaceutical care, quality care, and support the healthcare reform concept. In addition, the integrated health system concept was presented including pharmacy in the propose model. The pharmacy network may be the independent pharmacy, chain pharmacy or hospital owner pharmacy. Arkaravichien (2009) studied the perspective of senior executives of universal coverage health insurance and director of the hospitals in terms of the possibility to including the pharmacy to the national health insurance system. The majority of opinion that it is possible to incorporating the pharmacy is a part of the national health insurance system but the standard of practice and the quality of service will acceptance by the national health insurance first. In addition, the main issue is to find the answer to the payment as compensation for pharmacy services. Moreover, all executives believe that incorporating the pharmacy into the health insurance system will increase the accessibility of the patients to another dimension of health care. However, every partner must make the patient get the most benefit. Kessomboon (2010) studied the impact from incorporating pharmacy into the universal health coverage scheme in case of stable diabetes and hypertension. They found that the cost of dispense on prescription drug item is better 22-47 Baht while according to Kessornsomboon (2008) that was 25 Baht.

Costae (2004) explored the activity flow and information system for dispensing medication of a one of the biggest hospital in Brazil. The hospital has own pharmacy in the hospital area, prescription will be sent to the pharmacy to provide medication and sent back to the hospital by manual process. Problem is always an extremely delay and error. The study presents a new information system for the distribution of medication both in hospital and between hospital and pharmacy. Trimongkol (2008) found that when the VMI system is implemented in hospital, the fill rate increases 6-10 percent. Kritchanchai and Krichanchai (2010) studied on Vendor Managed Inventory (VMI) in Thailand healthcare industry to improving operational efficiencies and reducing cost whereas continuing to improve quality of care. VMI is a concept of sharing information among partners related to vendor decision in replenishment that will benefit to improve supply chain performance by decreasing inventory-related costs and increasing customer services. They presented a model for implement VMI in a big one of state-owned hospital in Thailand. However, their concept is still a concept that receiving prescription medicines from out-patients pharmacy within the hospital under VMI concept. In addition, Trimongkol (2008) also studied the inventory management under VMI concept in 2 hospitals in Ayutthaya province, Thailand. The vendor is the government pharmaceutical organization (GPO) which is the main source of supply medicine for government hospitals nationwide. Terms of contract price in this study is trading at a fixed price for unlimited quantities and use the fax or internet to send the on hand stock and financial statement. The result of the study is the reducing of stockpile and the expired products.

S.M. Disney et. Al. (2003) studied the impact of vendor managed inventory on transport operation and showed the possible transport cost saving in both short term and long term. VMI in practice eliminates customers’ needs to manage inventory and takes off one duplicate process in the supply chain. As a result, VMI brings focus on cost effectiveness over the entire supply chain, from manufacturing, inventory storage to transportation, and attempts to coordinate inventory replenishment and transportation in such a way that the cost is minimized over the long run (Campbell, & Savelsbergh, 2004). Optimal supply chain performance requires the execution of a precise set of actions. Unfortunately, those actions are not always in the best interest of the members in the supply chain, i.e., the supply chain members are primarily concerned with optimizing their own objectives, and that self-serving focus often results in poor performance. However, optimal performance is achievable if the firms coordinate by contracting on a set of transfer payments such that each firm’s objective becomes aligned with the supply chain’s objective. Various contracts have been proposed to coordinate the supply chain by aligning objectives of the supply chain members. Majority of supply chain concept focuses on a few popular contracts such as buy back (Pasternack, 1985), quantity flexibility (Tsay, 1999), revenue sharing (Cachon and Lariviere, 2005), quantity discount (Tomlin, 2003), sales rebate (Taylor, 2002). Wong (2009) presented two-echelon supply chain with a single supplier serving multiple retailers with the sales rebate contract under VMI concept. The results demonstrate that when the sales rebate contract combines with the VMI mechanism, the supply chain achieves perfect coordination that retailers can make price decisions to maximize the aggregate chain profit.

PROPOSED HOSPITAL-PHARMACY NETWORK MODEL

Changing from dispensing prescriptions with pharmacy department in the hospital to fill prescriptions at any local pharmacy, a sequence of steps is as follows; the physician in hospital write a prescription medicine then patient brings the prescription to a local pharmacy which is a member of the network, the pharmacist dispenses the medicines and keeps the prescription for reimbursement from hospital. The importation regarding information management, there should be at least a central database for all parties to verify the authenticity of the prescriptions and the healthcare coverage certain patient is under.

In this model, we propose 3 parties in the Hospital-Pharmacy Network model that are hospital, central department and local pharmacy stores. This change is a simple model that UC patients just receive the medicine at the
convenience local pharmacy stores of the hospital network without having to pay upfront. The hospital would either setup or outsource the out-patient medical dispensing related management to a unit called central department. The central department acts as a hospital-pharmacy network’s distributor who also manages of the qualified local pharmacies to dispense medicine to patients. The central department is responsible for providing a network of pharmacies and managing medicines to supply chain. It is responsible to coordinate between the hospital and the local pharmacies, to be the supply chain management centre, to be the auditor, to be the public relations and to support other works such as technical work, seminar, etc. The central department should possess ability to coordinate between the medical services, understanding the context of hospital and pharmacy services, and capabilities to manage finances. Due to the budget constraint and the constraints of the professional in understanding the hospital pharmacy system, the central department should be an organisation that already exists, it might be a community pharmacy association (Thailand) which is a pharmacist own association and pay a key role on the pharmacy certification. The other possible alternative is a combination between related parties with a minimum cost of administration or outsourcing to an existing potential wholesaler. For the local pharmacies which are private enterprise, the pharmacist must expect the compensation that they satisfy. In this model, the pharmacist must receive the return no less than before being part of the network. The local pharmacies also gain advantage from more traffic in the shop besides they also get more return while required investment increasing only slightly. However, pharmacy should get suitable fee for dispensing or other form of compensation. For the quality control, the pharmacies must be certified by the Pharmacy Council and qualified as quality pharmacy.

In order for the model to work, all participating party should get better benefit both in service and/or financial wise. In the proposed model, patient will receive faster and better consulting, the hospital pharmacy will have fewer burdens while the hospital will receive at least the same margin from selling medicine to out-patient. Additional, pharmacy in the network should also get benefit at least the same return for dispensing the medicine, or other form of compensation. For more efficiency system, the model in a VMI partnership should be set. VMI is an important flow coordination scheme which integrates operations between suppliers and retailers through information sharing and business process reengineering.

The retailers in this model are the pharmacies or drugstores. The retailers buy the medicines from the central department that acts as a wholesaler vendor. The central department gives a period credit term while the suppliers or distributors give more long period credit term for the central department. Figure 1 shows the way that signal for replenishment and medicine flows. The central department is responsible to replenishment signal from hospital and pharmacies by forwarding the signal to the pharmaceutical manufacturers or distributors. The central department as a vendor adopts a periodic review policy to replenish inventory for each retailer and the hospital. At the starting point, the central department first determines a base stock level and maximum inventory level for each retailer and hospital taking the customer service level (CSL), inventory holding cost and lead time in to account. For the medical transportation responsibility, the manufacturers or distributors should assume this responsibility to deliver medicine to hospital and drugstores.

**FIGURE 1**
MODEL FOR REPLENISHMENT SIGNAL AND MEDICAL FLOW
For the financial contract, when the supply chain is coordinate, one of regular contract in pharmaceutical retail industry which is consistent with the model that is the rebates contracts was chosen. A rebate is different from an order quantity discount as it only applies to items sold to end-users. There are 3 main reasons for choosing the rebate contract for the model. Firstly, the contract is familiar in this industry. Next, the rebate contract will give benefit to the retailers that are really responsible. Lastly, since the price would be much cheaper than drugstore could be from manufacturers, the rebate contract will control the volume so that pharmacy/drugstore could not greedily purchase more than the limit of conditions.

**FIGURE 2**

MODEL FOR FINANCIAL FLOW

![Model for Financial Flow](image)

Figure 2 illustrates financial flow of the proposed model. Patients under the UC Schemes could receive the medicine in two ways; in case of emergency at Emergency room or the drug cover for use at home. Most of the outpatient cases will obtain the medicine at pharmacy. Under the UC Schemes, patients do not need to pay for medicines except for rare case that the medicine is not covered by the insurance. Since the hospital has enormous bargaining power with the suppliers, the medicine purchased through the central department is always cheaper than or at least equal to the wholesalers’. Therefore, the pharmacy in the network will has lower medicines cost or equal to that of the other pharmacies. The payment process is pay forward to the level of vendor of each echelon.

For the model under the rebate contract, hospital and pharmacies must promise the minimum order quantity for archiving the target to get rebate. To prevent the pharmacies to take advantage from lower medicine cost when buy the medicine from the central department and damage the competition in the drug retail market, the central department should also set the maximum order quantity depending on the policy of establish the central department.

The following is the proposed model for hospital-pharmacy network with rebate contract. Since the medicine are from patient from hospital, the central department set the same wholesale price, $W_{ij}$, to both hospital and pharmacies and set the standard price to sell to the patients at $P_i$. Where, $s_j$ is the base-stock level of item $j$ determined by the central department for pharmacy $i$.

In this model the supplier give the retailer $\eta_j \%$ rebate from the value of $t_{ij}$. Now, the transfer payment with the rebate contract, $r_{ij}$, of the pharmacy $i$ to the central department is

$$
r_{ij} = \begin{cases} 
\sum_{j=1}^{m} W_j s_j, & r_{ij} = 0 \\
\sum_{j=1}^{m} W_j s_j - \eta_j \left( \int_0^t f_j(x) dx \right) - t_{ij}, & r_{ij} \geq 0 
\end{cases}
$$

(1)
is the order if the item \( j \) and \( i \) is the order of the pharmacy. When \( z \) is the dispensing value at price for pharmacy, \( z \geq 0 \). Baht, pharmacies pay only leftover stock at the pharmacy at the wholesale price minus the rebate of price \( z \) unit to the central department. Holding cost and purchasing cost are not including in the pharmacies transfer payment because pharmacy have to stock these items whether they are part of the network or not.

**Hospital transfer payment to the central department is**

\[
T_H = \sum_{j=1}^{R} (c_{jz}) - s_H \sum_{i=1}^{R} \left( \int_{0}^{\alpha} d_t (e^t) dy \right)
\]

(2)

Hospital pays \( P_j \) for every item quantities pharmacy purchased, and get the rebate \( \gamma \) of the selling price, \( P_j \). That is the hospital act as the payer at the selling price in this model.

The central department transfer payment to the suppliers or distributors is

\[
T_s = \sum_{j=1}^{m} (c_j q_j)
\]

(3)

So the central department’s profit function not including the management fee is

\[
\pi_0 = \left( T_H + \sum_{i=1}^{R} T_{di} \right) - T_0
\]

(4)

Profit for all of the parties could be boosted by increasing in \( P_j \) and \( Q_j \). If the model increase in \( P_j \), it will not only benefit for the hospital and pharmacy for increasing the gross profit, but also for the central department, because the rebate pay in the form of \% \( P_j \). However, increasing in the selling price, must be under the maximum mark up percentage allowed of the government hospital regulation. In addition, per capita budget under the UC is limited for the UC patients. Increasing in \( P_j \) must not come from dispensing more than necessary, but it is acceptable if the cost per head decrease or equal former while the hospital care the patient more than previous.

**A CASE STUDY**

The studies will be divided in 3 parts as follows:

**Part 1:** Study the OUT-PATIENTS pharmacy cost and benefit and interview the hospital executive for finding the hospital condition

The historical data were collected; the number of patient, the number of medicine items, the usage of the medicine, administration cost, inventory cost and selling price in the pharmacy department of a state own teaching hospital in Thailand. One of out-patients pharmacy that is the EENT (Eye, Ear, Nose and Throat) out-patients pharmacy was selected to study because completeness of the information at that time. The expense for one patient visit, gross profit, and then operation profit for EENT out-patients pharmacy department were calculated.

The data was collected from electronic database (pharmacy department), document research (policy and planning department) and interview the chief of pharmacy department and the director of the hospital. SPSS FOR WINDOWS version 12.0, Microsoft excel 2009 were used to analyze the data and descriptive statistics to summarise the list and calculated cost and benefit of the out-patient’s pharmacy services in the pharmacy department.
Part II: Study the related factor to the service of pharmacy when becoming the pharmacy in the network

The ten qualified local pharmacies in Bangkok, Thailand were selected by random. The collected data was about the financial system, medical supplies management system including the data collection of expense and revenue of the pharmacy or the group of disease. The data then was studied by separating the data as following topics:

- Analyse the missing medicine: by comparing the drug list of the EENT out-patients pharmacy department to the drug list of out-patient’s pharmacy services in the pharmacy department.
- Average revenue, average expense and operation profit: Collect data to analyze the capital (The number of staff and payment for all pharmacies and warehouses, the public utility expense for all pharmacies and warehouses, all expenses of all wasteful material cost and related durable articles, the revenue from selling and others revenue per month)
- Opinion on the investment: The previous area of the pharmacy and medical supplies warehouse and the increased area when becoming the pharmacy in the network. The area for the out-patient while waiting for the pharmacy service.
- Calculate the payback period

SPSS FOR WINDOWS version 12.0, Microsoft excel 2009 was used to analyze the data and descriptive statistics to calculate percentage and arithmetic means.

Part III: Applying the model of hospital-pharmacy network.

The data from Part I and Part II for model by hold on to the benefit of all related departments were used for analyzing the strength of each party and applied the VMI concept with rebate contract to the model. The patient under the UC for model was selected.

Results of the study are presented as follows.

Part I, Study the OUT-PATIENTS pharmacy cost and benefit and interview the hospital executive for finding the hospital condition

Finding cost of the OUT-PATIENTS pharmacy department

The structure of capital analysis as whole pharmacy department is as follows:

\[
\text{Total cost} = \text{direct cost (labour cost + material cost + capital cost)} + \text{indirect capital (from the other department)}
\]

Data collected from database is shown in Table 1-3. Please note that exchange rate was around 1USD: 30.92 Thai baht.

**TABLE 1**
THE DETAIL OF DIRECT COST OF THE PHARMACY DEPARTMENT

<table>
<thead>
<tr>
<th>Details</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total labour cost</td>
<td>39,108,782.79</td>
</tr>
<tr>
<td>Total material cost</td>
<td>71,651,798.23</td>
</tr>
<tr>
<td>Total capital cost</td>
<td>1,849,149.38</td>
</tr>
<tr>
<td><strong>Total direct cost</strong></td>
<td><strong>112,609,730.40</strong></td>
</tr>
</tbody>
</table>

Total direct cost = direct labor cost + direct material cost + direct capital cost
= 39,108,782.79 + 71,651,798.23 + 1,849,149.38
= 112,609,730.40 Baht

**TABLE 2**
THE DETAIL OF INDIRECT COST OF THE PHARMACY DEPARTMENT

<table>
<thead>
<tr>
<th>Details</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>The cost from the departments that does not generate revenue.</td>
<td>13,735,925.12</td>
</tr>
<tr>
<td>The cost from the departments that generate revenue.</td>
<td>449,464.62</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>14,185,389.74</strong></td>
</tr>
</tbody>
</table>
Total cost of the pharmacy department:
Total cost = Total direct cost + Total indirect cost
= 112,609,730.40 + 14,185,389.74 Baht
= 126,795,120.14 Baht

Because the hospital is also a school of medicine which the whole pharmacy department cost is separated by 3 types of activity, that are the cost of service 83.73 percent, the cost of learning 11.47 percent, and the cost of research 4.81 percent. In this case, costs associated with this study are only the service related costs, so the cost of pharmacy department for the service of the big hospital is equal to 106,165,554.10 Baht. In addition, the budget of the pharmacy department for the Inpatient and Outpatient’s service is 30:70. Then the cost of the pharmacy department for the Outpatient’s service is equal to 74,315,887.87 Baht. The number of visits of the outpatient is 1,266,947 visits. So the cost of the pharmacy department per visit is 58.66 Baht. The number of visits of the outpatient from the EENT department at the time of study was 210,600 visits. So the outpatient’s EENT department spent 12,353,796.00 Baht for the pharmacy department.

In conclusion, it is found that the cost of pharmacy department for the service to the outpatient is 74,315,887.87 Baht. The pharmacy department of EENT department uses budget 12,353,796.00 baht or the cost of the pharmacy department per patient visit is 58.66 Baht.

**Finding gross profit and operation profit of the out-patients pharmacy department**

<table>
<thead>
<tr>
<th>TABLE 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>REVENUE, COST AND DIFFERENCE OF REVENUE AND COST OF MEDICINE FROM EENT OUT-PATIENTS’ PHARMACY</td>
</tr>
<tr>
<td>---------------------------------</td>
</tr>
<tr>
<td>No of the medicine items</td>
</tr>
<tr>
<td>Revenue from selling medicine</td>
</tr>
<tr>
<td>Medicine costs</td>
</tr>
<tr>
<td>The difference of revenue and costs</td>
</tr>
</tbody>
</table>

The total drug sale amount of the OUT-PATIENTS pharmacy is 70,756,748.00 baht with the cost of drug is 49,863,428.97 Baht so the gross profit is 20,893,319.03 Baht or 29.5 percent of the total sale amount. Profit was calculated from drug sale deducted by the cost of the OUT-PATIENTS pharmacy, operation profit, and the operation profit is 8,539,523.03 Baht or 12.07 percent. So to remain the benefit of the hospital, the operation profit of the OUT-PATIENTS pharmacy department should be not less than 12.07 percent of revenue. For the condition of the hospital for this model, because the hospital would not want to reduce their finance benefit, the model must provide at least the same benefit as before.

**Part II, Study the related factor to the service of pharmacist community when becoming the pharmacy in the network**

The revenue, cost, and important opinion from 10 community pharmacists when the pharmacies become a hospital-pharmacy network were collected. All of the pharmacy are the owner of pharmacist and already are part of the local pharmacy.

**Finding additional medicine needed in order to service EENT patients**

The list of drugs available in pharmacies compared to the hospital’s drug list was explored in order to find the incremental cost of adding an entry of the inventory items.

Table 4 shows the items needed by comparing the OUT-PATIENTS pharmacy drug list with pharmacy drug list. The average cost that will increase when a pharmacy must have all items at least one unit or one treatment course was explored. Table 4 shows that the average value is 10,871.91 Baht that means the local pharmacy has to invest more about 10,871.91 Baht for covering the EENT drug list.
TABLE 4
THE AVERAGE COSTS THAT NEED TO INCREASE WHEN THERE HAS ONE TREATMENT COURSE

<table>
<thead>
<tr>
<th>Type of Drug</th>
<th>The cost when all list completes (Baht)</th>
<th>% of the missing items (%)</th>
<th>The cost according to the percent of the missing items (Baht)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pills, capsules</td>
<td>1,050.01</td>
<td>38.89</td>
<td>408.35</td>
</tr>
<tr>
<td>Ear drop</td>
<td>149.74</td>
<td>70.00</td>
<td>104.82</td>
</tr>
<tr>
<td>Inhaler</td>
<td>5,370.73</td>
<td>45.33</td>
<td>2,434.55</td>
</tr>
<tr>
<td>Eye drop</td>
<td>10,516.34</td>
<td>61.82</td>
<td>6,501.20</td>
</tr>
<tr>
<td>Syrup, powder, solution</td>
<td>361.45</td>
<td>30.48</td>
<td>110.17</td>
</tr>
<tr>
<td>Other drugs</td>
<td>2,500.61</td>
<td>52.50</td>
<td>1,312.82</td>
</tr>
<tr>
<td></td>
<td>9,948.88</td>
<td></td>
<td>10,871.91</td>
</tr>
</tbody>
</table>

Average revenue, average expense and operation profit of 10 local pharmacies were investigated in order to find cost-effective of the model. Data are shown in Table 5.

TABLE 5
SUMMARIZE THE AVERAGE REVENUE AND AVERAGE EXPENSE PER MONTH OF 10 LOCAL PHARMACIES IN BAHT.

<table>
<thead>
<tr>
<th>Revenue and Expense details</th>
<th>Value (Baht)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average revenue</td>
<td>102,500</td>
</tr>
<tr>
<td>Medicine cost (70%)</td>
<td>71,150</td>
</tr>
<tr>
<td>Average Expense</td>
<td></td>
</tr>
<tr>
<td>Labor cost (not including pharmacist)</td>
<td>18,250</td>
</tr>
<tr>
<td>Public utility expense</td>
<td>2,130</td>
</tr>
<tr>
<td>Others expense</td>
<td>2,020</td>
</tr>
</tbody>
</table>

From table 5, the difference from the average revenue and the whole cost of the local pharmacy is 8,350 Baht or the average operation profit of the local pharmacy is 8.15 percent from average revenue.

Opinion on the investment of 10 local pharmacies when becoming the network

The opinion of all pharmacies is that it is not necessary to invest in expanding the area of the pharmacy and medical supplies warehouse. In addition, when becoming the pharmacy in the network it will result in the increased revenue by 10 percent because of the increased reliability of the pharmacy in the eye of customers. Moreover, the pharmacies estimate the investment to increase when becoming the pharmacy in the network and result in the increase revenue 10 percent in table 6.

TABLE 6
ESTIMATED COST INCREASE

<table>
<thead>
<tr>
<th>Subject of concern</th>
<th>Average increasing in total investment (Baht)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Building / area</td>
<td>0.00</td>
</tr>
<tr>
<td>Equipment</td>
<td>4,700</td>
</tr>
<tr>
<td>Medicine cost</td>
<td>10,871.91</td>
</tr>
<tr>
<td>Labor cost</td>
<td>0.00</td>
</tr>
<tr>
<td>Total</td>
<td>15,571.91</td>
</tr>
</tbody>
</table>

Table 6 shows the average increasing in total investment is 15,571.91 Baht while the revenue increase 10 percent or the revenue increasing 10,250 Bath and average revenue will be 112,750 Baht. The calculation of payback period is 2.21 months. This cost of additional inventory apparently is not high and is acceptable by the pharmacies.
Part III: Apply the model of hospital-pharmacy network by using the data from Part I and Part II

From three majors’ perspective concern of becoming the healthcare network as Ratanavichitsilp (1998) suggested are service, financial, and management arrangement. In this study only the financial arrangement was focused on. The developed model is related to the benefit of 2 parties which are the pharmacy department of the big hospital and the local pharmacy. The idea of model is to keep hold of the benefit of all related parties by bring out the strength points of all related parties and then allocate the benefit accordingly on the basis of feasibility.

**Strength points**

The strength of the hospital is the power of purchasing negotiation, the intensity of technical knowledge, the reputation and reliability. The local network pharmacies’ strong point is the presence of pharmacist at all time in the open hour. The atmosphere is comfortable so the people who get the medicine could receive the pharmacist suggestion without a rush. In addition, the pharmacy is the primary health service unit for the people that there are lot outlets closer to home. So it will be more convenient for patients.

Previously, the hospital makes the gross profit is 29.53 percent of the sale amount or made the operation profit is around 12.07 percent of the sale amount. Therefore, at the beginning, it has to keep the operation profit 12.07 percent for the hospital when the local pharmacy become in the network. The hospital’s operation cost was 17.46 percent at the beginning of the model. The budget is covered for the pharmacy and the central department.

<table>
<thead>
<tr>
<th>TABLE 7</th>
<th>SUMMARY OF COSTS AND REVENUE EXPECTATIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sales price</td>
<td>Hospital</td>
</tr>
<tr>
<td>Cost</td>
<td>70.47</td>
</tr>
<tr>
<td>Gross profit</td>
<td>29.53</td>
</tr>
<tr>
<td>Operation cost</td>
<td>17.46</td>
</tr>
<tr>
<td>Operation profit</td>
<td>12.07</td>
</tr>
<tr>
<td>Expected profit when become network</td>
<td>At least 12.07</td>
</tr>
</tbody>
</table>

Table 7 demonstrates an initial allocation of benefits for each party, now it has 29.53 percent that is the average gross profit of hospital for starting this model. The hospital accepts the benefit at 12.07 percent while pharmacies 8.15 percent and the central department at least 5.78 percent. Hence, the required benefit that 3 parties is 26.00 percent. In addition, with more efficiency management administration and operation costs could be reduced.

Using model proposed in Section 3, the central department sets the same wholesale price, \( W_i \), to both hospital and pharmacies and set the standard price to sell to the patients at \( P_i \). Where, \( P_i \) is the base-stock level of item \( j \) determined by the central department for pharmacy \( i \). The central department give the local pharmacy a \( \% \) rebate or 8.15 percent from the value of \( e_{ij} \). when \( e_{ij} \) is a value of medicine from prescription. Given \( \sum_{j} \pi w_j q_j = \$ \) 50,000, \( e_i = 28,370 \), the transfer payment with the rebate contract of the pharmacy \( i \) to the central department allow equation (1) is \$28,370. Whereas hospital transfer payment to the central department allows the equation (2), given \( \sum_{j} e_{ij} = \$5,000,000 \) and \( P_i = 12.07 \) percent, is \$4,396,500. While the cost of the central department to pay allows equation (3) is the actual cost of purchasing goods from the suppliers and the central department’s gross profit is 9,396,500- 6,833,123 = \$2,563,377 when the \( P_i \) value is about 70.47 percent or \$6,833,123. When the operation cost is about 5.78 percent of the revenue or \$543,118, the central department still has the operation profit equal to \$2,563,377- \$543,118 = \$2,020,260 which therefore is attractive for investment.
CONCLUSION AND RECOMMENDATION

This model is very useful for changing the responsibility of dispensing medicine from out-patients pharmacy to local pharmacy by improving the quality of life of patients without a major change in reimbursement rules and the involved parties’ incomes are not reduced. With better operation synchronization, the profit could be increased. The model based on the balancing the returns of two parties that are hospital and pharmacy in order to better service patients. In our model, the gross profit need to be split to satisfy two parties and left just enough for the third party, the central department. However, more benefits could come from the supplier in form of management fee. When applied the VMI concept with rebate contract to the business process, the cost could also reduce. Moreover, from the mathematical model, three parties must conduct meetings to conclusion the suitable retail price, the wholesale price, the rebate for adjust the reasonably price in advance.

From the model of the pharmacy service providing to the outpatient of the hospital through the pharmacy, it is found that the model could satisfy the requirements of both the hospital and the pharmacy in the network. In addition to monetary benefit, hospital network has also been a powerful warehouse management system that easy to manage and response faster while hospital do not have to intense in the medicine warehouse and worry about dispensing quality. The most important prospect is the improved overall quality of treatment for patients.

The contribution of the proposed model is for the development of national health system without a major change in reimbursement rules and do not affect their income of the parties involved. The limitation of our model is demonstrated only one hospital in the hospital-pharmacy network. In addition, the benefit from supplier’s credit term has not been included in our model yet. For the future research the model will be extended to other hospitals that have own clients pharmacy which one pharmacy can be more than one hospital host, financial of regulations, and try to uncovered the most effective contract for the model.

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MANAGING THE BULLWHIP EFFECT IN AN ASIAN-EUROPEAN ELECTRONICS SUPPLY CHAIN

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ABSTRACT

As demand for consumer goods decreased significantly after the financial, banking and economic crisis in 2007, the intercontinental flows of information, goods and services had been disrupted. The production forecasts became invalid and demand more unpredictable in quantity and quality. The logistics processes that connected the Asian with the European supply chains had to face enormous challenges of satisfying highly uncertain but often urgent demand with time consuming common transportation (sea freight) or costly air freight. Presuming that demand satisfaction is at least uncertain, some clients placed “blind” or “double” orders. Besides such exogenous factors, also internal causes led to a higher demand variation, e.g. if the sales department leveraged the safety stocks. The effect of a higher demand variation over a supply chain is described as “bullwhip-effect”. Since Forrester (1958) discovered around 45 years ago that variations of demand (and based on that the variations of orders and stocks) are increased up the supply chain from customer to supplier, researchers look for reasons and try to find countermeasures. While in-depth academic analysis has been conducted for retail markets, very little research has been done on this in global business-to-business networks with relatively little empirical evidence. Therefore we used a case study approach of one global (resp. Asian-European) supply network in order to identify endogenous causes and counter-measures for demand variation. We analyzed the effects of changed demand on production and transport and clustered counter-measures with respect to information and behavior uncertainties. On basis of a literature review we will conceptualize the bullwhip-effect in global supply chains and illustrate our findings with a case study of a 2nd tier supplier of automotive electronics. The findings are clustered into potential managerial initiatives, which reduce behavioral and information impact on the bullwhip-effect.

KEY WORDS
Supply Chain Planning, Bullwhip Effect, Global Supply Chain Management, Electronics Industry

INTRODUCTION

Early findings have shown that a close cooperation of different organizations in one supply chain may decrease costs and optimize the flow of goods and information (Forrester 1958, Forrester 1961). Lacking coordination of demand and supply information is one of the main causes for demand variation which propagates upstream with amplification occurring at each echelon of the supply chain. Lee, Padmanabhan, and Whang (1997a) and Lee, So, and Tang (2000) popularized the term “bullwhip-effect” for this phenomenon of demand distortion. The bullwhip effect has been documented as a significant problem for modern supply management in an experimental context (Sterman 1989) and in a wide variety of companies and industries (Buzzell et al. 1990; Kelly 1995; Holmstrom 1997; Metters 1997; Warburton 2004). It appears that the bullwhip effect has a number of negative effects that cause significant inefficiencies, e.g. excessive inventory investments throughout the supply chain, poor customer supply service and lost revenues due to shortages, misguided management decisions regarding procurement, production, and logistics capacities (Lee et al. 1997a; Carlsson and Fuller 2000).

In-depth academic analysis has been conducted on the bullwhip effect for retail markets and operational causes such as demand signal processing, inventory rationing, order batching and price variations (Lee et al. 1997a; Chen et al. 1998; Cachon 1999). In the last years, also behavioral causes of the bullwhip effect have been investigated (Croson and Donohue 2006). Many proposed countermeasures have a history of successful application (Clark 1994; Gill and Abend 1997; Hammond 1993; Towill 1997). Oftentimes simulation is used to analyze and optimize a specific cause of demand variation (e.g. Banks and Malave 1984). On the other hand, if everybody reacts to the bullwhip effect with the same
counter measure, e.g. exponential smoothing technique, the demand variation will amplify up through the supply chain (Carlsson and Fuller 2000).

In contrast to this, the goal of this paper therefore is to shed light on a specific global (Asian-European) business-to-business network using a single case firm and its intra-logistic problems with the bullwhip effect. While many authors focus on retail and consumer industries, very little research has been done on global business-to-business networks in the automotive industry. Also, this paper tries to explain and illustrate the challenges of Asian-European supply networks regarding the bullwhip effect and presents the counter measures taken to reduce the operational and behavioural causes. Due to the specific circumstances of an Asian-European intra-logistics supply network, e.g. transport schedules, delivery time, we do not suggest a simulation-based optimization of single causes, but rather a general management approach to reduce the bullwhip effect.

Firstly, we are using a deductive approach and present brief insights of about 40 years of research in this field in our literature review. Then we introduce the case study as an empirical example for the illustration of the causes, effects and counter measures of the bullwhip effect. This is followed by the findings which we present in form of three managerial initiatives, which should reduce behavioral and operational causes of the bullwhip-effect. This paper concludes with a brief discussion and reflection of our findings.

**BRIEF REVIEW ON THE BULLWHIP EFFECT**

After introducing the problem of this paper, this section provides a brief review of the bullwhip effect. In our study we followed a three step analysis framework which firstly examines the causes of demand variances, then analysis the (negative) effects for the supply chain and finally proposes possible counter-measures (Scholz-Reiter 2005; Chen et al. 2000).

Analyzing the bullwhip effect, the researchers focus on linear supply chain models, whereas the flow of goods is strictly linear with a reverse flow of information (Chen et al. 2000; Lee et al. 1997a; Metters 1997). If the variance of the orders of one echelon in the supply chain is higher than the variance of the received orders of the same echelon, then we have a bullwhip effect (Cachon et al. 2007).

Five main causes of the bullwhip effect have been identified: the misinterpreting of demand information (forecasting), supply shortages, nonzero lead times, batch ordering, and price variations e.g. price promotions (Lee et al. 1997a and 1997b). In addition, simple mathematical models demonstrate that the bullwhip effect is an outcome of the strategic interactions among rational supply chain members (Lee et al. 1997b).

Carlsson and Fuller (2000) summarized the effects of the bullwhip effect following Lee et al. (1997a and 1997b):

1. Exaggerated inventory investments throughout the supply chain as all supply chain members need to safeguard themselves against the demand variations.
2. Poor customer service if one member of the supply chain runs out of products due to the variability and insufficient means for coping with the variations.
3. Lost revenues due to shortages, which have been caused by the variations.
4. The productivity of invested capital in operations becomes substandard as revenues are lost and capital is invested in inventories.
5. Decision-makers overreact to the demand fluctuations and make investment decisions or change capacity plans to meet peak demands. Such decisions are probably misguided, as peak demands may be eliminated by reorganisations of the supply chain.
6. Demand variations cause fluctuations in the planned use of transportation capacity. This will again produce sub-optimal transportation schemes and increase transportation costs.
7. Demand fluctuations caused by the bullwhip effect may cause missed production schedules, which actually are completely unnecessary, as there are no real changes in the demand, only inefficiencies in the supply chain.

Whereas some effects are the results of rational decisions of the supply chain members (operational causes), irrationality or opportunistic behaviour (behavioural causes) is another source of the bullwhip effect (Croson and Donohue 2006).

Counter measures focus either on operational or behavioural causes, but can also optimize both sources of the bullwhip effect. At this point, we want to stress three major counter measures: (1) Improved information of each supply chain member in order to enhance the basis for rational decision making; (2) Improved coordination of capacities and
batch orders in order to control the behaviour of single supply chain members; (3) Improved structure of the supply chain in order to reduce lead times (Lee et al 1997b; Bhattacharya and Bandyopadhyay 2010).

Another important measurement for retail industries – “everyday low prices” – aims at smoothing the demand of the end-customers (Lee et al. 1997b). As this paper focuses on a case firm and its intra-logistic, prices are not as important.

CASE STUDY SUPPLY NETWORK

The analysed case firm is a 2nd tier supplier of the European automotive industry. For this study we focused only on the logistics processes within the case firm (“intra-logistics”). We held several workshops at the European headquarters and interviewed five supply managers in four different organizational units. Additionally, we analysed purchasing, sales and forecast data. We studied the developments in the case firm starting from 2008 up to 2011.

At the beginning of our study, the structure of the supply network connects the Asian production units (factories) in China, Japan, and other countries by ship or plane with the European central or national warehouses. From these the clients in the automotive industry are supplied. The reverse information flows from the clients in either a national subsidiary or a national sales office (e.g., Germany, Italy, France etc.) of the European headquarters. The orders are then forwarded to the headquarters. The role of the Asian central headquarters of the case firm (which shall not be discussed in this paper) coordinates all orders from the world, including the orders of the regions North-America, South-America, Africa and Asia. This has led to a supply structure with many but unclear roles and responsibilities. A strict control of every order was not possible, because the subsidiaries had their own stock (Figure 1).

FIGURE 1
SUPPLY CHAIN NETWORK OF THE ELECTRONICS PROVIDER (SOURCE: AUTHORS’ PREPARATION)

The bullwhip effect can be shown comparing the variances of all outgoing goods with the variances of all incoming goods (Cachon et al. 2007). For the case firm, a bullwhip effect could be detected particularly in 2009. That year, the worldwide financial and economic crisis caused a significant decrease in the demand for automobiles, which forced European politicians to take action for protecting the automotive industry. In leading markets such as Germany or France so-called car scrap bonus systems were used to stimulate demand. The financial-economic crisis and the counter-measures led to several effects.

Firstly, demand decreased due to the crisis. The case firm had enormous problems with the capital lock-up of their stocks. In the most striking example, products had already been shipped Europe although it was clear that no client would need that delivery anymore. In order to reduce the capital lock-up in the central and national stocks and to get more stockage, some – older – electric devices were even scrapped up.
Then, due to the bonus systems in leading markets, the demand unexpectedly increased. This led to a bottleneck situation and demand exceeded the supply by several times. In order to somehow satisfy demand, the Asian factories produced at the ultimate limit and the electronic products of the case firm were transported to Europe by costly air freight. As the bonus system ended (2010), demand decreased again, due to a satisfied market situation. Production capacities again exceeded the demand by far. Altogether, the automotive industry and our case firm faced enormous challenges in the period from 2008 to 2010. (Figure 2).

**FIGURE 2**
**COMPARISON OF THE VARIANCES OF PURCHASES, SALES AND FORECASTS**

![Graph showing comparison of variances of purchases, sales, and forecasts](image)

Source: Croson, Donohue (2006), P. 329

**INFORMATION AND BEHAVIOR – MANAGERIAL INITIATIVES**

In this section we present the chosen counter measures of the case firm to reduce the bullwhip effect and the logistics footprint. According to the introduced counter measures, three main initiatives have been realized: a reorganisation of the supply chain structure, a change in the coordination and information system and the implementation of a forecast instrument.

**Reorganisation: Implementation of a central supply chain management**

The most challenging initiative for the case company was the transformation of the supply chain structure. Considering the flow of goods, there is now a strict policy with either direct delivery to the clients or deliveries to the central stock. This reduced “double” safety stocks in national and central inventories and enhanced the transparency. Considering the information flow, the objective was to avoid double structures and to reduce the number of interfaces. Therefore the national subsidies were transformed into national sales offices (“one face to the customer”). As sales offices, they are not allowed to have any own stock anymore. All goods have to be handled via the central warehouse of the European headquarters. At the same time, the European headquarters enforced the role of its central supply chain management department, which is now the connecting link of all European orders to the Asian factories. Altogether, the new supply network gave clear roles and responsibilities to each actor in the network, which reduces operational and behavioural causes of the bullwhip effect.

**Process Engineering: Bottom-Up and Top-Down Information Sharing/Decision Making**

The enforced role of the central supply chain management department allowed implementing a new method of capacity and batch order coordination. Firstly the national sales offices and the central supply chain management department have access to the same database. There is a transparent information technology tool in place. The national sales offices place their demand in the system (bottom-up) and the central department is strategically coordinating (top-down), e.g. considering key customers. This bidirectional information sharing and central coordination mechanism
reduced “blind” orders, risk-averse safety stocks and other behavioural causes of the bullwhip effect to an absolute minimum. Additionally, this also reduced the necessity for costly expedite shipments, as the central coordination also smoothed the demand orders of the sales offices.

**Controlling: Implementation of a forecast instrument**

As a third management initiative, a specialised forecast department has been built up. This department concentrates on the forecast of the automotive demand in Europe, provides additional information for rational decision making, and supports the central supply chain department with forecast data in case of coordination conflicts with either the national sales offices or the Asian factories. Roughly once a month, all forecast figures are collected and sent to the Asian factories by this department. With these data, the factories can manage their production planning more smoothly which also helps to reduce lead times.

Altogether the case company has implemented three main initiatives, which had significant impact on the stock levels and lead times. This is mainly the effect of reducing double or redundant interfaces in the information as well as in the logistical flows. Bidirectional information flows and a simple traffic light alarm system in connection with a top-down decision making in critical issues optimized behavioural causes of the bullwhip effect, e.g. “bottleneck-panic”, “blind orders”. The structure of the transformed supply network is as follows (Figure 3):

![Figure 3](image-url)
DISCUSSION AND CONCLUSION

This paper intended to analyse the bullwhip effect in an Asian-European business to business intra-logistics network in order to identify and evaluate management initiatives for reducing demand and stock variances. To do so, we first presented a brief literature review on the bullwhip effect, which is traditionally examined for retail markets. We adopted the concept on a global supply chain situation in the automotive industry using a case study of a 2nd tier electronics supplier. This provided the basis to present counter measures against the bullwhip effect in form of three management initiatives.

The bullwhip effect had significant impact on the supply chain of the case firm, demonstrated in the extreme differences of the variance of demand and supply. Counter-measures (managerial initiatives) like a central supply management, an improved information sharing between the organizations involved and an optimized controlling (forecast) led to a significant reduction in inventories. As opposed to former times, reduced stocks did not increase the danger of stock-outs implying costly air freight transports. The delivery performance has increased and dead stock or overstock was minimized.

This brief study on the bullwhip effect is limited in the sense that only one case was examined. However, we are confident that the extracted findings may apply to numerous firms which operate in the Asian-European logistics. Nevertheless, we suggest further research, on the one hand side to collect broader empirical evidence by examining other and more cases and on the other to align demand and supply in order to reduce the logistical footprint in total.

REFERENCES


CONTROLLING INVENTORY IN MANUFACTURING INDUSTRIES BY EFFECTIVE SUPPLY CHAIN MANAGEMENT

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ABSTRACT

Manufacturing companies are facing problem of the increasing product variety and inventory costs in supply chain. Inventories exist throughout the supply chain in various forms for various reasons and carrying these inventories can cost anywhere from 20 to 40% of their value a year. An attempt has been made to develop the decision support model for the design of supply chain management system in manufacturing industries that are based upon the inventory control at optimal level. Our research paper focuses on the practical issues of supply chain design in manufacturing industries. Recent years, researchers and practitioneres have explored different process and investigated individually within manufacturing supply chains. Attention has been given to the performance, design, and analysis of the supply chain as of increasing manufacturing costs, resources shrinkage, shortened product life cycles, and the globalization of market economies. One of the most important aspects of supply chain management is inventory control and a little work is available on controlling it and keeping it at optimal level in manufacturing sector to produce cost effective product. Our research focus is on the identification of control points i.e. to locate the output buffers, allowable container/batch sizes, optimal inventory levels, and ability of systems to automatically adjust to stochastic demand. Deviations from the plan are instantly to be highlighted and assuring that the performance of every inventory decision point in the supply chain is measured and communicated continuously and to all relevant departments for corrective action. The objectives of this paper are to: (1) provide a focused review of literature in multi-echelon supply chain modeling and (2) define a research agenda for controlling inventories in manufacturing sector and (3) development of conceptual framework of inventory control supply chain system in manufacturing sector.

KEYWORDS
Supply Chain, Production, Inventory, Manufacturing

SUPPLY CHAIN MANAGEMENT DEFINED

As the use of the supply chain got increase various definitions of the term SCM have been offered. The APICS Dictionary describes the supply chain as:

1. The processes from initial raw materials to the ultimate consumption of the finished product linking across supplier user companies; and
2. The functions within and outside a company that enables the value chain to make products and provide services to the customer (Cox et al., 1995).

Waller (1999), looking into the activity which the enterprise performs then defines the supply chain management for it, states, in manufacturing this supply chain is the linkage for the physical movement of all materials from suppliers, through transformation and then as finished goods for the customer. However, whatever organization is concerned, within the supply chain there is always an information flow back from the customer to the provider of the service.

Monczka and Morgan (1997) believe that supply chains and not firms compete, and that those who will be the strongest competitors are those that “can provide management and leadership to the fully integrated supply chain including external customers as well as prime suppliers, their suppliers, and their suppliers’ suppliers”.

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SUPPLY CHAIN MANAGEMENT FOR MANUFACTURING

Business vital and prime strategic part is manufacturing system. To remain in the market competition the management of the manufacturing operations decides its strategic potential. Without exception, when the manufacturing operations functions fail to contribute significantly, its a failure of top management (Kasul et al, 1995).

Customer satisfaction is due to right production capability to make money from with high quality services and products at the right price and delivered at the right time. The success of the operation is success as being a matter of flexibility to the changing of customers’ demands. This flexibility response is about strategy and the organization always focusing on customer satisfaction, which is a dynamic environment.

Manufacturing aims and objective can be achieved by delivering the best performance in Quality, Lead Time, Cost and Customer Services and this can be achieved through Continuous Improvement in Just–in –Time (JIT) Manufacturing, Total Quality Management (TQM) and Employee Involvement” (Keegan, 1997). The supply chain management is synchronization of a corporation’s operation and those of its corresponding suppliers in order to match the flow of materials, services and information with relevance to customer demand. To achieve important competitive priorities Supply-chain management has strategic implications over world-class manufacturers. Internal SCM is the back bone of co-ordination of key operations in the enterprise such as purchasing, production, information systems, and logistics, and external SCM is to close the gaps between outside enterprises, vendors and partners.

Supply-chain integrated processes are a series of stages in the beginning; manufacturers consider their vendors and customers to be independent of their operation. Relations with these entities are formal and there is little sharing of operating information and costs. Internally, purchasing, production control, and distribution act independently, each optimizing its own activities without considering the other entities. Each external and internal entity in the supply chain controls its own inventories, and often utilizes control systems and procedures that are incompatible with those of the other entities. Because of organizational and functional boundaries, large amounts of inventory exist in the supply chain and the overall flow of materials and services is ineffective.

In Phase 2, the firm initiates internal integration by combining purchasing, production control and distribution into a solid internal supply chain. Manufacturers in this stage utilize a seamless information and materials control system from distribution to purchasing, integrating marketing, finance, accounting and operations. Focusing on efficiency and electronic linkages to customers and suppliers are aspects that are embraced in this stage of progress toward full integration; the direction of data flow should be revealed and practiced by all activities and procedures. Nonetheless, the enterprise still considers its vendors and its clients/customers to be independent entities and focuses on tactical rather than strategic issues. The following step will be external integration, which we can call Phase 3. While internal integration must proceed it asks to be extended, to embrace vendors and customers, which defines the external integration term. During this stage, manufacturers need to alter their focal point from a service/product orientation to a customer orientation. For its industrial customers, the enterprise firm must develop a holistic understanding of their product, culture, market, and organization. The manufacturer strives to co-operate with its customers so that both can benefit from improved flows of data, materials and services rather than the traditional reaction of customer demand. On the other hand, manufacturers also need to have better understanding of its vendors’ organizations, capacities, strengths and weaknesses, and should include its suppliers earlier in the design process for new products or services. Phase 3 embodies what we define as Supply-Chain Management, the merging and integrating the internal and external supply chains.
SUPPLY CHAIN MODELS: A LITERATURE REVIEW (PAST, PRESENT AND FUTURE)

Supply Chain management started about in early 1950’s. Researchers have shown their interest in developing policies related to optimal inventory management. The first work in this field was development of model by Clark and Scarf (1958) and this is about managing inventories at multiple -echelons. Efforts were made by researchers to control inventory in stochastic and deterministic environments over the last half a century. Mainly research was carried out in the area of transportation, distribution and location models. Optimal policies were developed in specific supply chain issues and it was assumed that control is centralized. Later on researchers studied decentralized multi-agent approach to analyze supply chain problems, and development of new models for demand forecasting and product design. Example is the work of Tayur, Ganeshan and Magazine (1999). Some of the firms had put their efforts in this regards and successfully developed and employed large analytical and simulation models for supply chain optimization and execution. Like Arntzen et. al. (1995). Challenges of firm were at their peak in the twenty first century, due to global competition and customer requirement for greater variety, shorter and reliable delivery times and lower prices. The advent of electronic commerce has created immense opportunities but at the same time has made firms more vulnerable to logistics pitfalls. Today customers do not just buy products but they buy delivered products.

Need arises that an environment, firms need to develop greater trust so that they would be willing to share information with their supply chain partners and new models and analysis need to be developed. Moreover, issues related to coordination of global supply chain management are also important part of supply chain management. Another problem is that supply chain more complicated due to the inability to store inventory. Uncertainty is handled in those cases using additional buffer capacity. Now researchers are more concerned in internal supply chain in which products are kept at optimal level in the industry in order to be competitive in the market and availability at low cost to the customer.

INTRODUCTION

The problem of managing the inventory of a large number of items is very complex and industries are hit by it. To cover flexible demands development of an Expert system for the selection of model type for maintaining inventory at optimal level at inventory control points of a Flexible Manufacturing System.
Let the system under consideration consists of group of different machine cells. Each cell has limited capacity of keeping inventory in buffers. The system can process a number of assembly types. The production-scheduling problem is to develop an Expert system, which helps the system to select and change the models required to deal with particular situation. The objective is to keep the inventory level at a point where system maximize the machine utilization and minimize delays in order to reduce the overall cost of the products.

Inventory control parameters are encoded into rules such as a reorder point (s) and a reorder quantity (Q) or an order-up-to-level (S). The order quantity is predetermined or raised to level S as per policy. This is having impact upon the inventory holding cost and customer service. A change in the value of the reorder point may cause excessive or shortages resulting in loss of sales. Inventory managers have to take care of all the items and update of inventory and needs monitoring to multiple parts in a dynamic environment. Data analysis and model selection takes time and in our research work we have address it and applied an expert system for decision support in the area of inventory management to give better results in this dynamic area.

We have considered some important factors like, price, demand, suppliers, lead times, number of inventory control points with in the manufacturing company. Managers with in the organization are concerned with:

a. Enough quantity of parts and material;
b. Enlist slow and fast moving parts;
c. Provide accurate, concise and timely reports to top management;
d. Accomplishment of goals. This paper provides the minimization of gap between theory and practice of inventory control operations. To achieve this goal, we have designed and implemented the conceptual foundation of an expert system for inventory control. This study is helpful to the decision makers who want to make intelligent decisions. Their decision will not be burdened by the complexity and details of inventory control theory and can consult with the expert system for advice. It provides best possible solution as the knowledge is extracted from expert domain. Our expert system is having different models that are used in inventory control and rules that provide justification for those models. It is having mathematical modeling, reasoning knowledge for selecting the most appropriate model for the respective problem and situation.

WHY EXPERT SYSTEM

Expert systems have been successfully used as tools to aid decision making in a number of operations research applications (Bonczek et al., 1980).

Inventory management operates in a dynamic environment expert system provides decision aid in controlling it. Managers are facing problem in (a) Model selection (b. Model solution as there is a gap between theory and practitioner. The expert system is designed to address these issues. The output generated by the expert system includes when and how much to order, total inventory cost, turnover ratios, batch size and others. Following conditions are considered:

1. Manager constraints: (a) budget, space constraints, (b) minimum order quantity, fixed replenishment time, and, (c) minimum tolerable service level.
2. Supplier characteristics canalization.
3. Demand pattern: a data base containing historical item demand data.
4. Inventory knowledge base: the wide variety of inventory control models for single-item replenishment.
5. Interrelationships among data: the reasoning required for selecting those inventory control models
6. Solution knowledge base: The solution procedure varies by model from a simple algebraic expression to simulation. Selecting model approximations is also an important procedure. The expert system is implemented using an expert system shell called “VP Expert Shell.” An expert system shell facilitates the development process. This tool can integrate the expert system rules with the use of a database management system spreadsheet analysis, report, and graphics generation tools.

KNOWLEDGE REPRESENTATIONS

Knowledge gathered by the knowledge engineer is stored in knowledge base and historical data base. They are: (1) an inventory model knowledge base that contains knowledge that associates demand, replenishment, and cost parameters to an inventory control model, (2) a solution knowledge base that contains the knowledge particular to select a solution
procedure and implement it; and (3) the historical data base which contains data about item demand, replenishment, and cost. This data is helpful in selecting an inventory model and to achieve the goals of minimizing the overall cost.

**Inventory Model Knowledge Base**

This knowledge base deals with the selection of particular model and is concerned with the selection of an appropriate inventory model that suits the problem like single item, one location inventory. Factors affecting in categorization of model are:

1. **Type of Demand:** The following demand categories are considered:
   - (a) Pertaining to deterministic environment, with a known demand;
   - (b) Pertaining to probabilistic environment, with a known probability distribution;
   - (c) Pertaining to uncertain environment, with an unknown distribution of demand.

2. **Type of Supply Process:**
   - (a) All material ordered are received after a known lead time;
   - (b) All material ordered are received after a random lead time, assuming mean and variance are known.

3. **Types of Shortages:**
   - (a) Unfilled demand is back ordered;
   - (b) unfilled demand is lost.

4. **Type of Review Period:**
   - (a) Continuous review models, after each transaction inventory is reviewed;
   - (b) Periodic review models, after periodic intervals inventory is reviewed.

5. **Types of Costs:** Replenishment or ordering costs, carrying costs, and cost of shortages.

6. **Control procedure:**
   - (a) A fixed quantity Q is ordered as soon as the inventory level reaches s.
   - (b) The order is placed when the inventory position is at or below s.
   - (c) An order is placed every t time.

In diagram 3, we present a decision tree for selecting the inventory model for a single item giving the factors mentioned previously. Note that decisions pertaining to the probabilistic lead time case are not shown. Each node on the tree represents a decision. Each branch on the tree represents the criterion/factor that applies or is considered. The decision tree in Figure 1 establishes the foundation for the model selection.

**Solution Knowledge Base**

After the identification of inventory model expert system finds a solution that is based upon increase or decrease of its characteristics. These characteristics are tabulated in table 1.

The following strategy was applied in the implementation of expert system.

1. Find an exact solution. If exact solution is not found then approximations are determined by considering particular conditions. Check the historical data base to ascertain the application of condition and use the approximation model. If approximation does not work use analytical model. Use a simulation routine to find a pseudo-optimum solution.

An exact solution is commonly found for the deterministic demand and lead time. Most approximations have been formulated for a specific demand distribution (Wagner, 1975). Many can be applied only when the coefficient of variation is small (see Sahin & Sinha, 1987). Others can be solved analytically only if one of the variables is fixed. In order to solve the model, the expert system must have the ability to analyze the model parameters. It must, therefore, be able to retrieve the information regarding demand and lead time by analyzing the historical data base. Statistical analysis can be performed to calculate the mean and standard deviations for the item demand. The coefficient of variation can then be derived and its magnitude analyzed. Similar analysis can be performed on the lead time from each supplier. The demand distribution can also be determined by using a Chi-squared test.

Database for the product's characteristics (i.e., demand and supply) and displays those for the item, if found.

The user can then modify any of the information and add operational constraints. If the product is not in the database, the user is prompted for the required characteristics of the product. The Rule Set Sequence uses reverse reasoning to locate the appropriate control model for the product's inventory. With information provided by the Initialization Sequence, premises are validated and rules are fired until the model selection process is complete. Upon its completion, the procedure
knowledge base is accessed to generate either a feasible or an optimal solution to the selected inventory model given the product's characteristics. The Completion Sequence is then invoked to display the results of the expert system consultation. It can also be used to generate the reasoning for the selection process. Once the consultation process is completed, the user can invoke another consultation by changing any of the product's characteristics and/or constraints, or by selecting a new product. We present a sample consultation of the expert system in the Appendix.

Development of an Intelligent System

The problem of managing the inventory of a large number of items is very complex and industries are hit by it. To cover flexible demands develop an Expert system for the selection of model type for maintaining inventory at optimal level at inventory control points of a Flexible Manufacturing System.

Inventory Planning Decision Logic

Notation of Decision logic for an Inventory Planning

Let
\[ \begin{align*}
D &= \text{Gross requirement (Demand)} \\
S &= \text{Qty to be produced in period t} \\
I_t &= \text{Projected on hand inventory} \\
N_t &= \text{Net requirement for period t} \\
A &= \text{Setup or Purchased cost} \\
h &= \text{Holding inventory cost} \\
P &= \text{Period} \\
C &= \text{Unit production cost.} \\
F &= \text{Order Frequency.}
\end{align*} \]

FIGURE 2
DECISION LOGIC
FIGURE 3
DECISION TREE FOR EXPERT SYSTEM

**Deterministic**
- Demand = Fixed
  - Back Order = Yes
  - Simulate
- Demand = Varies
  - Review = Continuous
    - Lost sale = Small
    - Lead Time = Probabilistic
    - Use Simulation
  - Review = Periodic
    - Lost sale = Large
    - Time for order varies
      - Use approximation
- Inv Control

**Probabilistic**
- Back Order = No/Yes
  - Demand = Fixed
    - Simulate
  - Demand = Varies
    - Review = Continuous
      - Lost sale = Small
      - Use Backorder procedure
    - Review = Periodic
      - Lost sale = Large
      - Use Simulation
- Expert System

**Uncertain**
- Lead Time = Varies
  - Use domain knowledge
    - Approximate Demand, Use expert
  - Use Knowledge of Experts
    - Approximate Demand and Lead time,
      - Expert System
- Assess s, t, s
  - Expert System
- Demand and lead time varies
  - Assess Q, D, S, t
Writing the Rules

The system developed can be used to select the challenger tools for insertion in the tool slot. The system is constructed by extracting knowledge. Decision logic is constructed mathematically by breaking up knowledge and converted them into mathematical form in order to cover all possible conditions that can exit during the implementation phase. Expert thoughts and knowledge from decision logic is stored in the decision tree, which consists of circular nodes, arcs and decision nodes (rectangles). For further addition of rules, new nodes and branches can be added to the tree when additional attributes are needed. This whole knowledge is encoded in the form of production rules and each rule represents a small chunk of knowledge relating to the given domain of tool replacement. A number of related rules collectively responds outcome of some useful conclusions.

Path 1: 1, 3, 6, 11, 21. Part 2

The IF-Then is made up of the two parts. The IF part is comprised of conditions called clause and connected to one another by logical operators AND, OR. For example the path leading to conclusion 21 contains decision nodes 1, 3, 6, 11. The rule that generates this path is

IF 1
AND 3
AND 6
AND 11
THEN 21
IF Demand = Fixed
AND Lead Time= known
AND Mean and Variance = known
AND Back order = Yes
AND Ordering Qty= Fixed
AND Inventory = s
THEN Order sizes = Fixed Q
Place order after interval = t time

Similarly the following 9 paths can be drawn from the decision tree.

Path 1 1, 2, 5 Rule 9
Path 2 1, 4, 8, 15, 25 Rule 10
Path 3 1, 4, 8, 16, 26 Rule 11
Path 4 1, 4, 9, 18, 28 Rule 12
Path 5 1, 4, 9, 17, 27 Rule 13
Path 6 1, 4, 9, 19, 29 Rule 14
Path 7 1, 3, 6, 10, 20 Rule 15
Path 8 1, 3, 6, 11, 21 Rule 16
Path 9 1, 3, 7, 12, 22 Rule 17
Path 10 1, 3, 7, 13, 23 Rule 18
Path 11 1, 3, 7, 14, 24 Rule 19

CONCLUSION AND FUTURE RESEARCH DIRECTION

This research work provides methodology for making an expert system for Inventory control and comprises of mainly three parts, Introduction Supply Chain, Supply Chain in FMS, AI and Expert Systems, Methodology Expert System and Decision Logic for Inventory control system and software development and rules for VP Expert Shell. This research work will provide basis for: making right decision on model selection and is very suitable for real-time dynamic environment and will minimize the lost sales and maximize system utilization and makes it customer responsive. All conventional techniques are applicable to static environment and fails where the variant has slight exception or addition. This paper presents the development of a knowledge-based system for inventory management. The research work opens new avenues for future work. This field is new and study can be extended in several ways. Modification is easy and new information can be
added which are available for future reference. The research work is based on the condition that uses deterministic characteristics and probabilistic characteristics and unexpected breakdowns, refigturing, rework and tooling inventories lost. This can be improved by the addition of new dispatching rules. Research work will improve full utilization of manufacturing resources by having optimal inventories for the job at right time, and will minimize delays in production schedule, improve product delivery time, and will reduce costs associated with lower inventory. The system uses VP Expert development shell; it contains an inference engine, a user interface. It unable to process the strings but having ability to call programs made by procedural languages like, C++, C, and Basic. This paper describes the application of the system developed using a typical models.

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Logistics and Supply Chain Management
INCREASING EFFICIENCY AND REDUCING COST OF GREEN SUPPLY CHAIN: A CASE STUDY OF THAI FURNITURE INDUSTRY

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ABSTRACT

It has been increasing in environment responsiveness in recent years. People are aware of toxic substance usage, global warming, and non-replenish resource reduction. Numerous communities are aware of such problems and have developed and applied a concept of green principles to overcome the problems such as using the recycle papers for packaging, using environmental friendly raw material, and reducing the usage of petroleum power. Green supply chain was emerging and expanded to many organizations across supply chain. Managing green supply chain may cover all activities from upstream to downstream (i.e., product design to recycle) in different sectors such as manufacturing or service. Nevertheless, managing supply chain may need the measures and metrics in the success of an organization that has received much attention from researchers and practitioners. Green supply chain performance is found to have less attention due to the difficult of measuring toxic chemical substances usages or emission and waste that have an impact to environment. Therefore, the role of measures and metrics cannot be overstated because they affect strategic, tactical, and operational planning and control. The specific research objectives are as follows: 1) to develop a new theory and model of green supply chain performance index, 2) to assess performance index by developing green supply chain performance indicator, 3) to assess green supply chain cost analysis using regression model, and 4) to investigate the relationship between green supply chain performance and green supply chain cost.

KEYWORDS
Green Supply Chain, Furniture, Performance, Cost Analysis

INTRODUCTION

In recent years, it has been increasing in environment responsiveness. Nowadays, we are facing with environmental problems. People are aware of toxic substance usage, global warming, and non-replenish resource reduction. Numerous communities are aware of such problems and have developed and applied a concept of green principles to overcome the problems such as using the recycle papers for packaging, using environmental friendly raw material, and reducing the usage of petroleum power. Green supply chain was emerging and expanded to many organizations across supply chain, and is defined as “the process of using environmentally friendly inputs and transforming these inputs through change agents – whose byproducts can improve or be recycled within the exiting environment” (Penfield, 2007).

Managing green supply chain may cover all activities from upstream to downstream (i.e., product design to recycle) in different sectors such as manufacturing or service. Nevertheless, managing supply chain may need the measures and metrics in the success of an organization that has received much attention from researchers and practitioners. Green supply chain performance is found to have less attention due to the difficult of measuring toxic chemical substances usages or emission and waste that have an impact to environment. Therefore, the role of measures and metrics cannot be overstated because they affect strategic, tactical, and operational planning and control. It has a vital role to play in setting objectives, evaluating performance, and determining future courses of actions (Gunasekaran, 2004).

This Ph.D. research paper is aimed at investigating the performance index of green supply chain by proposing green supply chain performance model, and developing the green supply chain performance indicator along with green supply chain cost analysis using regression model. The green supply chain performance index to the company proposed in this study is developed based on a framework of the proposed model, and investigated by using a case study of furniture industry to identify the impact of green to the supply chain performance management. The specific research objectives are as follows: 1) to develop a new theory and model of green supply chain performance index, 2) to assess...
promoting environmentally-friendly practices. The results suggest that in order to be successful, environmental value chain. This taxonomy is then extended to develop a group of propositions concerning the role of management in industry to develop a taxonomy of environmentally-friendly ('green') best practices within the operations management.

Robert et al., (1998) draws on the results of interviews with five environmental managers in the furniture industry to develop a taxonomy of environmentally-friendly ('green') best practices within the operations management value chain. This taxonomy is then extended to develop a group of propositions concerning the role of management in promoting environmentally-friendly practices. The results suggest that in order to be successful, environmental management strategies must be integrated into all stages of the value chain, which includes all of the processes spanning product design, procurement, manufacturing and assembly, packaging, logistics, and distribution. While the potential for

**REVIEW OF LITERATURE**

*Thory and Definition*

Ecology is the scientific study of the distributions, abundance and relations of organisms and their interactions with the environment. Ecology includes the study of plant and animal populations, plant and animal communities and ecosystems. Ecosystems describe the web or network of relations among organisms at different scales of organization. Since ecology refers to any form of biodiversity, ecologists research everything from tiny bacteria's role in nutrient recycling to the effects of tropical rain forest on the Earth's atmosphere. The discipline of ecology emerged from the natural sciences in the late 19th century. Ecology is not synonymous with environment, environmentalism, or environmental science. Ecology is closely related to the disciplines of physiology, evolution, genetics and behavior.

Society or a human society is a group of people related to each other through persistent relations such as social status, roles and social networks. A large social grouping that shares the same geographical territory and is subject to the same political authority and dominant cultural expectations. Human societies are characterized by patterns of relationships between individuals sharing a distinctive culture and institutions. Without an article, the term refers either to the entirety of humanity or a contextually specific subset of people.

Economy consists of the economic system of a country or other area, the labor, capital and land resources, and the economic agents that socially participate in the production, exchange, distribution, and consumption of goods and services of that area. A given economy is the end result of a process that involves its technological evolution, history and social organization, as well as its geography, natural resource endowment, and ecology, as main factors. These factors.

Policy is typically described as a principle or rule to guide decisions and achieve rational outcome(s). The term is not normally used to denote what is actually done, this is normally referred to as either procedure or protocol. Whereas a policy will contain the 'what' and the 'why', procedures or protocols contain the 'what', the 'how', the 'where', and the 'when'. Policies are generally adopted by the Board of or senior governance body within an organisation where as procedures or protocols would be developed and adopted by senior executive officers. On the other hand, regulation is "controlling human or societal behavior by rules or restrictions." Regulation can take many forms: legal restrictions promulgated by a government authority, self-regulation by an industry such as through a trade association, social regulation (e.g. norms), co-regulation and market regulation. One can consider regulation as actions of conduct imposing sanctions (such as a fine). This action of administrative law, or implementing regulatory law, may be contrasted with statutory or case law.

Performance generally comprises an event in which one group of people (the performer or performers) behave in a particular way for another group of people (the audience). Sometimes the dividing line between performer and the audience may become blurred, as in the example of "participatory theatre" where audience members might get involved in the production. Singing choral music, and performing in a ballet are examples. Usually the performers participate in rehearsals beforehand. Afterwards audience members often clap, indicating appreciation. However, sometimes this rule is reversed. In Japan, the greatest compliment is complete silence. In business, retail, and accounting, a cost is the value of money that has been used up to produce something, and hence is not available for use anymore. In economics, a cost is an alternative that is given up as a result of a decision. In business, the cost may be one of acquisition, in which case the amount of money expended to acquire it is counted as cost. In this case, money is the input that is gone in order to acquire the thing. This acquisition cost may be the sum of the cost of production as incurred by the original producer, and further costs of transaction as incurred by the acquirer over and above the price paid to the producer. Usually, the price also includes a mark-up for profit over the cost of production.

*Literature Survey*

Robert et al., (1998) draws on the results of interviews with five environmental managers in the furniture industry to develop a taxonomy of environmentally-friendly ('green') best practices within the operations management value chain. This taxonomy is then extended to develop a group of propositions concerning the role of management in promoting environmentally-friendly practices. The results suggest that in order to be successful, environmental management strategies must be integrated into all stages of the value chain, which includes all of the processes spanning product design, procurement, manufacturing and assembly, packaging, logistics, and distribution. While the potential for
environmental performance improvement in all five of the companies is evident, all of them demonstrated ‘pockets’ of environmentally-friendly practices (EFP) in different areas of their respective value chain functions. The propositions and results emerging from the analysis also suggests that reacting to regulations is no longer sufficient. World-class EFP must anticipate and pre-empt changing environmental regulations and customer expectations, and proactively prepare products, processes and infrastructure for these changes without sacrificing competitive advantage.

Gunasekaran et al. (2004) investigated supply chain management that has been a major component of competitive strategy to enhance organizational productivity and profitability. The literature on SCM that deals with strategies and technologies for effectively managing a supply chain is quite vast. In recent years, organizational performance measurement and metrics have received much attention from researchers and practitioners. The role of these measures and metrics in the success of an organization cannot be overstated because they affect strategic, tactical and operational planning and control. Performance measurement and metrics have an important role to play in setting objectives, evaluating performance, and determining future courses of actions. Performance measurement and metrics pertaining to SCM have not received adequate attention from researchers or practitioners. We developed a framework to promote a better understanding of the importance of SCM performance measurement and metrics. Using the current literature and the results of an empirical study of selected British companies, we developed the framework presented herein, in hopes that it would stimulate more interest in this important area.

Anciaux and Yuan (2007) recommended that nowadays we are faced with lots of environmental problems: the erosion of biodiversity, the exhaustion of resources, the disorder of climate, the affection of human health by pollution and so on, as a result of industrial development and human unconsciousness. In all these respects, it is necessary for us to reorientate the progress, to use our technologies differently, to produce with rationality and no more take the way unslung. It has become a necessity for us to count in the costs of production the factor of environmental costs as social costs. And that is what we proposed to develop in this paper: how to integrate the environmental impacts into the transport function within the supply chain? Actually, the transport function, without the consideration to environmental impacts, remains outside of the integration of production system and is normally managed by external service provider. In fact, the flows between companies and performance supports are dissociated from the functions of production. The almost exponential increase of flows between companies thus requires nowadays a global evaluation of the performance and management of industrial transport. We proposed to show the issues for integrating the means of transport within the green supply chain, as well as a decision-aiding model, which allows optimising the solution choice of intermodal transport problems.

Khiewnavawongsa and Schmidt (2008) stated that green supply chain management (GSCM) was emerging in the last few years. This idea covers every stage in manufacturing from the first to the last stage of life cycle, i.e. from product design to recycle. Not only manufacturing, but GSCM can also be used to other business sectors such as government, education and services. The purpose of this paper was to describe the impact of green to the supply chain management. It started with the importance of GSCM to the company in different levels or what factors that influence the company to adopt the GSCM. These factors can be categorized by different drives such as government, whole market, industry, competitors, and within the company. Since GSCM can be applied to various areas within the company, this paper also discussed the implementation of GSCM to several areas. Furthermore, some examples of GSCM application were demonstrated to support the concept.
PROPOSED MODEL OF GREEN SUPPLY CHAIN PERFORMANCE (GSCP)

Local Suppliers

Overseas Suppliers

Source

Transport

Reclaim

Input

Water Energy

Plan

Water Energy

Deliver

Green Supply Chain

Wholesale

Customers

WASTE

Input

Air

Water

Air

Water

Air

Water

Air

Water

Air

Water

Air

Water

Air

Water

Input

Transformation

Output

Disposal Process

End of Life Raw Material

Improve By-Products/Reuse/Recycled Material

Enable
RESEARCH METHODOLOGY

Conceptual Framework

Independent Variables

<table>
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<tr>
<td>- Location (of facilities and sourcing points)</td>
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<tr>
<td>- Production (what to produce in which facilities)</td>
</tr>
<tr>
<td>- Inventory (how much to order, when to order, safety stocks)</td>
</tr>
<tr>
<td>- Transportation (mode of transport, shipment size, routing, and scheduling)</td>
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Dependent Variables

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<tr>
<td>- Green Supply Chain Performance Indicator</td>
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<td>- Green Supply Chain Cost</td>
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Methodology

1) Identify problem statement of the research study
2) Review and survey literature
3) Hypotheses development
4) Collect primary and secondary data
5) Develop a model of green supply chain performance
6) Develop green supply chain performance index
7) Investigate the model and index by using a case study of Furniture Industry
8) Analyze the results
9) Draw conclusion and recommendation

ANTICIPATED RESULTS

It is anticipated that the proposed model of GSCP will be of use for testing hypotheses to identify efficiency of green supply chain and determine its performance indicator. Moreover, the study also investigates how a cost reduction can be done across the supply chain of an exemplary company considering environmental impacts. Especially, this research study will collect primary and secondary data according to furniture manufacturing. It is due to all furniture manufacturers have focused more on design, but they are not yet fully aware of green production. Therefore, this paper will thoroughly investigate such issue to succeed the potential for environmental efficiency improvement to become evident. It is also suggested that the performance index of green supply chain by proposing green supply chain performance model, and the green supply chain cost analysis using regression model will be developed based on environmental management strategies that is integrated into all of the processes spanning product design, procurement, manufacturing and assembly, packaging, logistics, and distribution.

CONCLUSION AND RECOMMENDATION

In conclusion, green supply chain was emerging and expanded to many organizations across supply chain. However, a few researches have focused on how to develop the performance index of green supply chain and the green supply chain cost analysis. The focus of the study is that the factor that make the company in different industries to adopt the proposed model of green supply chain performance and develop its index in their organization. The survey will be sent to furniture manufacturers across the country. Survey questions will be asked to see the perspective of the manufacturers in green supply chain and what make them apply it, as well as the future trend. It is hoped that the
performance index and cost analysis presented here in the study would be a framework used for setting up green standard into all stages of the value chain.

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COMPLEXITY IN GLOBAL SUPPLY NETWORKS – MODEL TESTING USING A CASE STUDY APPROACH

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by

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ABSTRACT

In practice, there is a lack of knowledge about supply network complexity which may lead to unsatisfactory business results. Reliable instruments and models which support a supply network manager in systematically managing the complexity are not yet available. None of the existing approaches have been adequately transferred to the domain of supply networks characterised by fast changing conditions. On the basis of the existing approaches it is impossible to identify those partners in supply networks which are of primary importance from a company perspective. The purpose of this paper is the prototypical application of a decision model which has been developed with the aim to identify those partners in the supply network which are under fast changing business conditions from central importance. The practical applicability of the developed model is analysed within a multiple case study in the agricultural industry. An adapted version of the pattern-matching technique is applied for the case based analysis. This paper illustrates how a non-trivial topic – complexity in supply networks – can be operationalised in order to achieve practical applicability. Manageability is realised through an indirect determination of complexity using several parameters and the implementation of an easily adaptable graph-theoretic formalisation approach. Each partner is evaluated on the basis of the identified parameters to determine the contribution of a single partner to the overall complexity in the supply network. The central purpose of this paper is to assess the practical applicability of the developed model.

KEYWORDS
Complexity, Supply Networks, Case Study Design

INTRODUCTION

Innovations, the globalisation of markets or continuously growing and differing customer requirements are just a small selection of challenges which a company has to face. A growing number of variants is, in many cases, one possible answer of the companies. In further consequence, this leads to a decrease of the in-house value-adding depth in combination with an increase of the number of suppliers and a global dispersion of the required production processes. In the context of this paper all inter-connected companies that exist upstream to a company are subsumed under the term ‘supply network’ according to Choi et al. (2006). The buy-side flows are purposely excluded to simplify the conceptual discussion and may be supplemented in a later step. Relating the described development to the current market uncertainty (fluctuating customer demand, financial crisis in several countries...) leads to a growing number of variants on the one hand and a reduced number of sold items per variant and a decreased planning accuracy per variant on the other hand. The result is a continuous increase of complexity in economic supply networks. Supply chain managers are aware of these developments (Schuh et al., 2008) but in many cases methods on how to deal with the continuously growing complexity are not yet available (Sivadasan et al., 2006) or not applicable in fast changing business conditions.

The identification of the most relevant network segments from a complexity perspective is an especially critical success factor for a company’s competitiveness. Since it provides information to management about which improvement measures are most urgent and will deliver the most favourable impact in a certain economic situation. Especially in rapidly changing markets, a corresponding method has to be easy to apply and must allow fast execution to enable permanent and iterative application. Based on this idea we developed a decision model to identify those suppliers in the network which are...
of central importance for the company under the current fast changing business conditions. The model is based on findings from complex systems theory (CST – see especially Shahabi et al., 2007; Bar-Yam, 2003; Kappelhoff, 2000) and existing supplier evaluation methods. In order to limit length, the theoretical foundation of the developed model (see Gerschberger et al., 2012; Engelhardt-Nowitzki et al., 2011a) as well as fundamental concepts for the present paper in supply networks (see especially Lambert et al., 1998; Gosling, 2003; Müssigmann, 2007; Windt et al., 2008) and in depth analysis of the term ‘complexity’ (see especially Bozarth et al., 2009; Wycisk et al., 2008; Meyer, 2007; Engelhardt-Nowitzki et al., 2006; Choi et al., 2006 ) are not reproduced here.

The purpose of this paper is to test the practical applicability of the developed model within a multiple case study within the agricultural industry. The paper is organized as follows: First of all, the basic concept of the applied supplier network decision model is briefly explained. Then, based on this, the model is prototypically applied within a multiple case study approach in the agricultural sector.

A MODEL TO DETERMINE COMPLEXITY IN SUPPLY NETWORKS

As stated above, a model that intends to facilitate the identification of critical network segments regarding an inopportune degree of complexity must provide for a respective network structure and for the possibility to process multiple parameters. The model described within this section is a combination of the vector based idea to operationalise complexity in production systems proposed by Windt et al. (2008) and the supplier evaluation model developed by Müssigmann (2007), who applies graph theory to represent a supplier network or a selected segment of it. Within the model, a converging material flow as applicable in the automobile industry is assumed. Each element (company) and each interrelation (connection between supply network companies) in the examined network segment is represented through complexity parameters which are bundled in an evaluation vector (step 1 in Fig.2). The vector consists of those criteria (complexity determining and influencing parameters) which have been identified in an extensive and systematic literature review (Gerschberger et al., 2012; Engelhardt-Nowitzki et al., 2011b). More than 150 journal publications were identified in a structured and reproducible way within the twelve top journals of logistics and supply chain management (Menachof et al., 2009). On this basis the set of parameters to describe complexity within supply networks was identified – see Fig. 1. In a first step, possible attempts to operationalise these parameters were deduced from literature (Gerschberger et al., 2012) – followed by a company specific operationalisation described in the latter section of this paper.

![FIGURE 1 OPERATIONALISATION OF COMPLEXITY PARAMETERS](image)

In further succession the singular operationalised evaluation vectors - displayed in Fig. 1 - for each element and interrelation are consolidated in one overall evaluation vector for the entire supply network or the network segment examined (step 2 in Fig. 2). Due to the fact that the described model is a multi-criteria model the importance of parameters can differ from one company to another. This is taken into consideration by means of a weighting vector which allows for situational parameter prioritisation (step 3 in Fig. 2).

Finally, a position index for each network segment can be created prioritising the most important segments (step 4 in Fig. 2) through multiplication of each parameter of the evaluation vector with the corresponding element of the weighting
vector (e.g., parameter \( k_{1g} \) of the evaluation vector \( x \) element \( k_{1gew} \) of the weighting vector). Finally, all weighting pairs are cumulated in a position index for each network segment. From a company perspective, the supply network segment with the highest position index is of primary importance under current conditions and therefore for high-priority management activities (Gerschberger et al., 2010).

**FIGURE 2**

**CONCEPTUAL MODEL DESIGN TO DETERMINE COMPLEXITY IN SUPPLIER NETWORKS**

We assume that for most cases the model implementation will proceed iteratively: Starting with the focal company, first of all relevant direct suppliers should be inspected. Therefore the model implementation is limited in a first step to the direct suppliers of the focal company. The consideration of all suppliers involved in the network segment seems desirable at first sight but has to be considered in the face of significant challenges; the effort to implement all suppliers in the supply network is rather high due to the potentially high number of suppliers and respective data access. These efforts outweigh the benefits of considering all suppliers especially in relation to the presumably low percentage of those which would be identified as important under particular conditions.

**MODEL TESTING USING A CASE STUDY APPROACH IN A SUPPLY NETWORK SETTING**

Case research has its roots originally in the broader field of social sciences, in particular ethnographic studies and anthropology. Eisenhardt (1989) brought together much of the previous work on building theory from case research. In further succession a roadmap for designing, developing and conducting case-based research and also to describe some recent examples of case-based research in the field of operations management and technology management is provided by Voss et al. (2002). In general, case studies are applicable if the examined phenomenon cannot be separated from its real-life context especially when the boundaries between phenomenon and context are not clearly evident (Yin, 2003). To be more specific, case studies can be used for different types of research purposes such as exploration, theory building, theory testing and theory extension or refinement (Voss et al., 2002). Referring to Handfield et al. (1998) one central research purpose of the theory testing stage is to evaluate if the developed theory/the developed model is able to survive the test of empirical data. It becomes obvious as complexity in supply networks is a phenomenon that cannot be examined separated from its real-life context and the aim is to test if the developed model survives using empirical data. Besides the general examination of the applicability of a case study approach to test the developed model the problem of how the model results can be evaluated has to be solved. Keeping in mind that the goal of the model is the identification of the most critical partners in the supply network no influence on a target variable can be quantified – neglecting all general problems when attempts are made to establish and prove causal linkages. Therefore, a different way to demonstrate the practical applicability has to be developed.
Finally – after long and intense discussions with scientists and an extensive literature review – an adapted version of the pattern-matching technique (Yin, 2003) is used. Adapted in a way that not the model developer but an expert from the company predicts a pattern (= a selection of critical partners is identified by the expert) which is compared with the empirically based patterns (= selection of critical partners identified by model application). In general a triangulation setting is installed as the pre-identification of critical suppliers is made by the previous SC-manager, the real evaluation of each single supplier is executed by the purchasers in charge and the weighting of the single parameters according to the current business conditions is made by the actual SC-manager. This procedure guarantees that the influence of a single person is minimized.

As findings cannot be generalised on the basis of a single case (Abdelkafi et al., 2008) a multiple case study approach is realised. Following the classification given by Yin (2003) we talk about an embedded case study with four units of analysis in the context of this paper. Referring to Eisenhardt (1989) one idea to define the right number of cases can be in relation to the number of variables investigated the chosen sample size is a good starting point as four different types of parameters are used to describe complexity in supply networks. Furthermore, case analysis based on four cases goes along with statements made in literature; e.g. Voss et al. (2002) proposing 3-30 cases or Eisenhardt (1989) suggesting 4-10 cases. In general, the discussion about the ideal number is obsolete as the subject of consideration and the degree of difficulty of the research question differs from case to case. The number of cases is usually determined by the degree of new confirming or conflicting insights achieved by conducting an additional case. Theoretical saturation is achieved if the additional findings according to a previously investigated phenomenon by conducting an additional case are minimal (Glaser et al., 1998).

Much more effort is needed for the selection of cases which should be based on theoretical sampling. The challenge is to choose cases that differ as widely as possible from each other to fill theoretical niches. The case company is a premium producer in the Austrian agricultural industry providing products in two different market segments – grassland and tillage. Grassland subsumes all products required for a careful mowing process (e.g. disc mowers, drum mowers, loading wagons/silage trailers). Tillage encompasses all products necessary for a sound ground/field preparation (e.g. ploughs, stubble cultivators, disc harrow, rotary harrows, drilling technology). Within the supply network of this company four segments of the supply network (= units of analysis) are analysed. Each single segment represents all suppliers which are required to manufacture the specific products of unit of analysis. Therefore, the developed decision model is applied in four product-specific supply network segments. Considering the two product segments it is obvious that the four units of analysis are divided equally (two for grassland, two for tillage). Cross-checking this idea with one of the most important decision variables in companies (= turnover) the equal partition becomes illogical as the product segment ‘grassland’ is responsible for more than 60 % of the annual turnover (tillage = 20 %; spare parts = 20 %). As a result a break down from three units of analysis for product segment ‘grassland’ and one for ‘tillage’ seems to be more representative. Beyond this, the variable ‘turnover’ is the basis for the decision-making to consider loading wagons/silage trailers as the first unit of analysis as this product segment is responsible for 20 % of the overall turnover. The second decision variable mainly concerning the supply network specifics of the case company is the method of manufacturing – customer individual or anonymous. As customer individual product segments are very specific the units of analysis are divided equally – one for ‘grassland = the loading wagons/silage trailers’, one for ‘tillage = the plough’. These product segments are manufactured to customer specifications as no sufficient number of a standardised variant is realised (e.g. from the 1,300 loading wagons manufactured in the last review period 1,000 were different). The remaining two units of analysis are manufactured without knowing the final customer in advance. This is possible as only a small number of variants with satisfying lot sizes per variant are manufactured. Following the logic, these two units of analysis (namely disc mowers and tedders) are selected and assigned to the market segment ‘grassland’.

Summarising the findings of this section, the four units of analysis within the embedded case of a premium producer in the agricultural industry in the Austrian market are:

- Loading wagons/silage trailers
- Tedders
- Disc mowers
- Ploughs
PREDICTED PATTERN – SUPPLIER IDENTIFICATION THROUGH PREVIOUS SC-MANAGER

In the first step of the analysis the previous SC-manager was asked in an expert interview to identify those suppliers which contribute significantly to the degree of complexity within the analysed segment of the supply network (= unit of analysis). As preparation for the interview the suppliers of the single units of analysis have to be identified (loading wagons/silage trailers = 162 suppliers, tedders = 98, disc mowers = 86, ploughs = 110). The SC-manager’s task was to shortlist the suppliers according to the most critical ones from a complexity perspective within the supply network segment. In figure 3 the identified critical suppliers arranged by unit of analysis are displayed (loading wagons/silage trailers = 20+2, tedders = 12, disc mowers = 10, ploughs = 13). Due to data confidentiality reasons the names of the suppliers have been deleted but a configured supplier identification number secures the uniqueness. Figure 3 represents an e-mail section sent to the previous SC-manager to confirm the correctness of the data.

EMPIRICALLY BASED PATTERN – SUPPLIER IDENTIFICATION BY APPLICATION OF THE MODEL

Before the model can be applied, the operationalisation methods of the five complexity parameters used (number of elements, number of interrelations, uncertainty, variety, geographical components) have to be briefly described.

The differentiation between complexity of elements and complexity of interrelations originates from systems theory (Reiß, 1993). Each element (= E) in the network segment is considered to be set to 1 if the subject of analysis is a supplier (= evaluation vector of an element) and to 0 if the subject of analysis is an interrelation (= R). The operationalisation of the number of interrelations is applied accordingly but bidirectionally. In Table 1 both parameters are set to 1 as a relationship consisting of an element and an interrelation is the subject of consideration.

In principle, three potential sources of uncertainty exist: suppliers, production and customers (Davis, 1993) and numerous supply network decisions have to be taken without knowing all relevant variables. Reflecting the different decisions to be taken and the difficulty of specific situations, numerous attempts to quantify uncertainty were developed (see...
John et al., 1988; Vickery et al., 1999; Milgate, 2001; Christensen et al., 2007). In this context the parameter ‘uncertainty’ (= U) is operationalised on the basis of the supplier reliability. Referring to Table 1, the supplier reliability is calculated in an inverse way (1 – row 6/Sum(row4:row8) as all parameters follow the same direction (0 = no contribution to the complexity in the supply network, 1 = maximal contribution). This results in an uncertainty value (= row 9 in Table 1) of 0.79 for supplier No. 3103.

Variety (= V) is measured on the basis of a case-specifically developed specificity measure (= S; evaluating the time required and money needed to set up a relationship to an alternative supplier) and the adapted product line breadth (= PLB\textsubscript{a}; the number of variants within a product group) to get an insight into the supplier’s importance on the influence on handling variety from at least two perspectives. Row 10 in Table 1 represents the adapted product line breadth. The PLB\textsubscript{a} for supplier No. 3103 is the relationship of the number of variants in which parts of the analysed supplier are included (n = 210) compared to the overall number of variants within the unit of analysis (n = 257). Both figures (210 and 257) are determined and counted on the basis of a maximal bill explosion. The specificity measure is based on the estimation of the purchasers in charge according to the amount of time and money required to guarantee supply by an alternate supplier.

The supply network is affected by specific factors for certain geographical regions which have the potential to influence supply network performance (Guisinger, 2001). The orchestration of the supply network is easier if the companies involved share the same language, belong to the same cultural area, apply similar working standards and are situated in geographical proximity. These factors are subsumed under the parameter ‘geographical components’ (= GEO). Several attempts have been made to evaluate the influence of geographical components on the supply network performance. Two main groups can be identified. First, a group of substantial frameworks with large amounts of data that has to be collected situation-specifically (Kinra et al., 2008; Guisinger, 2001). Second, fully developed and online available indices (LPI – Logistics Performance Index Arvis et al., 2010; AI – Access Index FedEx et al., 2008) which evaluate specifics in geographical regions according to their potential influence on the ease of doing business in supply networks. In this model application the LPI in combination with a geographical distance factor is used to operationalise this parameter. The combination is valuable as the single consideration of the LPI does not consider the origin of the analysing company. The LPI for Austria is 3.76 independent of whether the analysing company is situated in Germany or in China – but there will be great differences in the ease of doing business. An adapted version of the LPI (1 – country LPI/optimal LPI) is calculated to go along with the general alignment of the operationalised parameters (0 = no contribution, 1 = maximal contribution). Using once more supplier No. 3103 as a representative this means that this supplier is situated in Austria (LPI = 3.76) and therefore the adapted LPI is 0.25 (1 – 3.76/5). The geographical distance factor (EF = 0.01) in row 13 is the result of the relation between the distance from supplier No. 3103 to the premises of the analysing company (= 20.1 km) and the supplier within the unit of analysis that is farthest away (= 2188 km). The product of both factors, the adapted LPI and the geographical distance factor, represents the operationalised version of the parameter ‘geographical components’. For further in-depth information concerning different operationalisation methods and a more detailed description of how they are applied within this model see (Gerschberger et al. (2012), Engelhardt-Nowitzki et al. (2011b)).

**Unit of analysis - loading wagons/silage trailers**

In Table 1, the detailed result of the evaluation of the unit of analysis ‘loading wagons/silage trailers’ is displayed. The target rule that has to be reached within all four units of analysis is that 50 % of the suppliers defined as critical have to be ranked within the first 20 % of the evaluation results. Using this unit of analysis there are 162 active suppliers and 20 % of them are 33 suppliers. As a result 10 out of 20 determined suppliers have to be ranked within the first 33 suppliers. Considering Table 1 – 11 suppliers can be found within the defined section. Two of the suppliers determined as critical within the predicted pattern section had to be removed as these are no longer active suppliers.

In Table 1 the entire calculation of the determinants (described in the previous section) of each single parameter and the aggregation to one position index representing the contribution of complexity of the single supplier and its interrelation to the company can be seen. The interpretation of the weighting vector in the top right section of Table 1 is the outcome of a pair-wise comparison of the single parameters according to their importance realised by the current supply chain manager on the basis of an analytic hierarchy process (= AHC).
### TABLE 1
EVALUATION RESULT FOR UNIT OF ANALYSIS - LOADING WAGONS/SILAGE TRAILERS

<table>
<thead>
<tr>
<th>UNIT OF ANALYSIS</th>
<th>weighting</th>
<th># supplier</th>
<th>999-3 days to early</th>
<th>1-2 day(s) to on-time</th>
<th>2-1 day(s) to early</th>
<th>3-999 days to late</th>
<th>supplier-ID</th>
<th>E</th>
<th>R</th>
<th>S</th>
<th>EF</th>
<th>LPI'</th>
<th>GEO</th>
<th>Σ</th>
</tr>
</thead>
<tbody>
<tr>
<td>loading wagons/silage trailers</td>
<td>PLBₐ adapted product line breadth</td>
<td>162</td>
<td>246</td>
<td>634</td>
<td>324</td>
<td>204</td>
<td>131</td>
<td>0,79</td>
<td>0,82</td>
<td>0,39</td>
<td>0,32</td>
<td>0,01</td>
<td>0,25</td>
<td>0,002</td>
</tr>
<tr>
<td># supplier</td>
<td>PLBₐ specificity</td>
<td>32</td>
<td>162</td>
<td>245</td>
<td>344</td>
<td>166</td>
<td>220</td>
<td>108</td>
<td>0,85</td>
<td>0,53</td>
<td>0,40</td>
<td>0,16</td>
<td>0,06</td>
<td>0,25</td>
</tr>
<tr>
<td>20%</td>
<td>EF calculated distance factor</td>
<td>1,00</td>
<td>0,09</td>
<td>0,36</td>
<td>0,03</td>
<td>0,27</td>
<td>0,18</td>
<td>0,04</td>
<td>0,25</td>
<td>0,012</td>
<td>0,19</td>
<td>0,34</td>
<td>0,004</td>
<td>0,36</td>
</tr>
<tr>
<td></td>
<td>LPI' adapted version LPI</td>
<td>20%</td>
<td>0,79</td>
<td>0,85</td>
<td>0,36</td>
<td>0,03</td>
<td>0,27</td>
<td>0,18</td>
<td>0,04</td>
<td>0,25</td>
<td>0,012</td>
<td>0,19</td>
<td>0,34</td>
<td>0,004</td>
</tr>
<tr>
<td></td>
<td>geographical components - GEO</td>
<td>0,56</td>
<td>0,21</td>
<td>0,09</td>
<td>0,03</td>
<td>0,1</td>
<td>0,02</td>
<td>0,002</td>
<td>0,03</td>
<td>0,33</td>
<td>0,006</td>
<td>0,33</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>EF calculated distance factor</td>
<td>0,56</td>
<td>0,79</td>
<td>0,36</td>
<td>0,03</td>
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<tr>
<td></td>
<td>LPI' adapted version LPI</td>
<td>0,56</td>
<td>0,21</td>
<td>0,09</td>
<td>0,03</td>
<td>0,1</td>
<td>0,02</td>
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<td>0,25</td>
<td>0,012</td>
<td>0,19</td>
<td>0,34</td>
<td>0,004</td>
<td>0,36</td>
</tr>
</tbody>
</table>

Summing up the result of the unit of analysis ‘loading wagons/silage trailers’, the application of the model can be evaluated as successful as eleven (see count in the last column of Table 1) instead of the requested ten suppliers defined as critical were identified within the first 20 % of the active suppliers.

**Unit of analysis – disc mowers, tedders, ploughs**

The result of the three remaining units of analysis (disc mowers, tedders and ploughs) is displayed in a more compressed manner in Table 2. For each unit of analysis the overall number of suppliers as well as the number of suppliers predicted as critical which have to be identified within the model application are mentioned first. Visualised for the unit of analysis ‘disc mower’ Table 2 can be read as follows. 4 to 5 of the previously defined critical ten suppliers (one is no longer a regular supplier) have to be identified within the first 20 % (= 17) of the 86 suppliers. The black line after 17 suppliers separates the first 20 % from the remaining ones. Within this section 50 % of the suppliers predetermined as critical have to be identified for a successful model application. The last column (= column 8 of each section) counts the number of predetermined suppliers (data printed in bold) that were identified through the model application as well.
The analytic hierarchy process to evaluate the parameters in a pairwise comparison to determine their importance seems to be an appropriate method to cope with this challenge. Therefore the AHC is consequently implemented within the third step of the model application the creation of the weighting vector.

The model application has indicated that a standardised method to determine the importance of single parameters within the weighting vector is desirable. The model application showed the difficulty for the applicant has to be aware of the challenge to secure the desired influence. The model application the creation of the weighting vector.

The graphical representation of the evaluation result for the three units of analysis 'disc mowers', 'tedders' and 'ploughs' shows the following pattern:

**Unit of analysis - disc mowers**
- # suppliers predicted: 12-1 = 11
- Supplier-ID: E R U V GEO
- [Table showing evaluation results for disc mowers]

**Unit of analysis - tedders**
- # suppliers predicted: 10-1 = 9
- Supplier-ID: E R U V GEO
- [Table showing evaluation results for tedders]

**Unit of analysis - ploughs**
- # suppliers predicted: 13-1 = 12
- Supplier-ID: E R U V GEO
- [Table showing evaluation results for ploughs]

Summing up the findings of the three units of analysis, the model application can be evaluated as successful as in all cases the required number of predetermined suppliers was reached. Ranging from an excellent result for the unit of analysis ‘disc mowers’ (6 identified instead of the requested 4 to 5) to an exact result for ‘ploughs’ (6 identified and requested) and a close run for ‘tedders’ (5 identified compared to 5 to 6 requested). Further conclusions as well as the required next steps are summarised in the concluding section of this paper.

**FINDINGS AND FUTURE RESEARCH DIRECTIONS**

In general the four units of analysis within the embedded case study can be seen as a first hint concerning to a possible practical applicability of the developed decision model to identify critical suppliers. In further consequence, the developed model has to be applied on a continuous basis within changing business conditions and different companies to improve and determine the practical applicability.

Besides the positive application of the developed model in four cases, a number of potential connecting factors for further research as well as for the ongoing improvement of the developed model were identified. These are:

- **Extension of evaluation differences**
- Due to the fact that the operationalisation range for all parameters is aligned from 0 to 1 and most of the parameters are evaluated on the basis of the product of at least two determinants the differences between the contributions to complexity of single suppliers become very narrow. Especially when considering the additional combination with the weighting vector.

For future model applications it could be advisable to define alternative operationalisation attempts for the single parameters.

- **Influence of single parameters**
- As the operationalisation of single parameters differs and is based on one, two or more determinants the model applicant has to be aware of the challenge to secure the desired influence.

- **Interpretation of the weighting vector**
- The model application within the embedded case study has indicated that a standardised method to determine the importance of the single parameters within the weighting vector is desirable. The model application showed the difficulty for the person in charge to evaluate the importance of single parameters in relation to each other. The implementation of the analytic hierarchy process to evaluate the parameters in a pair wise comparison to determine their importance seems to be an appropriate method to cope with this challenge. Therefore the AHC is consequently implemented within the third step of the model application the creation of the weighting vector.
• Predicted pattern on the basis of multiple users
  For the first model application, the critical suppliers determined within the predicted pattern are based on the assessment of a single person. In future, more people in charge can be asked to evaluate the suppliers prior to model application to reduce the personal bias.

  Altogether, the main value of this paper lies in its advanced ability to identify critical value network locations through facilitating network boundary decisions from a complexity perspective, and at the same time extending the academic knowledge of this subject.

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THE ROLE AND POSITION OF SUPPLY CHAIN MANAGEMENT IN CORPORATE LEVEL STRATEGY AT COMPLEX PRODUCT INDUSTRIES

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THE ROLE AND POSITION OF SUPPLY CHAIN MANAGEMENT IN CORPORATE LEVEL STRATEGY AT COMPLEX PRODUCT INDUSTRIES

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ABSTRACT

With evolution of strategic management perspective from industry structure view to resource based view and also to relational view, in following that changing of strategy analysis unit from industry to firm and also to dyad processes and routines; we can see promoting of role and organizational position of supply function and supply chain management in corporate level strategy. This changing is significant particularly in some industries in which classified as low clock-speed and complex product industries. In this article first we have developed a conceptual framework for role and position of supply chain management in corporate level strategy and then we try to explaining the framework with a single case study in agricultural machinery industry. The results indicates that in multi-business firms with these characteristics: low clock-speed industry, high reciprocal interdependence between OEM and immediate suppliers, related diversification strategy, focus on economy of scale advantage, and looking for synergies such as vertical integration, centralized procurement, asset improvement and centralized inbound and outbound logistics; need to consider supply chain management at the corporate level strategy.

KEYWORDS
Corporate Strategy, Corporate Center Structure, Supply Chain Management, Complex Product Industries

INTRODUCTION

Many researchers claim that in some industries supply chains are competing with each other. (Christopher 1996;Anderson and Katz, 1998; Birou et al., 1998;Lummus et al.,1998;Morgan and Monazka, 1996;Zhang,2006;Rice and Hoppe, 2001). In Supply chain management literature there are two path for studies on this subject. A path that considered supply chain management from the perspective of supply function and supply management and another path are logistics and transportation. (Tan, 2001) In the first approach, many researchers (Johnson and Leenders, 2008) study the role and strategic position of purchasing function and supply management in the corporation and claim that supply chain management play an essential role in coordinating and connecting the other functions of the firm and its organizational position must be under corporate CEO especially in industries with complex products (Kim, 2006). In other words, in corporate level strategy companies face with two significant questions: first firm need to enter in which businesses and the second, how they can coordinate different businesses with each other (Porter, 1985; Johnson and Scholes, 2002). Interrelationships between business units are very important coordinating them (Porter, 1985). Some researchers (Johnson and Leenders, 2008) argued that supply function can play a role in coordination between business units from the view of interrelationships between units in purchasing and procurement. Also, in some industries which mentioned as industries with complex products (Tompson, 1967;Pfeffer and Salancik,1978; Dyer, 2000) coordination between final assembler and key suppliers have a very important role in companies’ success. Fine (1998) divided industries into two categories: industries with low clock-speed and industries with high clock-speed. Relating to this subject based on corporate strategy and industry’s clock-speed, there are few studies about role and position of supply chain management in corporate strategy and organizational structure and there is still a gap in strategic and supply chain management’s literature. In this article based on corporate strategy and industry clock speed literature we tried to develop a conceptual framework for examining the role and position of supply chain
management in organizational structure and then through a case study in agricultural machine industry (Iran Teraktor-Saziye Company) we have attempted to clarify different aspects of this subject in more detail.

**LITERATURE REVIEW**

In this section research history will be reviewed and studied in three parts. First, research history about industry clock-speed and industries categorization and their influence on companies function and supply chains will be studied. In the second part, we tried to study literature about supply chain strategic importance and its organizational position, and finally we will review literature about corporate level strategy and supply chain management.

**Industry Clock-speed**

It is obvious that industry clock-speed’s concept has a lot of effects on the way of organizing and managing organizations in twenty first century (Meijboom et al., 2007). Fine (1988) has introduced the industry clock-speed concept to covering industry change rate that it is guided through endogenous factors (technological and competition). He has specified three dimensions of industry clock-speed: Product, Process and Organizational. Product clock-speed defines rate of new product introduction and rate of product obsolescence. For example, aircraft industry is a low clock-speed industry. The firms in this industry introduced two new products as average per each decade. In contrast, in cinema industry, studios introduce more than twenty new products during a year and are classified as high clock-speed. Process clock-speed determines change rate of process technology in an industry. High change rate in semi-conductor industry experience more frequent changes in process technology. For instance semiconductor companies invest approximately 1 billion dollars in a chip-making plant and it is expected that the plant will be obsolete in four years. In the other hand, change rate in automobile industry is low. In this industry process technologies’ substitution rate is less frequent and automobile companies expect that obtain good cash flow from an assembly plant or engine plant during twenty years. Organization clock-speed determines change rate in organizational actions (e.g. merger, acquisitions, internal development and organizational alliances) and structures (e.g. restructuring and CEO changing) of companies which are in the related industry (Fine, 1998; Nadkarni and Narayanan, 2007).

Fine (2000) has stated that there are some differences in supply chain design considerations and their success in industries with low and high clock-speed, and the options in designing supply chain for high clock-speed industries have conclusions that can be used for all industries. The industry clock-speed effect on supply chain coordination was studied and it is determined with increasing industry clock-speed, amount of using inventory for protecting against uncertainty is decreased while relationships with customers and suppliers is increased. Also, it was determined that the role of outsourcing in both cases (high clock-speed and low clock-speed) is very important and in medium clock-speed it plays a less important role. (Meijboom et al., 2007) Despite the common imagination, in high clock-speed industries deep relationships with suppliers and the performance of supply network have negative correlation with each other and in low clock-speed industries there is a positive and significant correlation among deep relationship with suppliers and the performance of supply network (Guimaraes et al., 2002). In another study (Fernandez and Kekale, 2005) the influence of industry clock-speed on reverse logistic activities was examined and it is specified that industry clock-speed and product architecture are important factors in determination of reverse logistic activities.

**Strategic importance of supply chain and its organizational position**

Strategy approaches and analysis unit within it have changed from industry in industry’s structure approach to the firm in resource-based approach and to dyad processes or procedures in relational approach (Dyer and Singh, 1998). Most of theoretic principles regarded to supply chain and its strategic nature is related to relational approach. There are two perspectives about supply chain management in the literature. Perspective of purchasing and supply that is related to former distinct functions of purchasing and functions of industrial buyers' supply management, whereas logistics and transportation perspective in supply chain management literature is evolved from functions of transportation and distribution of wholesalers and retailers (Tan, 2001). Purchasing and supply management perspective in supply chain management literature is more strategically in nature and it leads to the claim that competition unit is changed to supply chain versus supply chain. Ketchen and Guinipro (2003) state that there are a lot of common research areas between supply chain management and strategic management fields. Relatedly they state that strategic management researches can pose following key questions for supply chain management researches:

1. Are some of activities or specifications of supply chain rare, valuable and inimitable? (Resource based view)
2. What extent knowledge exchange can facilitate the coordinated supply chain actions and improve the results? (Knowledge based view)
3. In what time a member of supply chain attempt to abuse other members? (Agency theory)
4. In what time supply chain activities should imitate industry best practices so that it can reflect the unique characteristics of chain partners? (Institutional theory)
5. How and to what extent supply chain activities directly and indirectly affect firm's profitability and stock price? (Emphasize on explaining firm's performance)

In the other words, the questions that supply chain management researches can pose for strategic management are as follows:

1. How and to what extent supply chain analysis level can assist to clarifying the firm's conduct and results beyond offered explanations in other analysis levels? (Supply chain as an analysis level in strategy)

2. To what extent strategic supply chains can represent as an organization? In what time likely such chains are developed? What are performance implications for development of such chains? (Supply chain as an organization)

With dissatisfaction of vertical integration in many industries and increase in wave of outsourcing the activities by the firms, concepts of operations strategy are influenced and these concepts are carried to supply strategy or supply network strategy. Supply strategy is related to integration of supply activities within the firms, in dyad relations, in chains of companies, and in inter-organizational networks (Harland et al., 1999). In this case, the role of purchasing and supply function is changed from an operational and departmental function to a strategic function and organizations' managers should be able to determine their position on a network of cooperation relationships and with adapting the appropriate direction in the network be able to fulfill final customer requirements. With increasing strategic importance of supply, many studies (Ketchen and Hult, 2007a; Cousins, 2005; Katz et al., 2003; Halldorsson et al., 2007; Ketchen and Hult, 2007b; Miles and Snow, 2007; Sahay et al., 2006; Chen and Curtis, 2006; Hult et al., 2007; Ireland and Webb, 2006; Cousins and Menguez, 2006) and also Karimi and others (2008) are reviewed the characteristics and specifications of strategic supply chains and are determined that the purchasing and supply function become an important driving force of strategic management of supply chains. Increasing importance of supply chain management leads to recognition increase of strategic role of supply which recently is evolved and developed from purchasing to procurement and to supply management. Meanwhile it is specified that firms with higher level of strategic purchasing comparing to firms with lower level, have better performance in most aspects of the performance (Poulraj et al., 2006). Strategic purchasing is a proper index of supply chain's performance. Overall accomplishing higher levels of strategic purchasing by the firms lead to support of relational capabilities (Dyer, 2000; Dyer and Singh, 1998) and these cause to attaining of sustainable competitive advantage (Poulraj et al., 2006). Strategic purchasing can create a win-win situation for both buyer and seller companies. Also strategic purchasing will cause to create and protect of sustainable competitive advantages for both buyer and supplier companies, which therefore lead to maximization of exchange value (Dyer, 1997) instead of minimization of exchange cost (Williamson, 1985).

**TABLE 1**

**A GENERAL FRAMEWORK FOR SUPPLY STRATEGY (NOLLET ET AL., 2005)**

<table>
<thead>
<tr>
<th>Corporate Strategy: Decisions/ Corporate-level goals/ Business</th>
<th>Supply Strategy: Decisions/ Supply function goals</th>
<th>Specific Share/ Performance measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>What is Competitiveness (business goals)? Why?</td>
<td>Strategic scope and attention</td>
<td>Strategies/ Sourcing decisions (global), Supplier selection strategies, Outsourcing decisions, In-sourcing decisions, Partnerships and supply chain management, Investment and technology adaption, Competitive intelligence, Innovation management and product lifecycle, Effective participation in value-adding and corporation goals, Defining and designing performance measurement system (measures)</td>
</tr>
<tr>
<td>How organizational (Tools)? Centralization/ Decentralization/ Outsourcing of purchasing function/ Procurement</td>
<td>Tactical attention and scope</td>
<td>Benchmarking and research, Definition of processes and procedures, Sourcing analysis (make or buy), Value-added analysis, Price determination, Management of supplier base, Supplier approval programs, Supplier quality-assurance programs, Budgeting and reporting, Project management, Insurances and legal aspects, Contract management, Risk management</td>
</tr>
<tr>
<td>Results/ performance (efficiency/ effectiveness) , implementation</td>
<td>Operational attention and scope</td>
<td>Quality, Volume, Cost/ Price, Deliver/ Service, Flexibility, Innovation</td>
</tr>
</tbody>
</table>
Some other researchers (Nollet et al., 2005) submitted a general framework for supply strategy through studying supply strategy which is shown at table 1.

Strategic supply chains are chains that their members are strategically, operationally and technologically integrated and emphasize on long-term relationships based on consistency and flexibility (Ireland and Webb, 2007). Strategic embedded-ness: Long-term nature of relationships among chain's members and commitment for common effort for efficiently and effectively coordinating chain's members' responsibilities along a collection of required activities for discovering and applying of future opportunities.

Operational embedded-ness: it represents the integration of product and process along member's firm of strategic supply chain. Product integration with supplier means assigning product engineering activities responsibilities and developing its components to suppliers, and process integration with supplier means involving suppliers to comprehend scope and complexity of synchronized processes. Technological embedded-ness: Knowledge and capabilities sharing among strategic members of supply chain and being undaunted of opportunism (Ireland and Webb, 2007). For achieving rents of these supply chains, commitment and appropriate governance structure are necessary. Supply chain management is managing of cross-functional processes within the firm and process management beyond of organizational boundaries. For this end, it is needed that intra-organizational and inter-partner commitment creating mechanisms be designed. Herein there are four kind of commitment for achieving partnership and cooperation in supply chain recognized (Fewcet et al., 2006):

- Chief executive commitment
- Comprehensive functional support
- Channel partners support
- Commitment to developing infrastructure and governance mode

A model is presented for the governance mode in supply chain that it is shown in Figure 1 (Fewcet et al., 2006). Figure 1 shows a model with supply chain dominance that it is followed by strategic importance of supply function and supply chain management in the firms. Also in multi-business corporations with different business division, issue of position and role of supply chain management and logistic function has been got importance. In a study (Koshinen, 2009) a case-study approach on paper-making companies about supply chain strategy is applied. In this research it was determined that in addition of business units that have abundant interest in supply chain management; centralized supply chain management at corporate-level also would be much useful for the business units.
**FIGURE 1**
A MODEL OF SUPPLY CHAIN GOVERNANCE (FAWCETT ET AL., 2006)

**FIGURE 2**
PROCESS-STAFF AND FUNCTIONAL STRUCTURE OF SUPPLY CHAIN (KIM, 2006)
In another research (Kim, 2006) based on three structural characteristics: formalization, centralization and structural relationship, five types of organizational structure for supply chain are submitted. In this research, relationships among each type of supply chain structures with supply chain integration stage and two performance aspects of supply chain, executive performance and technological performance, is examined and determined functional structure and process staff structure of supply chain management have better condition in both supply chain management performance and assistance to supply chain integration. These two types of organizational structure of supply chain management are illustrated in Figure 2. Also, in Table 2 characteristics of each kind of organizational structure of supply chain management is explained.

Corporate-level strategy and supply chain management

Mahoney and Pandian (1992) state that strategy is nothing more than continuous searching of rent and rent means bringing more output than lost-opportunity cost of a resource for its owner. Thus attempting for create above normal output rate or rent, is focal point of competitive advantage analysis (Porter, 1998). Principal kinds of rent are as follows; (Mahoney and Pandian, 1992; Dyer and Singh, 1998; Lavie, 2006; Duschek, 2004)

- Monopoly rent: is obtained when obstacles for potential competitors are high and the firms establishes possible desirable as position with aim of local monopoly (Industry structure approach).
- Ricardian rent: due to using of valuable, non-imitable and non-substituable (Barney, 1991) (Source-based approach).
- Relational rent: relational rents are consisted of appropriative assets that companies assign for their alliance relations and form complements between their resources and their partner's resources. (Dyer and Singh, 1998) (Relational approach)
- Shumpterian or entrepreneurship rent: is obtained when new innovations are discovered and convert to sellable products in the market and lead to exceeding from competitors. (Powell, 2001) (Austrian school)

Supply chain management can play an effective role in realizing of mentioned rents. Herein Nodson (2003) has explained procurement function role in creating monopoly, Ricardian and shumptrian rents. Given that procurement and supply function is fundamental of supply chain management and many of researchers have been accepted cross-functional integration role for supply chain management, supply chain management affect in establishing each of mentioned rents which some of them such as relational rent that in Nodson (2003) are not considered, can be more studied. In the following, the role of supply chain management in creating each rent will be explained:

- Competitive forces (Industry structure):
  a. Rent type: Monopoly
  b. Strategic logic: Positioning and strengthen it
  c. Way of attaining competitive advantage: Using market power through obstructive actions such as establishing barrier for new arrivals, increase in bargaining power with suppliers and customers, and advancing of competitors.
  d. Supply chain management role in rent creation: Maintain and enhance bargaining power against suppliers and customers and avoid of long-term relationships with them which might cause to decreasing competitive advantage. Emphasis on cost reduction in all stages of procurement and costumer order processing.

- Resource-based view:
  a. Rent type: Ricardian
  b. Strategic logic: Establish, deploy and retain of strategic resources
  c. Way of attaining competitive advantage: Establish, deploy and retain of resources and capabilities which are valuable, rare, costly to imitate and non-substitutable.
  d. Supply chain management role in rent creation: Establish, deploy and retain of strategic resources and capabilities for cross-functional integration within company.

- Relational theory
  a. Rent type: Relational
  b. Strategic logic: Establish, deploy and retain of strategic resources and capabilities in inter-firm dyad processes and routines.
<table>
<thead>
<tr>
<th>Structure type</th>
<th>Strategic position of SCM department</th>
<th>Scope of business control by SCM</th>
<th>Theoretic record</th>
<th>Representative firms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Functional structure</td>
<td>There is a particular unit for SCM as a functional area equivalent to existing functional areas including IS unit</td>
<td>SCM department controls traditional SCM activities and SCM-related activities that are performing in other functions. Both SCM unit and IS unit in common, undertake responsibility and authority of scheduling and using SCMIS.</td>
<td>Lambert and Stock (1993) Bowersox and Daugherty (1995) Johannessen and Solem (2002)</td>
<td>LG, Cisco, Benetton, Eli Lilly, Corning Glass, Honeywell</td>
</tr>
<tr>
<td>Matrix channel structure</td>
<td>Although SCM unit has equal position relative to existing functional units, but it doesn't play a role as a function but it does as a planner or coordinator</td>
<td>SCM unit focuses on activities aiming coordinate and connect other units or other channel members. In this kind of structure high priority is given to revising primary SCM activities within organization like SCMIS and then linking them to outside organization activities.</td>
<td>Pritsker (1997) Johnson (1997); Huang and Lin (2002) Monczka et al., (2002) Johannessen and Solem (2002) Bowersox et al., (2002)</td>
<td>Texas Instrument, Shell Oil, Daewoo Matsushita, SONY, Hewlett-Packard, General Motors, ABB</td>
</tr>
<tr>
<td>Process-staff structure</td>
<td>Although SCM unit has higher position than existing functional units like IS unit, but plays a role not as a function but as a staffor comprehensive coordinator of other functional areas</td>
<td>Although SCM unit assist to all SCM activities within and outside of corporation and coordinate them, but real work about each SCM activity is performed by line functions like IS unit</td>
<td>Benita et al., (2002) Lamberton and Stock (1993) Bowersox and Daugherty (1995) Johannessen and Solem (2002) Monczka et al., (2002)</td>
<td>Toyota, Nike, BMW, Motorola, Benetton, Dell Computer, General Motors, General Electric</td>
</tr>
</tbody>
</table>
c. Way of attaining competitive advantage: Establishing strategic alliances with suppliers and customers which are inimitable and non-replicable.
d. Supply chain management role in rent creation: Establish, deploy and retain strategic resources and capabilities in dyad routines and processes in order to establishing cross-boundary integration with suppliers and customers.

- Austrian school
  a. Rent type: Entrepreneurship
  b. Strategic logic: Seeking innovative opportunities
  c. Way of attaining competitive advantage: Quick action and seeking opportunity for discovering and accessing of superior information about new innovations. Entrepreneurship role is gathering, assessing and using information.
  d. Supply chain management role in rent creation: Searching, finding and giving identity to new suppliers and customers and new and innovative products and services; Making all supply chain management activities ready for fast action.

Two basic questions in corporate-level strategies (Porter, 1985, 1998) are: first, corporation should enter what businesses and second, how to co-ordinate these businesses with each other. About first question, many researchers (Porter, 1985, 1998; Chandler, 1992; Hax and Majluf, 1996; Johnson and Scholes, 2002) believe that economic corporations are changing from irrelevant or heterogeneous diversification to related and homogenous diversification and more coherence amount in corporations means existence of related technologies and market/product relative to unrelated technology, market/product lead to better performance for corporation (Piscitello, 2004). Companies seek their related-growth strategies more often based on economy of scale and economy of scope (Chandler, 1992). Piscitello (2004) states corporate coherency or related diversification isn't only based on products/markets and companies should consider to diversity in their technological competencies and whatever firm's technological base has more related to firm's product/market base, amount of corporation coherency is increased and in this way firm will exploit from both economy of scale and economy of scope. Thus if firms can use same technology for different market/product with lowest consistency cost, then they can exploit from economy of scale; in the other hand, different technology has potential for growing other technologies and if combination among technologies occur then it cause to new function and enhancing product/process performance that it is called economy of scope.

Synergy forms among a corporation's business units can have different types (Arnold, 1999; Goold and Campbell, 2000; Rozemeijer, 2000; Porter, 1985, 1998) including:

- Vertical integration
- Sharing tangible and non-tangible resources
- Sharing technical knowledge and best practices
- Centralizing purchasing power

From other hand, Markids and Williamson (1994) believe that in companies with related diversification strategy, four kinds of following synergies are accessible:

- Asset amortization: ability of realizing economy of scope across SBUs which can share the same strategic assets.
- Asset improvement: ability in using of a core competency that is accumulated in make/store period of a strategic asset in SBU and assist to improving strategic asset in other SBUs.
- Asset creation: ability in using a core competency that is developed by experience in creating strategic assets in existing businesses to create new asset in a new business.
- Asset split and analyzes: ability in process of creating related diversification for developing existing stock of core competency in corporation because it will learn new skills during creating strategic assets in a new business that will make improvement in existing assets of current businesses.

Given to synergy forms that mentioned above, two forms of them are thoroughly related to supply chain management topic: Vertical integration and centralizing purchasing power. And in second categorization, improvement in asset is one of the points of noteworthy of supply chain management. Kitchen and Guinipero (2003) believe that supply chain is something between vertical integration and buy from market that there is both of their benefits in supply chain. In other hand, subject of centralizing purchasing power is also one of most fundamental discussions in supply chain management that is one of the evidences of economy of scale. Many scholars (Woodside and Samuel, 1981; Rozemeijer, 2000; Smart and Dudas, 2007; Munson and Hu, 2010; Johnson and Leenders, 2008) have studied about synergy among business units of a company through centralizing purchasing function (procurement or supply management) at corporate level. Some samples of companies which proceed to centralize their purchasing and procurement activities are as follows (Smart and Dudas, 2007): Ford Motor Co, SONY, Motorola, Otis, Safeway Ahold and Kruger, Great Atlantic & Pacific Tea & Co., American Stores and Co., Wakefern Food Corp., Union Pacific.
Railroad • Major stock-exchange registered company • Dow Chemical • Alcoa • 3Com • IBM. Johnson and Leenders (2008) studied organizational position of chief purchasing officer (CPO) in 26 great American and European companies. By using contingency theory they examined CPO appointment in companies and determined that 80 percent of changes in method of CPO's reporting and his appointment is created because of changes in corporate strategy. Two points were determined in this research: First, in studied firms the function of supply which is responsible of SCM's activities is organized at corporate-level and second, supply and purchasing activities that previously was done as un-centralized in business units, now they are organized at corporate level and as centralized.

In multi-business corporations, new structure is necessary for realizing synergy among businesses (Chandler, 1992). This structure called headquarter, its logic and existential philosophy and size and performance implications are studied in many studies (e.g., Foss, 1997; Collis et al., 2007; Goold et al., 2001; Johnson and Scholes, 2002; Knotes, 2004; Sanford et al., 2005; Ward et al., 2005). In all performed researches about corporation’s headquarter, value-adding role is emphasized in corporation’s headquarter. Porter (1985, 1988) mentioned this structure as horizontal organization that its components are: horizontal structure, horizontal systems, horizontal human resource activities and horizontal activities for removing conflict and disagreement. One mechanism in horizontal structure is partial centralization, in that kind of centralization, procurement activities, sale and common logistics systems among business units of a corporation are done as centralized (Porter, 1985, 1988). This mechanism distinctly points out to role and position of SCM at corporate level. Also Ward and et al., (2005) proposed a model for designing corporate centers or headquarters that it is shown in Figure 3.

As it is shown in Figure 3, companies that follow related growth strategy or homogenous diversification (two upper parts of Figure 3) take advantage based on economy of scale or economy of scope (Chandler, 1992; Pitscelslo, 2004). Provided that source of corporate advantage be economy of scale and due to related-growth or homogenous diversification strategy headquarter should have direct involvement in business units' activities and plans, the most important skills in headquarter must be supply chain management skills.

DEVELOPMENT OF CONCEPTUAL MODEL

Based on identified gap in literature about SCM position depending on type of industry and corporate strategy in literature that is determined in previous section, in this article we have tried to develop a conceptual model for specifying role and position of SCM in industries with low clock-speed and or in industries with complex products (those industries that have bilateral and reciprocal close dependence among final assemblers and key suppliers) (Krause et al., 2007; Dyer, 2000). This model is shown in Figure 4.
In the model (Figure 4) four factors are known as principal factors in increasing the importance of cross-functional and cross-boundary integration among business units. Industry clock-speed (low), relationship between OEM\(^1\), corporate level strategy: related diversification, corporate advantage: economy of scale.

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\(^1\)Original Equipment Manufacturer (OEM)
and supplier (too much reciprocal relationship and dependence), corporate growth strategy (related or homogenous) and corporate advantage (economy of scale) and type of corporate’s synergies all are factors that make integration between company’s different business unit functions and integration of corporate processes with suppliers and customers very essential and important. Given to this importance increasing we believe that SCM should have special importance in corporate level strategies and its organizational structure in headquarter (Horizontal organization) at corporation should be enhanced.

**RESEARCH METHODOLOGY**

Although studies with large samples are useful for identifying characteristics of a broad population, case study approach are more appropriate for explaining how and why of events (Yin, 1994). Many researches are done usefulness of case study approach for SCM studies (Seuring, 2008; Dubois and Araujo, 2007; Stuart et al., 2002). Yin (1994) has explained three determinant conditions in selecting research method: type of research question, extent of researcher’s control on events’ real behavior, and whether the research focused on historical or contemporary events. These conditions determine which empirical approach: experimental, survey (statistical study), archive analysis, historical and case study are appropriate for different situations. This research question is: "What is the role and position of SCM in corporate level strategy?" This question inherently is an explorative question and requires the researcher gain deep background comprehension in order to answer it. Also this study is focused on contemporary events and there is no control on event's behavior. Depending on Yin’s idea (1994) and with regard to these conditions, three types of research strategy and method are feasible to select: Case study, survey researches and archive analysis. Among these selections, case study method is selected as main selected method for aims of this research. This selection has several reasons. First because of the aim of this study which is the role and position of SCM in corporate level strategy, case study method has superiority than archive analysis method, because archive data is not stating the style of organizing and strategic position of SCM, although in this study archived data are used also. From other hand studied phenomenon was not adequately determined and intelligible and there was not many prior studies done about it so that we can use survey method (statistical analysis). Case study method increases comprehension and understanding about phenomenon during the study. Also case study method is appropriate for studying complex phenomena that a lot of variables affect it and in our opinion this study has these characteristics.

There are three types of case study (Yin, 2003):

1. **Explorative case study**: The aim is to define question and assumptions for later studies.
2. **Descriptive case study**: Provides complete explanation of a phenomenon in its context and environment.
3. **Explanative case study**: Includes studying data related to causal relationships and it explain how events occur.

This study fall in explorative category and its aim is to suggest some proposition about the strategic and organizational role and position of SCM in corporate level strategy.

**Case study selection**

According to Yin (1994) single case study plan is justifiable under special circumstances: situation which case study states important test of existing theory, situation that case study of an event is scarce and unique, situation that case study fulfill a visional goal. From other hand, it might be argued that single case study is not adequate for providing reliable and generalizable result. In this research we do not intend to generalize the results, but merely to apply developed theory about SCM position in corporate strategy in a single case.

One frequent technique in doing case study is theoretic sampling that it is related to selecting case studies because of theoretic reason not statistical reason (Glaser and Strauss, 1967; Eisenhardt, 1989; Stuart et al, 2002). A main criterion used in this research for selecting case study is theoretic reason.

This study is a part of greater research about re-structuring “Iran Tractor Manufacturing” group. Companies that are studied includes business units and Iran Tractor Manufacturing group companies named as follows: Tabriz Tractor Manufacturing company, Kurdistan Tractor Manufacturing company, Urumyi Tractor Manufacturing company, Machines and Tools Manufacturing company, Industrial Services company, Foundry company, Motor company, Ven-Iran company, Taj-Iran company, Oog-Iran company, Iran Tractor After-sale service company, Engineering and supply company.
Gathering data

Site visiting took place over several steps which they usually last one day. The interview schedules were set previously with CEO and some other executive and in each company we have interviewed with most of functional department directors. Average time length of these interviews was 100 minutes; some interviews took far more time than this amount.

Using of a protocol in interviews for case study researches is recommended (Yin, 1994). Interview protocol included several pre-designed tables and several questions, and we tried to revise these questions and tables during interview process. Prior to holding interview sessions, some documents like company’s strategy and its organizational structure were studied. Interviews were designed as semi-structured to provide opportunity to interviewee for stating his/her comments and opinion.

Gathering data is not limited to interview protocol. Several data-source including related documents and other related information was considered. As mentioned, some data was studied before the interview and other information was gathered from managerial reports, website and some managerial presentations for board of directors.

One of the methods for improving research validity is reviewing case study content by experts (Yin, 1994). In this research, first of all, by explaining research objectives for CEOs of studied company in Iran Tractor Manufacturing group and with their permission, required data about research concepts was gathered in companies. As another step in research, we have asked of CEOs to verify the gathered information in each studied firms.

Data analysis

Yin (1994) states that there are two approaches for analyzing qualitative data: theory-based and case description. Theory-based approaches uses the knowledge resulted of existing theories, as a basis for establishing initial proposition which guides the study design and analysis. Case description strategy is relied on rich description of case that performs as a mechanism for framing and organizing the study. In this research with broad reviewing of literature and developing a conceptual model, first strategy was used for research, but yet the researcher was open-minded and welcomed new ideas during research process.

According to Miles and Huberman’s (1994) analysis of data includes three distinct stages: data reduction, data display, verification and conclusion. Each three types of activity that are completed by data-gathering activities are constituted an interactive and cyclical process (Miles and Huberman, 1994).

Data reduction refers to process of selecting, focusing, simplifying, summarizing and moving data from written notes and recorded tapes (Miles and Huberman, 1994). Gathered data including recorded interviews, written notes related to interview and documents about strategies and strategic planning of each company and also documents about procurement of parts and inbound logistic system.

According to Miles and Huberman (1994) suggestion we have listened to recorded transcripts and wrote the important points down on a piece of paper. Written points of recorded files was completed by taken-notes during interview and based on it, temporary summary of case study was prepared. A temporary summary of case study represents a combination of what the researcher knows about case study and what he obtains during case study (Miles and Huberman, 1994). Temporary summary of case study in this research is used as a mechanism for summarizing case study-related data in a document and obtaining a general understanding of different aspects of the case study. Temporary summary of case study includes background information of studied company, its position in growth strategy of Tractor Manufacturing group, interdependence relationships of that company with other group’s companies in term of value chain activities point of view.

Data display states organized assembly of data that reinforces conclusion of data (Miles and Huberman, 1994). In this study, because of using conceptual framework and well-defined concepts, it was possible to show data within case study and in specified concepts.

Conclusion and results’ verification refers to making the findings meaningful and conceptualize them, and is happening with considering to discipline and arrangement, patterns, explanation, possible configuration and causal flows. In this study main mechanism is conclusion and verification of result based on developed conceptual model.
FINDINGS

In this section, research’s findings are presenting based on developed concepts in conceptual model: industry clock-speed, relationship between OEM and suppliers, corporate level strategy, corporate advantage and type of synergy among business units. Tables and charts in this section are used as data-reduction tools in analysis stage (Miles and Huberman, 1994).

Industry Clockspeed: in this research a company which is being operated in agricultural machinery industry was selected as a case study. In this industry, low clock-speed signals are obvious and specified. Average time of introducing new tractors in Tractor Manufacturing company is almost 4 years and there are no special changes in process technology of this company during previous years except that, for entering from semi-heavy tractors market (model no. 285) to heavy ones (model no. 399) too little changes is taken place in process technology. There are also no general structural changes around organizational characteristics during recent 10 years and strategic alliance of this company with Messy Ferguson Company is also stayed with no changes. So with regard to prior classifications of this industry as low clock-speed (Fine, 1998), according to above witnesses, we can conclude that the type of industry that Tractor Manufacturing Company takes part in it, is placed in low clock-speed.

Relationship between OEM and suppliers: From point of view of relationship between OEM and suppliers, industries are divided into two parts: industries with simple products and industries with complex products (Krause et al., 2007; Dyer, 2000). In some industries due to increasingly growth in outsourcing the non-core activities to suppliers, suppliers play a very important role in success of that industry’s companies and OEMs have too much interdependence with first-tier suppliers. In other industries which are classified as simple product industries such as retailing industry, this condition is not existed. Agricultural machinery industry is classified as complex product industries (Krause et al., 2007). Therefore there is a lot of mutual interdependency between Iran Tractor Manufacturing Company and its suppliers like Engine Manufacturing Company and Casting Company and other suppliers which during our interview with CEOs they have approved it.

Corporate level strategy: For growth of companies two alternatives are presented: each alternative has its own course of action. These alternatives are as follows: 1. Expansion into existing businesses and 2. Diversification into new businesses. There are two paths for expanding into existing businesses; the first path is related to changing product, market and geographic scope. In this path three things are suggested as follows: 1. Existing products and markets, 2. Deploying existing products to new markets and 3. Introducing new products to existing markets.

Now we are going to study these conditions for Iran Tractor Manufacturing Group: they offered tractor model 285 and 399 and they sell them in Iran market that it is complemented by establishing Kurdistan Tractor Manufacturing Co. for assembling tractor model 285 in order to penetrate more in the market of west provinces of country. Also, Establishing Ven-Iran, Taj-Iran, Oog-Iran and Kurdistan Tractor Manufacturing companies is another way of growth for Iran Tractor Manufacturing group. In this way of growth, Tractor Manufacturing Group tried to offer manufactured tractors to different internal geographical market (the west region of Iran market), and international (Venezuela, Tajikistan, Uganda) and the growth of the corporation has been from geographical scope (Chandler, 1992).

Iran Tractor Manufacturing group obtain more share of light tractors market by purchasing Uromiye Tractor Manufacturing which is another part of growth method for Tractor Manufacturing Group in existing products and markets. Also, Iran Tractor Manufacturing Group has tried to develop scope of its assemble line with offering different models of semi-heavy tractors (MF/135,165,185,295,285,ITM/800,840) in semi-heavy tractors’ market and models MF/399,6290 in heavy tractors’ market in single-differential and double-differential models and garden models -930, 938 and 942- in light tractors’ market.

Another way of growth for companies can be viewed in Figure 5, is expanding value chain or vertical integration. There is two directions for expanding the value chain: forward or getting closer to end customers and backward or getting closer to raw material suppliers. In this section of growth for Tractor Manufacturing Group there is a business unit called Tesco which offers trade and after-sale services and also performs as dealer. In the backward direction there are some companies which all owned by the Iran Tractor Manufacturing Group: Engine Manufacturing Co., Foundry Co., Engineering and Supply Co., and other entities such as Uromiye Foundry, Uromiye Soldering Iron and also Foundry of training organization. But in other direction of Figure 5, there is another way for firm growth that is creating diversity in result of founding new business. From this point of view the chart is divided into another two parts again which in first part refers to related diversification (horizontal strategy) and in second part refers to unrelated diversification (or Conglomeration).
In first part, we can refer to changing tractor usage by Kurdistan Tractor Manufacturing Co. through adding mechanical shovel to the tractor and selling these tractors as construction machinery. Although this section does not make much financial turnovers for Kurdistan Tractor Manufacturing Co., but it needs more attention as a growth strategy for Tractor Manufacturing Group. In Product technology it is related to tractor and agricultural machinery industry and main business of Tractor Manufacturing Group; hence it is mentioned as a horizontal growth strategy.

In the other hand, Iran Tractor Manufacturing Group has followed another way of growth. Because of reciprocal interdependence in value chain in dimension of process technology, manufacturing process and assemble process with tractor manufacturing process, this group enters into the market of conversional machinery through producing tractors and established a company named Machine and Tools Manufacturing Company. This reciprocal interdependence between process technology, manufacturing and assembling process is existent between Iran Tractor Manufacturing Group and Machine and Tools Manufacturing Company.

In the way of entering into new businesses, Tractor Manufacturing Group attempt to enter into commercial vehicles markets with Azerbaijan Diesel Auto-manufacturing Company through following an unrelated growth strategy. Based on study of interrelationships between strategic business units we haven't found any substantial interrelationship areas between commercial vehicle business unit and other business units. This means that entering this business classified as an unrelated growth strategy or diversification.

From other hand, the performance of Engineering and Supply Company and Tesco Company can be studied in this growth strategy. Given that there is high reciprocal interdependence between Engineering and Supply Company and other business units of Tractor Manufacturing Group in terms of procurement, and within this company the knowledge of sourcing and contracting with suppliers and generally supply of material and component parts is created, considering of entrance in parts and material procurement business for the group is possible.

In this regard in case the firms can obtain knowledge and experience in field of distribution, retailing and providing after-sale services so that this knowledge and experience closely related to their main business, they can create new businesses in this context. The Iran Tractor trade and after-sale service Company (Tesco) in Iran Tractor Manufacturing Group has this potential for growing the group on this context. Currently this company operates on three fields: trading of agricultural machinery attachments and implements, providing after-sale services and retailing tractors. In this way of following related horizontal growth strategy, producing and trading agricultural machinery attachments and implements could be considering as a new business area for the group, given that they are complement product for agricultural machinery. This way of group growth is shown in Figure 5.

About Tesco activities as mentioned before, we can imagine growth field on the basis of distribution, retailing and providing after-sale services and also introduce new business. Nowadays Tesco company is entered retailing as an agent in agricultural machinery industry and the possibility of entering distribution business can be achievable for this company. We tried to explain growth options of Iran Tractor Manufacturing Group in Figure 5.
FIGURE 5
GROWTH STRATEGY OF IRAN TRACTOR MANUFACTURING GROUP

Options for growth

Expansion into existing Business

Diversification into new business

Changes of Product, Market, and Geographical Scope

Existing Products and Markets
Ven-Iran, Taj-Iran, Oog-Iran and Kurdistan
Tractor-Man. and Uromiye Tractor-Man.
Releasing existing products to new markets
- Uromiye Tractor-Man. and paddy
Releasing new products to existing markets
- Variety of tractor models in heavy, semi-heavy and light section

Forward: Getting closer to customer
Tesco company (after-sale services and
Backward: Getting closer to suppliers
Engine Co. and Foundry Company, Engineering
and Supply Company

Product technology
Procuremenit
Basic raw materials
Processes or fabricated materials
Fabricated components
Assembled products
Experiment
Distribution
Marketing and sale
Retailing
Services
Machines and Tools Company
Engineering and Supply Company
Tesco Company

Unrelated (Conglomeration)

Related (Horizontal strategy)

Vertical integration (extending value chain)

Azerbaijan Diesel Auto Company
Thus we can conclude that in general the growth strategy of Iran Tractor Manufacturing Company is a related growth strategy except one case (entering into diesel automobiles section).

**Corporation advantage:** Given that most of growth areas of Tractor Manufacturing Group are either in expanding product lines or expanding of its market and geographical scope, the advantage that group can obtain, is economy of scale. In other hand, companies with related growth strategy predominantly exploit from economies of scale (Chandler, 1992).

**Type of synergies between business units:** Synergy areas between Iran Tractor Manufacturing Group business units are as follows:

- **Vertical integration:** As depicted in Figure 5, some of group’s companies are placed in area of synergies related to vertical integration. Thus in Figure 6, group supply chain is shown only for companies inside the group of Iran Tractor. Ownership of these companies by the group is considered as an evidence of vertical integration for Tractor Manufacturing Group and we should mention that in advanced topics of supply chain, firms try to use less from ownership alternative for making coordination between OEM and their own suppliers and there are more effective solutions that they are identified and used by successful companies of the world like John Deer, Toyota on this field.

- **Centralizing purchasing power, assets improvement and centralizing logistics activities:** For studying this types of synergies, we used from value chain approach (Porter, 1985,1998; Hax and Mujluf, 1996) for identifying areas of reciprocal interdependence between business units. These areas of reciprocal interrelationships are classified in R&D activities, production activities (manufacturing and inbound logistics), activities related to market (outbound logistics, marketing, selling and after-sale services) and activities related to procurement. Tables 3 to 6 depict these areas of reciprocal interdependence between business units of Tractor Manufacturing Group.
TABLE 3
INTERRELATIONSHIP AMONG BUSINESS UNITS IN R&D

<table>
<thead>
<tr>
<th>T.Tabriz</th>
<th>T.Oroumiyeh</th>
<th>T.Kordestan</th>
<th>Vaniran</th>
<th>Oogiran</th>
<th>Tajiran</th>
<th>Tesco</th>
<th>Motorezan</th>
<th>SakhteMashin</th>
<th>Rikhategar</th>
<th>Kh.Dizeli Az.</th>
<th>Kh.Dizeli Sanati</th>
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Guide:
1: Similar or same product technology
2: Similar or same process technology
3: Common technology in other activities of value chain such as inbound and outbound logistics, procurement, marketing and sales, and after-sale services
4: Technological aspects of integrating one product in another product
5: Common interface between products

TABLE 4
INTERRELATIONSHIPS AMONG BUSINESS UNITS IN PRODUCTION AND MANUFACTURING

<table>
<thead>
<tr>
<th>T.Tabriz</th>
<th>T.Oroumiyeh</th>
<th>T.Kordestan</th>
<th>Vaniran</th>
<th>Oogiran</th>
<th>Tajiran</th>
<th>Tesco</th>
<th>Motorezan</th>
<th>SakhteMashin</th>
<th>Rikhategar</th>
<th>Kh.Dizeli Az.</th>
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Guide:
1: Common location of supplying raw materials or common supplier
2: Similar or same manufacturing process
3: Similar or same assemble process
4: Similar or same quality test/control procedure
5: Common plant supportive activities such as preventive maintenance

TABLE 5
INTERRELATIONSHIPS AMONG BUSINESS UNITS IN MARKET

<table>
<thead>
<tr>
<th>T.Tabriz</th>
<th>T.Oroumiyeh</th>
<th>T.Kordestan</th>
<th>Vaniran</th>
<th>Oogiran</th>
<th>Tajiran</th>
<th>Tesco</th>
<th>Motorezan</th>
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<th>Rikhategar</th>
<th>Kh.Dizeli Az.</th>
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</table>

Guide:
1: Common customer
2: Common distribution channel
3: Common geographical market


TABLE 6
INTERRELATIONSHIPS AMONG BUSINESS UNITS IN PROCUREMENT

| Table 6 depicts type of asset improvement synergy that a company can use its technological assets in other businesses. In Table 4 we see synergies of inbound logistics and asset improvement type between business units. Table 5 shows synergies of outbound logistics and asset improvement type. And finally Table 6 depicts synergies of centralizing purchasing power type between business units of Iran Tractor Manufacturing group’s business units.

DISCUSSION AND CONCLUSION

As it is shown in developed conceptual model in Figure 4, low clock-speed industry, vast reciprocal interdependence between OEM and suppliers, homogeneous growth strategy, advantage of economy of scale and synergy areas in vertical integration, asset improvement, inbound and outbound logistics and centralizing purchasing power are resulting in importance of cross-functional and cross-border integration in order to pay more attention to issue of supply chain management in corporate level strategy and also promote supply chain management organizationally in corporation. These concepts studied in former section for Iran Tractor Manufacturing Group. On the basis of studies in Iran Tractor Manufacturing group, it is recognized that mentioned concepts that leads to increasing of importance of supply chain issues in corporate level strategy are applicable for Iran Tractor Manufacturing Group. Following this importance, it was suggested that the company considers a structural position for supply chain management in headquarter of this group and it is better that this position be as a vice president.

This research is done based on single case-study. For generalizing the results of this research and suggestion for future research following proposition is presented:

Proposition 1: In corporation with related diversification strategy and low rate of industry clock-speed, the advantage of corporation is usually would be in economy of scale.

Proposition 2: corporations that following advantages of economy of scale have these types of synergies: vertical integration, asset improvement, centralized procurement, and centralized logistics activities.

Proposition 3: corporations with related diversification strategy, low rate of industry clock-speed, and economy of scale advantage will need to high cross-functional and cross-boundary integration.

Proposition 4: corporations with related diversification strategy, low rate of industry clock-speed, and economy of scale advantage will emphasize SCM in corporate level strategy and promote its organizational position.

Above theorems should be studied future studies as an assumption or research questions. It is noticeable that the results of this study and as a single case study is not generalizable to other corporations, but this study based on developed conceptual model tried to examine a case study deeply and find evidences for concepts of the model for a company. It is obvious that multi case studies and or survey studies should be planned to increase the generalizability of the results of this research.

Companies should pay special attention to SCM subject in order to obtain relational advantages. Predominant strategy approach of this article was relational approach that is studied thoroughly in another research about automobile industry (Feizabadi, 2009) and a model for explaining strategic conduct of supply chains is provided.
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EFFICIENCY IN LOGISTICS FACILITIES

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ABSTRACT

Due to the growth in shipment volumes in recent years, many plants have reached the limits of their capabilities, leading to bottlenecks in transport chains. There is a great potential for increasing the efficiency of processes in logistics facilities such as terminals, distribution centers, or production sites and thus ensuring economic growth. These logistics facilities are contributing factors in determining the performance, quality, costs and carbon emissions of superior supply-chains and transportation networks. The aim of the collaborative project "Efficiency in Logistics Facilities" is to develop a prototypical software so-called “EcoSiteManager - ESM”. The ESM will be a suitable modular software tool for the control of logistic resources and large factory sites. The development of this newly developed software is based on three areas of innovation. These Innovations are: 1) unitCV Storing relevant shipment information in an electronic CV and an IT-platform, 2) HugO Application of human guided optimization methods and therefore interactive software and , and 3) X-Ray Monitoring functions of all resources within the system. To implement these fields of innovation in the software prototype mathematical optimization, material flow simulation and forecast methods are developed and used. This technology would increase the amount of available information at logistics facilities including shipments and their properties (e.g. volume, form, handling requirements) in relation to resources and their current status (e.g. use of warehouse floor space). Results will be integrated in an application-GUI that has intuitive handling and assistance for the user.

KEYWORDS
Logistics Facilities, Efficiency, Mathematical Optimization, Simulation, Logistics Management

INTRODUCTION

The Ruhr metropolis is with approximately 5.2 million inhabitants the third biggest population center in Europe next to Paris and London (Wirtschaftsförderung Metropole Ruhr, 2010). With an accessibility of approximately 20 million people within a radius of two hours travel the Ruhr metropolis and its adjacent regions represents a unique consumer region and thus a center for work and consumption in Germany and in Europe. Due to its geographical location in Europe the Ruhr metropolis has a central role in the global goods stream during the past decades. 20% of the federal freight haulage is generated in North Rhine-Westphalia and a majority of it in the metropolis Ruhr (Statistisches Bundesamt, 2006). As a result a high number of logistics facilities established in the Ruhr metropolis to supply the population and resident enterprises.

In recent years the performance and quality requirements affecting logistic facilities grew constantly. Resulting from an increase of shipment quantities many facilities reach the limit of their performance ability and thus become a bottleneck in the supply-chain. They turn into an endangerment for defined cost and service goals in superordinate transport, procurement or distribution nets. To solve the problem by building new facilities or to provide more capacity seems to be obvious. However, additional surface and financial investments are needed. Furthermore, the needed space for facility enhancements is not always obtainable.

Various unused potentials exist for increasing efficiency of logistic facilities instead of enhancing through building operations (Göbel, 2011). For example, processes and procedures can be intelligently steered and indistinct or decentralized information can be made transparently and available. In order to strengthen the competitiveness the efficiency of logistic facilities (i.e. quantity, speed and quality by the same amount of resources) has to be increased as well as to adapt the facility layout to future developments.

An efficient operation of existing logistic facilities is essential for the development of metropolitan regions such as the Rhine-Ruhr. Regarding the economic power and the global commodity flows of the region and in addition against
the tightening of space for logistic facilities innovative control and steering mechanisms are needed. In the followings this paper gives an overview about the solution approaches and the special software requirements.

**PROBLEM DESCRIPTION**

Initially, the object of study has to be pointed out. Accordingly, a logistic facility can be understood as a terminal, a distribution, or a production site (Pfohl, 2009). As shown in figure 1 the open-air site respectively the yard, on which transportation and maneuver processes take place, the loading ramp, as delivery place for shipment from the vehicle into the logistic system, as well as the sections inside the transshipment hall and logistics buildings are in the focus of research.

**FIGURE 1**

**OBJECTS OF LOGISTIC FACILITIES**

The following aspects are presently problematic regarding an efficiency increase in logistic facilities:

**Objects** (e.g. shipments or vehicles), which in the context of processes (e.g. unloading, placing, loading, commissioning), resources (e.g. unloading points, forklifts, personnel, surfaces) within the facility access, are in its characteristics (e.g. volume, form, arrival plans, technical criteria), which essentially their requirements to the processes and resources used within the framework process execution define, not sufficient accurate and above all not continuously transparency seized. Often, e.g. transmission characteristics before their arrival are not well known, which leads to the fact that resources cannot be coordinated, planned and steered optimally.

**Resources** instituted in logistic facilities and their current status (e.g. filling degree, orders on forklift trucks, allocation of unloading points) are not accurately described. This leads to the fact that scientific methods, e.g. mathematical optimization, material-flow simulation or logistic prognosis and effective key performance indicator systems have not reached a sufficient penetration in logistic facilities. Above all the application of the methods is actually not expedient due to missing real time data and a missing comprehensive fielding. In this case, especially the result determination bases on hypothetical conditions of resources.

**Human expert's decision mechanisms** are the basis of current control and planning mechanisms for facilities. In practice decisions depend on this human expert knowledge. The above specified scientific methods are used rarely or only in sub-sectors (e.g. picking). Here, a transmission of the expert knowledge in formalized and automated procedures in a software tool is missing (Klau, 2002; Klau, 2009). With the application of formalized expert knowledge logistics facilities can be controlled and steered in order to increase the efficiency.
SOLUTION APPROACH

The primary aim is to close information gaps in logistic facilities. Another aim is to support human experts by an integrated methodical intelligence by planning and controlling of the facility. However, the user support is always in first instance.

In order to model such automatic decision mechanisms, continuous and consistent information are necessary. Therefore, in a first step the project partners systematically collect additional data referring shipment characteristics e.g. form, volume, handling requirements or the current status of resources. These data are essential for evaluation and control mechanisms, which ensure that each moved commodity has suitable resources available. A superordinate control monitor measures and evaluates the efficiency and effectiveness of the actions taken.

Therefore, each project partner takes into account for its own area of operations and develops in close interchange with the Institute of Transport Logistics independent software prototypes. At the end of the project these fragments summarizes the different aspects of a logistic facility in the „EcoSiteManager“. For example to advance their processes in inbound control or intelligent land allocation in its retail facility a project partner worked on their two central questions: How can be surfaces and resources used optimally? And how can they combine their retail and fashion transportation network to cut down costs and resources.

In order to solve these and similar questions, for example the material flow in the logistics facilities is simulated for different situations. To achieve a better overview about incoming and outgoing flows of goods inside the facility and to increase the analytical options mathematical optimization is used.

The application of these methods enable the software prototype to deliver the information how the operational sequences in logistic facility can be design more intelligent and operations can be controlled more efficient. To cover a wide range of challenges of all sorts of logistic facilities the “EcoSiteManager” will be built in three individual modules, “unitCV”, “HugO” and “X-Ray”. In the following the innovation fields are shown:

FIGURE 2
ECOSITEMANAGER

**unitCV** apprehends detailed information about objects, such as shipments or vehicles, which access in the context of processes (e.g. unloading) resources (e.g. loading yard) within the facilities. With the detailed information through the facility the unitCV enables separate object detection. The important information for a shipment is stored in an electronic CV and assigned to the transmission.

**HugO** (= human guided optimization) is a planning and control software for user-controlled optimization of resources in logistic facilities. Optimization methods are integrated with expert human knowledge and allow manipulation of partial solutions so that new solutions and decisions can be generated.

**X-Ray** is a method technique to report the status of a resource or the location of a vehicle in the system. This method will provide optimal control of all objects and resources within the system.

For all practical purposes the ESM assigns the right shipment to the right resource at the right time, referring to the stored data of the unitCV. The unitCV obtains information of the objects and the current state of resources. Thus, resources can be more efficiently used through human guided optimization methods and controlled by the X-Ray module.
CONCLUSION AND OUTLOOK

With this background, the goal of the project is to develop new software that can be used at large logistic facilities or production sites by embedding methods of mathematical optimization, simulation and forecasting. The ESM will increase the amount of available information and usable data at logistic facilities and lead to a better resource utilization and economic growth. The project results will be integrated in an application-GUI with intuitive handling and assistance systems for the operators of a logistic facility.

ACKNOWLEDGEMENTS

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PERFORMANCE MEASUREMENT FOR FORWARDERS

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ABSTRACT

Performance Measurement is still a challenge for forwarders. The main reason is on the one hand missing resources and on the other hand missing tools. The research project “Management Information System for Logistics Service Providers” aims for closing the gap between needed and disposable solutions by developing a performance management system for forwarders. Due to the insufficient systems for forwarders, a performance management system has been developed. The aim is a continuous control of costs, performance and quality taken under consideration of company structure and goals. The system is built modular and contains a performance management system, calculation of profitability and a benchmark module. Every module can be used in combination or in a single use. Several forwarders were involved in the project to achieve a best fit of the prototype. Therefore, special performance indicators are developed. A special focus lies on the needed and available data for the performance indicators. A combination of conventional and weighted indicators ensures the application of the performance management system in practice. Concerning the forwarder requirements, a benchmark platform was developed which contains the main indicators for company comparison. The major challenge is the collection of company data. This lack of information has been closed through the optional participation and anonymous data evaluation. Beside the performance management system, the prototype contains cause-and-effect chains. These cause-and-effect chains consist of single indicator groups as well as possible characteristics and sanctions.

KEYWORDS
Performance Measurement, Forwarder, Controlling, Logistics Management

INTRODUCTION

About 15,300 forwarder companies exist in Germany and nearby 90 % are small and medium sized companies. Therefore, most of the forwarding agencies are not equipped with enough manpower or knowledge to build up and implement an own controlling system. Controlling had a subordinated role for quite a long time (Clausen, 2003). An own empirical inquiry about the adoption of controlling in German logistics companies shows, that more than 60% of these companies have employ less than 50 employees and 30% of the medium-size companies (50 to 200 employees) do not possess a comprehensive controlling system (see FIGURE 1).
The European Union market opening towards East intensified the competition. The revenues fell around 30 to 50% (Deutsche Gesellschaft für Mittelstandsberatung, 1996) and a significant increase could not be determined. The nowadays-average profit margins are between 1 to 3% of the turnover for break bulk transports (DVZ Brief, 2005; Mercer Management Consulting, 2007). As a result, forwarders necessitate a comprehensive controlling system, which allows them to monitor their costs and performance.

Thus, the implementation of a performance measurement system offers the possibility to improve process speed. For this, an implementation and use of a comprehensive controlling system is necessary. Reports of forwarder companies, which avoid insolvency or managed difficult restructuring phases, underline the need of such management information systems (Wöhrle 2005; Hassa, 2005; Bottler, 2006). Especially for small and medium-sized companies a functioning controlling represents a compelling necessity. Small and medium-sized forwarders can benefit from their flexibility and short communication structures in contra wise to big companies.

STATE-OF-THE-ART PERFORMANCE MEASUREMENT SYSTEMS

A comprehensive controlling system contains key performance indicators to steer and manage processes. If they are connected in a performance management system it is possible to analyze process or even company entrapments. Therefore, multiplicity performance measurement systems were already formed. Most of the appendages are descended from industrial or retail companies and only unconditionally adaptable for forwarding companies. Most of these performance measurement systems refer exclusively to monetary aspects. Thereby a controlling under achievement and/or quality aspects is not possible. Existing financial performance indicators are general and do not face the forwarders requirements.

General financial oriented performance indicator systems are the ZVEI the DuPont and the RL-Kennzahlensystem e.g. according to Reichmann and Lachnit (Zentralverband Elektrotechnik und –Elektronikindustrie, 1989; Reichmann, 2001). Well-known performance indicator systems come from the VDI, Filz et al. or Syska (VDI 4400; Filz, 1989; Syska, 1990). Even though, they were developed for logistics in industrial companies, they do not sufficiently consider the interests of forwarder companies. Their focus is on the extent of utilization of its systems and the fast and reliable transport of goods. Even the performance measurement systems of Stölzle and Gaiser, Berg and Mouse as well as Pföhle and Zöllner are focusing the distribution and trading ventures (Stölzle, 1996; Berg, 1980; Pföhle, 1991). The mentioned performance systems lack of important indicators e.g. cargo handling.

Recapitulatory, the mentioned systems cannot be transferred completely into the transportation sector. Furthermore, the specialization of performance and quality indicators fails as well as a calculation of profitability.
DEVELOPMENT OF PERFORMANCE MANAGEMENT INFORMATION SYSTEM FOR FORWARDER COMPANIES

Due to the inadequate performance measurement systems for forwarder companies, the Institute of Transport Logistics has developed a management information system for forwarder supported by the AiF and BVL. The aim is a continuous control of costs, performance and quality taken under consideration of the companies’ structure and goals. The system is built modular and contains a performance measurement system, calculation of profitability and a benchmark module, which can be used in combination or in a single use.

FIGURE 2
MODULES OF THE MANAGEMENT INFORMATION SYSTEM

To assure a best fit of a reference application various project partners were involved. Therefore, special performance indicators were developed with a particularly focus on the needed and available data for the performance indicators. Thus, a combination of conventional and weighted indicators ensures the application of the performance measurement system in the operational business. The performance measurement system was transferred into a software prototype. The structure of this management information system enables a modular implementation of the system in existing forwarder company structures.

First of all, the company targets have to be defined. These targets are the base to accumulate the performance indicators. The targets are divided into financial, performance and quality levels. Each level refer to different characteristics. TABLE 1 contains all levels and their targets.

<table>
<thead>
<tr>
<th>TABLE 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>LEVELS AND TARGETS</td>
</tr>
</tbody>
</table>

| Financial Level | Profit Gaining  
| --- | Liquidity |
| --- | |
| Performance Level | Velocity  
| --- | System Utilization  
| --- | Flexibility  
| --- | Sustainability |
| Quality Level | Reliability  
| --- | Robustness |

After the target definition the inquiry of processes was carried out. Relevant company processes were identified and described. Based on single processes of the project partners standard processes were built. Besides the already defined targets the standard processes are the groundwork for the deduction of the operating performance and quality indicators. In the next stage, special indicators could be determined for each sub-process. Under consideration of the defined target deviation each process step was considered and performance indicators were developed. The proceeding is described in FIGURE 3.
FIGURE 3
DEDUCTION OF INDICATORS FROM PROCESSES AND TARGETS

<table>
<thead>
<tr>
<th>Reliability</th>
<th>Robustness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Securing of Load</td>
<td>Delivery</td>
</tr>
<tr>
<td>[ ] Flexibility</td>
<td></td>
</tr>
</tbody>
</table>

Target Level

Ratio Level

Damage free Shipments
- # Claim Free Shipments
- # Damaged Shipments
- Ratio of Complaints [%]
- Ratio of Damaged Shipments [%]

Ø Time of Delivery
- # Replenishments
- Ratio of Wrong Deliveries [%]
- Total Delivery Time
- ...}

Measure Level

- # Shipments
- # Damaged Shipments
- # Orders
- # Complaints
- ...
In addition, the Institute of Transport Logistics developed a benchmark platform, which contains the main indicators for process and company comparison. For small and medium forwarders, especially the comparison with an anonymous competitor is attractive. A great challenge was the collection of companies’ data. This lack of information was closed through the optional participation and anonymous data evaluation. Therefore, selected indicators were evaluated. Each company has its own competitor and the possibility to compare the target deviations.

The management information system includes also cause-and-effect chains. These cause-and-effect chains consist of single indicators as well as possible characteristics and sanctions. In FIGURE 6 a cause-and-effect chain of vehicle utilization is shown.
CONCLUSION

The developed performance measurement system resolves the lack of common controlling tools for small and medium-sized forwarder companies. To support forwarders in strategic questions, the management information system includes economic viability calculations to forecast the effect of decisions on the financial figures. The optimal point for replacement of e.g. trucks can be calculable as well.

Additionally, a benchmarking tool was implemented. Due to the fact that one-on-one comparisons between companies are very sensitive, benchmarks was surveyed from the branch and implemented in an own internet platform based on the tool. This allows a benchmarking with an average anonymous competitor. In summary, the adoption of the performance management system strengthens the position of small and medium-sized forwarder companies on the market.

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ACTORS AND STAKEHOLDERS IN HUMANITARIAN, BUSINESS AND MILITARY ORGANIZATIONS AND THE RESULTING POSSIBLE SYNERGIES IN LOGISTICS

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ABSTRACT

Kovacs and Spens (2007) identified 10 characteristics of humanitarian logistics. This paper is one of a series of conceptual papers comparing humanitarian, business, and military logistics along these characteristics. The focus of this paper is on the actors and stakeholders with regards to logistics in each of these three kinds of organizations. The authors identified possible synergies that can be gained if the strengths of each type of organization are used to compensate for the weaknesses of the others. The aim of this paper is to propose a model that can be further tested and should eventually help practitioners to increase efficiency and effectiveness.

KEYWORDS

Humanitarian Logistics, Disaster Logistics, Organization Types and Logistics

INTRODUCTION

In comparing logistics across three types of organizations, this paper compares the actors and stakeholders in typical humanitarian, business and military logistics activities. Military organizations have used logistics for centuries, with Napoleon Bonaparte’s success often attributed to this. Businesses discovered in the 20th century that they can increase efficiency and therefore profits by implementing logistics policies, and since the Indian Ocean Tsunami in 2004 and Hurricane Katrina in 2005, Humanitarian Relief Organisations (HROs) have become aware of the importance of logistics (Fritz, L., 2007; Keskinocak, 2010; Kovacs and Spens, 2007).

Logistics however is a wide field comprising of many areas including transportation, warehousing and inventory, customs procedures, procurement, communication and information exchange, to name but a few (Branch, 2006).

We are looking at who is involved in and who is affected by logistics operations conducted by the three kinds of organizations, namely businesses, NGOs and the military. This paper aims to find synergies and make recommendations on how these organizations can work closer together in humanitarian logistics and increase the efficiency to save lives at lower cost. This would be desirable for both the initial emergency phase as well as the recovery phase.
The aims of this paper is to propose a model by combining literature research with the authors’ empirical observations in logistics as performed by businesses, NGOs, military organizations and other governmental and supra-governmental organizations.

**LITERATURE REVIEW**

The paper which started the authors’ curiosity about the difference between the logistics of the three types of organizations was entitled “Humanitarian logistics in disaster relief operations” (Kovacs and Spens, 2007). In this paper, the authors show that humanitarian logistics has ten specific characteristics:

### TABLE 1
**CHARACTERISTICS OF HUMANITARIAN LOGISTICS**

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>The main aim</td>
<td>Alleviating the suffering of vulnerable people</td>
</tr>
<tr>
<td>Actor Structure</td>
<td>Stakeholder focus with no clear links to each other, dominance of NGOs and governmental actors</td>
</tr>
<tr>
<td>3-phase setup</td>
<td>Preparation immediate response, reconstruction</td>
</tr>
<tr>
<td>Basic features</td>
<td>Variability in supplies and suppliers, large-scale activities, irregular demand, and unusual constraints in large-scale emergencies</td>
</tr>
<tr>
<td>Supply chain philosophy</td>
<td>Supplies are &quot;pushed&quot; to the disaster location in the immediate response phase. Pull philosophy applied in reconstruction phase</td>
</tr>
<tr>
<td>Transportation and infrastructure</td>
<td>Infrastructure destabilized and lack of possibilities to assure quality of food and medical supplies</td>
</tr>
<tr>
<td>Time effects</td>
<td>Time delays may result in loss of lives</td>
</tr>
<tr>
<td>Bounded knowledge actions</td>
<td>The nature of most disasters demands an immediate response, hence supply chains need to be designed and deployed at one even though the knowledge of the situation is very limited</td>
</tr>
<tr>
<td>Supplier structure</td>
<td>Choice limited, sometimes even unwanted suppliers</td>
</tr>
<tr>
<td>Control aspects</td>
<td>Lack of control over operations due to emergency situation</td>
</tr>
</tbody>
</table>

Source: Kovacs and Spens (2007)

Looking at the actor structure, we find “Stakeholder focus with no clear links to each other, dominance of NGOs and governmental actors” in Table 1.

The stakeholders in a humanitarian disaster situation are:

- Beneficiaries (victims)
- Institutional and private donors
- International and local non-governmental organisations (NGOs)
- The government of the affected country and their military organisations
- Foreign governments acting as donors of goods and manpower, including military
- UN agencies
- Logistics organisations
- The media
The media play an important role as they create awareness, which for large disasters (like the earthquake in Haiti) can encompass the world and for smaller disasters (like the flooding in Germany in 2011) the country. This will increase the willingness of the general public to donate and will also help the government actors to provide assistance from the tax payers’ money. In addition, it will put pressure on the government and non-government actors to provide humanitarian assistance to a higher level than without the media (Fritz, 2006). However, the media are not involved in providing logistics, so we will not mention them further in this paper.

Logistics organizations include businesses that operate warehouses in which they either store goods or can make them available on short notice. In the aftermath of hurricane Katrina, Wal-Mart was the first organization to deliver relief goods from their own stores before the government had decided on a distribution plan. Banomyong (2009) suggested that the big discount stores in Thailand should be contracted under a private-public partnership to provide relief goods in case another disaster hits. Therefore, the discount stores, which are located in many provinces in Thailand, act as warehouses, distribution centers and even transportation providers for the emergency goods. Since the discount stores outsource their transportation, local truckers can be used who know the area, rather than nationwide truckers. Discount stores have knowledge and experience in moving large quantities efficiently. In addition, the contractual agreements could fix prices, so that the relief goods and services will not come at sudden inflated prices, which often happens when goods are services are urgent and demand is suddenly rising.

The victims of a disaster are the beneficiaries of the humanitarian assistance and the end-users of the goods. The users of the logistics services are the governmental and non-governmental organizations distributing the relief goods.

Institutional and private donors will contribute money, which is often earmarked for certain purposes, or they will contribute goods-in-kind (GfK). This often causes problems, because there may be too many blankets donated after a specific disaster, clogging up the supply chain and the filling the limited warehouse space, while other urgently needed goods are missing. It also happened that the wrong goods were donated, such as canned food containing pork after the Pakistan earthquake. Islam is the main religion in Pakistan, followed by 95% of the population (CIA, 2011).

The actors involved in the logistics of humanitarian relief and assistance are the UN Agencies, NGOs, and the governments.

The UN coordinates logistics through Logistics Clusters which are operated by the World Food Program (WFP, 2011a). At this moment, Logistics Clusters are operating in 11 countries including Haiti and Somalia. As part of the Logistics Clusters, the WFP operates the UN Humanitarian Air Service UNHAS (WFP, 2011b). The WFP takes the lead of coordinating all organizations, not only UN agencies, on logistics as a mandate of the UN. The UN or UNHAS do not own aircraft; they charter aircraft from commercial companies.

Governments often use their military organizations to provide logistics in the emergency phases of disaster situations, because the military are at the ready, well equipped, and usually not otherwise busy unless they are involved in a war that uses up their manpower and logistics equipment. Military organizations of several countries have made it one of their missions to provide humanitarian assistance: The German Armed Forces (Bundeswehr) have signed an agreement with GIZ, a German HRO (Berg, 2011), after the German Navy had already declared that the new mission of the German Navy is to “Contribute to Collective Defence, Crisis Management and Conflict Prevention, Multinational Partnership and Cooperation, and Disaster Relief and Participation in non-Art. 5 Crisis Response Operations” (Schomburg, 2002). The Royal Thai Army conducts Humanitarian Disaster Relief Operations (Royal Thai Army, 2011) and the Australian Defense Force was the main government organisation providing humanitarian assistance and logistics during the Queensland floods in 2010 (Weaver and McKenzie, 2011).

Many NGOs have their own logistics departments now. Other NGOs use commercial companies, such as DHL, Kuehne+Nagel, HK Logistics and others. In the past, NGOs were gladly accepting volunteers who would donate their time and expertise, but they have changed towards commercial companies who have experienced and professional staff. Even though it would cost them money, the end-result is that if they save on personnel cost, the total cost will be higher.

Some NGOs enjoy good support from their governments and can use military service and equipment for their logistics (Müller, 2011), or, under circumstances, the UN Humanitarian Airlift Service UNHAS.

The main aim of businesses may be profit (McLaughlin et al., 2009), customer satisfaction (Plunkett et al., 2008) or market share (Kotler and Keller, 2006), but they intend to achieve these goals by increasing their efficiency. Kaizen is a Japanese business philosophy looking for continuous improvement in all aspects of business (Cappelli, 2007) including logistics.
The stakeholders in businesses are:
- Shareholders
- Employees
- Suppliers
- Customers
- External Community

The shareholders are interested in the shareholder value, which for some is monetary, for others requires a Balanced Scorecard (BSC). The BSC has four bottom lines: Financial, Internal Business Process, Learning and Growth, and Customer. In addition, Corporate Social Responsibility (CSR) is considered increasingly important for companies, along with Green Logistics. It depends on the vision of the company whether the shareholders are interested in these values and direct the management accordingly.

**TABLE 2**

**SIX DOMAINS FOR A BSC FOR NGOs IN AFGHANISTAN**

NGOs also use the concept of BSC, but it is not uniformed. For example, the Poverty Eradication Network in Kenya (PEN) uses “Objectives, Indicators, Targets, Initiatives” (PEN, 2010) and the Ministry of Public Health in Afghanistan uses for the NGOs active in health care in Afghanistan the following categories:

1. patient perspectives
2. staff perspectives
3. capacity for service provision (structural inputs)
4. service provision (technical quality)
5. financial systems
6. overall vision for the health sector.

Source: Peters (2007)

In any case, businesses are looking to improve their net profits and this can be done by making their supply chains more efficient. Tompkins et al. (2003) define Supply Chain Excellent as a six-step process: Business as usual, Link Excellent, Visibility, Collaboration, Synthesis and Velocity. In order to achieve this, a lot of information us required and needs to be exchanged among the companies or entities involved in a supply chain.

Employees as stakeholders in a company require good working conditions, which may be a problem in an emergency relief situation. However, in the recovery and development stages of a disaster, these can be provided.

The customers of a company will certainly benefit from an efficient supply chain, as they receive the goods faster and cheaper, as the logistics cost will be lower than with an inefficient supply chain. In humanitarian assistance, the customer of a company may be a donor organization, as they are the decision makers, as opposed to the beneficiaries. The donor organization will benefit from an efficient supply chain, as their donated goods arrive faster. Whether the donor organization pays for the logistics or the NGO they donate the goods to, will be of interest: If the logistics cost are lower due to increased efficiency, the NGO will be able to buy more of the same goods, or use the freed funds for other requirements, and the donor organization will be the happier. A happy donor organization is good because the NGO wants to solicit future donations.

Businesses need to be concerned about the external communities and the environment. In today’s market economy, the brand image is increasingly important (Kottler and Keller, 2006), which is the reason why many companies try to get a clean and environmentally-conscious image, and publish their engagement in CSR.

The companies do not employ child labourers or even shy away from doing business in countries that are considered undemocratic (Keida, 2006). These increasing ethical standards of businesses work into the hands of the NGOs and UN agencies.

Suppliers of the companies must therefore also adhere to these ethical standards. In addition, they must be reliable; otherwise the companies will lose customers. It is best if the companies and their suppliers are electronically connected in a Supply Chain Management System, which allows them to view online when their goods will be ready, and they can connect their customers, so that the customers can track their own order. Many large retail stores have this in place (ASA Research 2010), and many logistics service providers such as DHL or Kuehne+Nagel offer order tracking as a standard service.
MODEL DEVELOPMENT

Military organizations have the advantage of having logistics personnel and equipment available at any time, because their main stakeholders are people of the country they are serving. Their mission includes preparedness, so that these resources can be mobilized within a very short period of time. If we look only at this aspect, military organizations are the best suited type of organization to take care of logistics in the emergency response phase.

Businesses are concerned with efficiency and cost-saving. While the military organizations are fast, they do not need to watch the cost as closely, because in the initial phase, the priority is on saving lives, not saving money. However, in the subsequent phases after there was time to analyze the supply chain needs in terms of infrastructure and supply and demand, the businesses can set up these supply chains more efficiently and allow the military to go back to their main objective, providing security to their country and protecting them from outside aggression. The businesses have to answer to their usual stakeholders in terms of efficiency and cost, in addition to the environment and the treatment of people.

The NGOs and UN agencies are mainly concerned with bringing food and other relief items, including clothes and medicine, to the beneficiaries. They have to determine the demand of goods, solicit donations, procure goods, and answer to their donors. Logistics can be carried out by them, but it appears that the logistics manuals of each organization are different. The UN makes an effort to coordinate all organizations involved in a country’s relief operation.

However, judging alone from the stakeholders that every type of organization has to respond to, it seems to be beneficial if logistics, after the immediate emergency and recovery phases, is centralized and left in the hands of professional logistics companies.

TABLE 3
LOGISTICS SOLUTION PROVIDERS IN THE DIFFERENT PHASES

<table>
<thead>
<tr>
<th>Phase</th>
<th>Logistics solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial phase</td>
<td>Military is best suited to provide emergency logistics</td>
</tr>
<tr>
<td>Recovery phase</td>
<td>Many organizations are on the ground and need to be coordinated. UN Logistics Cluster best equipped for this task</td>
</tr>
<tr>
<td>Reconstruction phase</td>
<td>Businesses have enough information to build up efficient supply chain</td>
</tr>
</tbody>
</table>

This leads directly to our proposed model:

GRAPHIC 1
PROPOSED PHASE-DEPENDENT INVOLVEMENT OF MILITARY, BUSINESSES AND HUMANITARIAN ORGANIZATIONS IN LOGISTICS
REFERENCES


LOGISTICAL CRASH BARRIERS -
AN ALTERNATIVE PROCESS EVALUATION METHOD

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ABSTRACT

The increase in the degree of customisation to satisfy customer needs often leads to extremely high product variety within corporate networks. This circumstance causes barely manageable material flows as the processes are getting more and more diverse. In particular, it is a main challenge to identify which trouble or delay in the value-adding processes is caused by which product variant or customer modification. Companies therefore need methodical support for the identification of the greatest optimisation potentials. This paper provides a method to continuously evaluate the material flows of existing parts based on logistical criteria to identify their weaknesses. The outcome of this evaluation provides optimisation potential of existing as well as new parts in the material flow. In further succession, the course of action when applying the developed method within a real life context is visualised within a multiple case study in the agricultural industry.

KEYWORDS
Process Evaluation, Parts Segmentation, Material Flow Evaluation

INTRODUCTION

The attempts of companies to realise a high degree of added value, lead in combination with an increased product customisation to increasing complexity in material flows. Due to the large number of in-house production parts and purchased parts (in the considered case company there are 16.000 in-house production parts and 7.000 purchased parts) a considerable number of in-house production parts, and especially their material flows, are not analysed on a continuous basis. In many cases, the parts are classified once when they are implemented in the system and the manufacturing processes are designed once in the conception phase of the production process. The problem is that logistical criteria are only considered marginally in the evaluation of parts and processes as in many cases financial aspects are the single source for decision making. Day-to-day business has shown that the value of a part is absolutely negligible when it comes to production delays or, in the worst case, to production downtimes. As a result, the purpose of this paper is to present a method to continuously evaluate the material flows of existing parts based on logistical criteria to identify their weaknesses and to enable the improvement of existing as well as newly introduced material flows. This paper describes therefore in its introductory phase the developed concept of logistical crash barriers to identify critical parts and the related weaknesses within the production process. Subsequently, the developed method is prototypically validated within a multiple case study approach in the agricultural industry. Therefore the managerial value of this paper is to give real life insights how logistical criteria are deduced in a company case and how these criteria are used in further succession for the creation of a company-specific method to identify critical materials.
CASE RESEARCH IN LOGISTICS

The origins of case research lay in the broader field of social sciences, in particular ethnographic studies and anthropology. Eisenhardt (1989) brought together much of the previous work on building theory from case research. Voss et al. (2002) provides in further succession a roadmap for designing, developing and conducting case-based research and also describes some recent examples of case-based research in the field of operations management and technology management. In general, case studies are applicable if the examined phenomenon cannot be separated from its real-life context especially when the boundaries between phenomenon and context are not clearly evident (Yin, 2003). To be more specific case studies can be used for different types of research purposes such as exploration, theory building, theory testing and theory extension or refinement (Voss et al., 2002). Referring to Handfield et al. (1998) one central research purpose of the theory testing stage is to evaluate if the developed theory/the developed model is able to survive the test of empirical data. Applying these thoughts to the purpose of this paper the applicability of a case based approach becomes obvious. It becomes obvious as material flows in supply networks can’t be examined separated from its real-life context. Furthermore the logistical drivers are identified company-specific and therefore the treatment of the company as an (embedded) case and the evaluated material flows as units of analysis is a proper way on how to display the intermediate results.

As findings can hardly be generalised on the basis of a single case, (Abdelkafi et al., 2008) a multiple case study approach is realised. Following the classification given by Yin (2003), we talk about an embedded case study with six units of analysis in the context of this paper. Furthermore, case analysis based on six units of analysis goes along with statements made in literature; e.g. Voss et al. (2002) proposing 3-30 cases or Eisenhardt (1989) suggesting 4-10 cases. In general, the discussion about the ideal number is obsolete as the subject of consideration and the degree of difficulty of the research question differs from case to case. In general, the number of cases is determined by the degree of new confirming or conflicting insights achieved by conducting an additional case. Theoretical saturation is achieved if the additional findings according to a previously investigated phenomenon by conducting an additional case are minimal (Glaser et al., 1998). Closing the general case research section, we would like to point out that the identified logistical drivers as well as the described methodology to evaluate material flows is applied once and therefore only first assumptions about the practical applicability can be made. In further succession, the developed material evaluation method has to be applied within different companies and in various industries to achieve a proper size of analysed cases and to further conclude on the practical applicability from a broader (not a general!) perspective.

LOGISTICAL DRIVERS TURNED INTO LOGISTICAL CRASH BARRIERS

One possibility to identify relevant logistical drivers which serve as a constraint to material flows is to find the assignment of all in-house production parts within a process and afterwards to classify them as ‘good’ and ‘poor’ parts. Since this process would be too complex, the case company asked themselves a counter question: Why is a process ‘good’ or ‘poor’? The repetitive comparison of good and poor processes in cross-departmental workshops enables the step by step identification of logistical drivers, which are seen as the root of the main differences between ‘good’ and ‘poor’ processes. Depending on the product, type of business or customer base, the logistical drivers will differ in each company or corporate network and therefore have to be defined individually. In the considered case company, for example, the number of plants involved in the production has a high impact on the logistical costs of material flows. In contrast, for other companies, highly customised engineering efforts or the number of companies involved in the supply network might be more important. The accurate identification of the appropriate criteria is the key success factor for such a project. (Traxler et al., 2011)
Based on the identified drivers the following ‘logistical crash barriers’ were categorized. The term ‘crash barrier’ was chosen to indicate the attempt to determine boundary values for each relevant driver which must not be exceeded. Due to the restriction of length the deduction process of the single crash barriers as well as the single underlying logistical are not described in detail. For an in depth description see Traxler et al. (2011), Gerschberger et al. (2010). In the following explanations the determined crash barriers are visualised and briefly described.
FIGURE 1
EXTERNAL PROCESSING

The term ‘External Processing’ means that process steps of an in-house production part are carried out externally to benefit from technologies which are not available in-house or to cover peak loads in production. When the maximum of 1 external processing is exceeded, it is necessary to consider the total outsourcing of the product or the acquisition of the technology needed. Therefore the value of the logistical crash barrier ‘External Processing’ is set to 1.

FIGURE 2
PLANTS INVOLVED

Due to the processing in several plants a lot of non-value adding process steps (e.g. quality check, relocation of semi-finished goods) will lead to significant cost and cycle time increases. Especially when considering that these process steps are executed in each plant involved. As the aim of production is to gain a high capacity utilisation, to reduce cycle times and to benefit optimally from the technology development in the company’s plants, the logistical crash barrier ‘Plants Involved’ was introduced. In-house production parts must not be processed in more than 2 plants.

FIGURE 3
LEAD TIME

The third logistical driver is related to lead time. As a high lead time can lead to delays in deliveries and subsequently to dissatisfied customers, a high lead time is unacceptable. Therefore, an in-house production part is not allowed to exceed 15 days of lead time. In general, the case company has decided not to calculate the real lead time but to award each production step the same amount of time (= each production step has under current conditions one day to finish the required processing).
Due to the fact that the degree of complexity and an inadequately wide range of product or part variety can be effectively reduced in the course of the product definition and construction phase, ‘Parts List Level’ was chosen as a further relevant driver. In-house production parts must not have more than 3 parts list levels. When a raw material, semi-finished or finished good is relocated to another plant, an additional level is automatically generated. In this case, a level in addition is allowed. Figure 4 shows an in-house production part which consists out of 3 parts on the first level of the parts list. Part 2.A of these three is built up out of three parts (2.A.A, 2.A.B, 2.A.C) whereas 2.A.C is based again on three parts and one of these (= 2.A.C.A) is manufactured in a different plant and therefore relocated. This results as displayed in figure 4 in an additional and automatically generated parts list level. (IHP = in-house production part, PP = purchased part)

Relocations are physical stock movements of semi-finished goods, raw materials etc. And must be regarded as non-value adding but costly activities which should be reduced to a minimum. Nevertheless in some cases relocations are a necessary evil especially when capacity utilisation of large and investment intensive facilities are a topic (e.g. optimal utilisation of a paint finishing system). When considering the number of relocations in relation to the number of in-house production parts, a maximum value of 1 is allowed.

The last logistical crash barrier provides an identification of suboptimally coordinated manufacturing processes. The intention is to limit the production steps of an in-house production part to the value of 8 to reduce lead times, to increase the performance and to realise room for improvement.
at this early stage. In the following section a selection of material flows which were identified when applying the described method within the case company are highlighted.

**PROCESS EVALUATION AND TARGET PROCESS IMPLICATIONS BY LOGISTICAL CRASH BARRIERS**

The easiest way to get the data needed in the case company is the ERP system. The system enables the identification of the current production process steps of in-house production parts including information about e.g. various raw materials, materials, finished or semi-finished goods. The data derived from the ERP system is displayed in a parts list level structure including the various process steps of the concerned in-house production part. To show the current processes we want to illustrate a draft of the process steps of several in-house production parts violating at least one logistical crash barrier. As the target processes are automatically derived, the target process of all in-house production parts violating a specific logistical crash barrier consists of the same aim: reducing the external processing, plants involved, lead times, parts list levels, relocations or production steps down to the determined target value.

The first current process (Figure 7) displays a semi-finished good with the material number 1.2.345.678 and the related process steps (process 1-4) that have to be carried out during the production process. In addition, it is apparent that raw material (8.9.785.324) is necessary to manufacture the semi-finished good. The parts list structure also contains important information about plants, lead time and work stations. As workstations starting with 7*** are process steps carried out externally, this specific in-house production part violates the logistical crash barrier ‘External Processing’ as two process steps (No. 2 – workstation 7850 and No.3 – workstation 7650) are executed external. In this case, the target process would be either reducing the externally processed steps or starting to think about the total outsourcing of the semi-finished good if e.g. the necessary technology is not available at the company’s plants.

**FIGURE 7**
CURRENT PROCESS I VIOLATING THE BARRIER ‘EXTERNAL PROCESSING’

To demonstrate the difference to the typical target process modelling we take e.g. an in-house production part that does not provide a process step which is carried out externally. Therefore, it is not possible to say that the target process should have zero or one process step carried out externally because sometimes an external processing is unavoidable or even requested due to various economic reasons.

The following parts list structure (Figure 8) demonstrates the process flow of another semi-finished good. It is more extensive than the last one as it has three parts list levels. The considered semi-finished product (6.854.248.3) exists of another semi-finished product (4.6.897.321) in its parts list. When taking a closer look at plants, one semi-finished product is manufactured in plant 01 while the other one is manufactured in plant 02. In addition, it is apparent that one raw material is provided from plant 03 to enable production. The target process does not have more than 2 plants that should be involved in the production process of the semi-finished goods. This can, for example, either be done by having raw material 2.3.56.78 available at plant 01 or by manufacturing one semi-finished good (e.g. 4.6.897.321) at plant 01.
The third parts list (Figure 9) particularly focuses on lead time. Semi-finished product 4.6.897.653 has a total lead time of 16 days. Therefore, it is clear that it exceeds the allowed value of 15 days. The target process aims at minimizing lead time.

Figure 10 shows the parts list structure of the semi-finished product 7.89.543.22. It is apparent that it violates the logistical crash barrier ‘Parts List Levels’ as it has more than 3 parts list levels. This in-house production part would be allowed to have 4 levels as the relocation within the parts lists automatically generates a level in addition but as there are five levels it obviously exceeds the allowed value. Therefore, the target process of this semi-finished good does not have more than 3, respectively 4, parts list levels.
The next parts list (Figure 11) of a semi-finished product includes several relocations. As described above, relocation is a physical stock movement from one stock to another one. Taking a closer look at the raw material 72.35.684 it is apparent that the considered raw material is relocated from the stock of plant 01 to the stock of plant 02 as two part lists levels have the same number. The considered value is the ratio of relocations to the number of in-house production parts. In the parts list level there are three relocations but only two in-house production parts (semi-finished product 8.9.10.654 and semi-finished product 456.358.2.2). The ratio of these two figures results in a value of 1.5 which is obviously too high as only a value of 1 is allowed. Relocations are non-value adding process steps. Therefore, they should be reduced to a minimum within the target process.
Figure 12 shows the current processes of another semi-finished process. In contrast to Figure 7 showing workstations starting with 7***, these production steps are only carried out within the company’s plants. When looking at the logistical crash barriers above it is obvious that this parts list violates the last identified driver ‘Production Steps’. The target process should therefore not exceed the target value of 8 production steps per in-house production part. Taking a closer look at the required production steps one possible optimisation attempt might be the consolidation of milling or drilling processes within one milling and one drilling step.

**FIGURE 12**
CURRENT PROCESS VI VIOLATING THE BARRIER PRODUCTION STEPS

CONCLUSION AND MANAGERIAL IMPLICATIONS

The initially described challenges in current material flows and the difficult identification of parts that currently disturb logistical processes were solved by identifying important logistical drivers within the case company. As 1400 parts violating the determined bounds were identified, the modelling of target processes was simplified as the target processes can be automatically derived. Supporting the introductory statement, that the financial value of a part becomes negligible when it comes to problems in the production process, we double-checked this result with a common ABC-analysis. It is remarkable that only 350 parts of the identified 1400 were previously classified as A-parts. In other words, 75% of the identified 1400 parts did not appear to be of main importance in an ABC-analysis. Therefore, it is essential to look at those parts violating a logistical crash barrier in detail to form the improved target process. It remains especially important to continuously:

- reevaluate the defined boundary values as they have to be constantly adjusted and improved
- reevaluate the logistical drivers as new ones may arise or existing ones may become less important
- check the compliance of logistical crash barriers when implementing new in-house production parts within the production process
- cross-check the conspicuous parts of the logistical view with conspicuous parts of other evaluations (value-oriented evaluations, amount-oriented evaluations, …) within the company to retain an overall view
- use the cross-departmental knowledge of e.g. sales-, purchase-, engineering-, distribution-, and logistics-department
- keep the direct partners within the supply chain in mind as the cross-company processes influence the flow of internal production processes

The prototypic implementation of logistical crash barriers offers the first valuable clues to the potential of assessing material streams with the help of logistical parameters. In addition, the project team expects a particular leverage effect in the engineering of new in-house production parts.

The described course of action, including the deduction of criteria by the comparison of good and poor processes with the result of the described logistical crash barriers, provides a possibility how a company can possibly identify the relevant logistical drivers within their specific context.
In summary, it can be stated that the identification and appliance of logistical crash barriers as a method to systematically assess logistical material flows, has proven to be effective and will be continuously developed further by the project team to consequently enhance the practical applicability. Logistical crash barriers can become an effective tool to identify non-value adding process steps and not optimally adjusted logistical processes. Especially under turbulent market conditions, the main focus of the project is to make the company more adaptive through a better capability to quickly identify the sources of performance limits.

ACKNOWLEDGMENTS

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SUPPLY CHAIN INTEGRATION AND PATHWAYS OF LEAST RESISTANCE

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ABSTRACT

Exploratory, site-centred research used a systems theory lens to investigate real-world pathways to supply chain integration. The longitudinal studies involved four New Zealand-based case companies and utilised a rigorous, multi-method supply chain integration benchmarking procedure. Findings indicate that, regardless of best practice recommendations, supply chain managers adopt the integration pathway favoured by senior management in order to secure the level of authority they need for often cross-functional projects. Similarly when seeking to improve external relationships, integration pathways that would have the company negotiating from a position of strength are favoured, even though more effective negotiation strategies may be possible. In short, supply chain managers appear to be risk averse and favour pursuing integration pathways which they perceive will be less problematic for them.

KEYWORDS
Supply Chain Management, Supply Chain Integration, Longitudinal Case Study, Contingency Theory, Supply Chain Change

INTRODUCTION

The ultimate goal in supply chain management is to create value for end customers and other organisations in the supply chain network (Christopher 1998). While it is generally accepted that supply chain players must integrate process activities (e.g., Lambert, Cooper, and Pagh, 1998), the situation remains chaotic in many organisations (Böhme, 2009). This state of affairs is not helped by a lack of knowledge about specific pathway(s) to improve internal process integration and linkages with external suppliers and customers (Pagell, 2004; van Donk & van der Vaart, 2005). This article reports an early attempt to address this shortcoming.

Following a review of the relevant literature a rigorous multi-method approach termed the ‘Quick Scan Audit Methodology’ is introduced. Four comparative longitudinal case studies then provide insights into actual pathways to successful supply chain integration, findings are discussed, and potential research avenues highlighted.
LITERATURE REVIEW

Supply chain integration

The concept of integration originates from a systems perspective whereby optimisation of the whole is held to achieve better performance than a string of optimised sub-systems; because trade-offs and wider ranging decisions can be made based on shared information and co-ordination (Christopher, 1998). Integration of supply chains continues to be a subject of significant discussion and debate within the academe (Flynn et al., 2010; Frohlich & Westbrook, 2001; Swink et al., 2007; Towill et al., 2002; Zhao et al., 2011).

Internal integration aims to overcome functional silo boundaries that obstruct seamless material and information flows; thus inter-departmental collaborations aim to bring functional units closer together into a cohesive organisation (Kahn & Mentzer, 1998). Similarly, external collaborations aim to soften company boundaries and advance integration toward a wider supply network. Figure 1 depicts the authors’ view of supply chain integration, which is one shared by many authors (e.g., Bowersox et al., 2002; Fawcett and Magnan, 2002; Lee, 2000; Stevens, 1989). In such a simplified supply chain network structure diagram the 'focal company' is shown at the centre. In general terms, both internal and external integration is aimed at making more effective use of the combined resource base, together with better-integrated information and material flows. External integration is often viewed as partnerships and strategic alliances (e.g., Droge et al., 2004; Kim, 2006; Maloni & Benton, 1997; Spekman et al., 1998), which appears to run counter to the aim of optimising material and information flows (Frohlich and Westbrook, 2001; Gimenez, 2004). In any event, key supply chain business processes (comprising information and material flows) are perceived to piercing the functional silos within the focal company and the corporate silos existing across the wider supply chain (Bowersox et al., 2002; Lambert et al., 1998).

Pathways to integration

Many researchers have highlighted the continuing lack of understanding and knowledge about actual pathways to supply chain integration (e.g., Cigolini et al., 2004; Frohlich & Westbrook, 2001; Pagell, 2004; van Donk & van der Vaart, 2005) and note that much of the research on integration has been predicated on the assumption that integration occurs in distinct stages (e.g., Narasimhan and Kim, 2001). Possibly the most influential work is by Stevens (1989) who proposes a four stage evolutionary model of supply chain integration and argues that organisations 'need to get their in-house processes in order first' before attempting to integrate with external suppliers and customers. However, this view is contested by others who have shown that even similar companies may progress through quite different stages in pursuit of supply chain integration (e.g., Gimenez, 2004; Lambert et al., 1998; Lee, 2000). Halldorsson et al. (2008) also report that managers appear to more readily achieve successful integration with their external suppliers and customers than is...
achieved internally. This study aims to shed further light on these issues by investigating how companies have chosen to improve their level of supply chain integration.

METHODOLOGY

Site-based longitudinal case studies were undertaken with four New Zealand-based companies, Table 1. All the companies were selected on the basis that they maintain a global supply chain, represent a range of industry sectors, and all had undertaken a supply chain integration change initiative following the first data collection. The average time period between data collections was 25 months.

<table>
<thead>
<tr>
<th>Company</th>
<th>1st data collection</th>
<th>2nd data collection</th>
<th>Time frame (months)</th>
<th>Researcher Days</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manufacturer</td>
<td>Dec. 2006</td>
<td>Mar. 2008</td>
<td>16</td>
<td>41</td>
</tr>
<tr>
<td>Pulp/Paper</td>
<td>Mar. 2006</td>
<td>April 2008</td>
<td>25</td>
<td>32</td>
</tr>
<tr>
<td>Food</td>
<td>May 2006</td>
<td>May 2008</td>
<td>24</td>
<td>27</td>
</tr>
</tbody>
</table>

Each case study involved a site-based audit methodology known as the ‘Quick Scan Audit Methodology’ (QSAM), which is explained in considerable detail in Naim et al., (2002). QSAM utilises several forms of triangulation to improve researcher judgment by providing several sources of verification (Flynn et al., 1990). A research team approach is employed, which enables the case situation to be viewed from different perspectives to achieve in-depth understanding of the supply chain and its state of maturity/sophistication. Data is collected from four distinct sources to facilitate methodological triangulation and increase internal validity: process maps; attitudinal and quantitative questionnaires; semi-structured interviews; and archive information. Summary data and tentative conclusions are formally presented to management and staff for review and agreement. The follow-up audits also included interviews backed by collection of confirmatory archive data to comprehend the reasons for the choice of pathway and the nature of the change improvement activities. A total of some 134 researcher-days was spent auditing the four organisations.

FINDINGS

Individual case findings

A focal company’s process integration initiative typically focuses on improving the internal material and information flows and/or the external supply-demand linkages. Figure 2 summarises the changes in supply chain integration achieved by each case company during the time period between the audits. At the time of the follow-up audit all four companies were at different stages of supply chain maturity, and although none had achieved complete internal integration the projects were deemed a success by the managers concerned.
Table 2 provides an overview of the change programmes implemented by each focal company. Only changes occurring since the first QSAM audit are noted, which are arranged in chronological order (top-bottom). The table clearly indicates that each case company had its own particular focus when attempting to improve integration of its supply chain. For example, case company 'Manufacturer' chose to focus on improving internal coordination, whereas the others had an external and an internal focus. While none of the four case companies has managed to completely get its own house in order, which would be evidenced by high levels of integrated and coordinated information and material flows, the case company 'Food' has achieved high levels of information and material flow coordination on the supplier side. The company now has in place mature vendor managed inventory agreements with key suppliers, monitors a high performing small supplier base, and shares information intensively with its suppliers via the internet.

**TABLE 2 CHANGE INITIATIVES OVERVIEW**

<table>
<thead>
<tr>
<th>Manufacturer</th>
<th>Pulp/Paper</th>
<th>Dairy</th>
<th>Food</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Daily cross-functional production meetings</td>
<td>- New SCM-related employees</td>
<td>- A new CEO</td>
<td>- New logistics manager</td>
</tr>
<tr>
<td>- Three new SC professionals hired</td>
<td>- Combined management of four closely related plants</td>
<td>- Flattened organisational structure</td>
<td>- Improved 3PL relationship</td>
</tr>
<tr>
<td>- Empowered staff</td>
<td>- A new procurement manager</td>
<td>- Training through job rotation</td>
<td>- New S&amp;OP software package integrated into current ERP</td>
</tr>
<tr>
<td>- Shop floor staff training</td>
<td>- Track &amp; trace system</td>
<td>- Appointment of purchasing manager</td>
<td>- Updated warehouse management system</td>
</tr>
<tr>
<td>- New ICT communication platform</td>
<td>- Non-compulsory training</td>
<td>- Fortnightly S&amp;OP meetings</td>
<td>- Up-skilling &amp; empowerment of warehouse staff</td>
</tr>
<tr>
<td>- A ‘no blame’ culture</td>
<td>- Intra-net web site to enhance cross-functional visibility</td>
<td>- Increased SC measures (efficiency/effectiveness)</td>
<td>- Restructuring of order information flows</td>
</tr>
<tr>
<td>- Increased SC measures (efficiency/effectiveness)</td>
<td>- Consolidation of supplier base</td>
<td>- SC strategy aligned to product type</td>
<td>- 2-Bin System leading towards Kanban</td>
</tr>
<tr>
<td>- Cross-functional KPIs</td>
<td>- Standardisation of S&amp;OP for four plants</td>
<td>- Outbound information system sets desired stock levels</td>
<td>- Update of current ERP system including MRPII</td>
</tr>
<tr>
<td>- Implementation of 2-Bin System leading towards Kanban</td>
<td>- New SCM-related employees</td>
<td></td>
<td>- New logistics manager</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- Improved 3PL relationship</td>
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<tr>
<td></td>
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<td></td>
<td>- New S&amp;OP software package integrated into current ERP</td>
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<td></td>
<td>- Updated warehouse management system</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>- Up-skilling &amp; empowerment of warehouse staff</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- Restructuring of order information flows</td>
</tr>
</tbody>
</table>

**Cross-Case Comparison**

From a cross-case analysis of the longitudinal case studies two main patterns emerged; the first concerning reasons for supply chain managers’ choice of change pathway, and the second concerning the order of the change initiative activities. Findings indicate that, regardless of best practice recommendations, supply chain managers adopt the
integration pathway favoured by senior management in order to secure the level of authority they need for such projects. Similarly when seeking to improve external relationships, integration pathways that would have the company negotiating from a position of strength are favoured, even though more effective negotiation strategies may be possible.

Examining the order of the change activities reveals that no clear staging is evident. However, every case company chose to improve its knowledge and skills base before addressing inefficient internal processes and/or external relationships. Furthermore, every case company addressed its information technology requirements towards the end of the initiative. Figure 3 summarises the overall implementation process.

**FIGURE 3**
THE SUPPLY CHAIN IMPROVEMENT IMPLEMENTATION PROCESS

**DISCUSSION AND CONCLUSION**

This study indicates that current supply chain integration models are deficient because they fail to acknowledge two preconditions that determine the change pathway likely to be pursued in practice: (i) top management support for the initiative; and, (ii) a strong negotiating position (in the case of initiatives involving external power/dependency relationships). This situation is depicted in Figure 4, which adapts the Handfield and Nichols (2002) supply chain integration model by inclusion of the preconditions. Also, highlighted are the people and cultural change factors that tend to be tackled first; since integration is arguably a function of how well people work together both internally and externally with key entities. In contrast, although technology is a powerful enabler it is not the key to supply chain integration; people are (Mentzer et al., 2000). This was borne out by the case companies when the technology requirements received attention towards the end of the initiatives.

This paper aimed to answer the research question “How do companies try to achieve supply chain integration in practice?” To this end the original QSAM was extended to enable longitudinal case study data collection and four case companies were studied. The research demonstrated that there is no single identifiable route to successful supply chain integration. Simply put, the 'best' pathway to supply chain integration appears to be organisation-specific and is dependent on two preconditions being met: top management support (internally) and a favourable power and dependency structure (externally). In short, the findings indicate that supply chain managers tend to pursue integration pathways which they perceive will experience least problems during implementation.

In addition to the need to confirm these exploratory findings there are many avenues for further research. A most intriguing question is whether supply chain integration improvements should be attempted at all when there is a lack of top management support or when balances of power are held by the external entity. A related question concerns suitable procedures for evaluating and championing those change paths which are perceived to be more effective for achieving supply chain integration, yet have a higher perceived risk of being problematical.
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ABSTRACT

A key purpose of this paper is to stimulate researchers into utilising a more balanced portfolio of research methods when generating supply chain theory. The supply chain/logistics literature overwhelmingly exhibits objectivist/positivist philosophical assumptions, indicating that this is what researchers believe constitutes valid discipline knowledge. In contrast, this paper demonstrates that an interpretive perspective is capable of yielding a comprehensive picture of the relationship between the supply chain and the ‘messy’ environment within which it is embedded (contingency theory). By reflecting on lessons learned through many years of practical researcher experience with such a methodology, this paper serves to motivate the supply chain research community to consider adopting a more interpretive stance when conducting supply chain research.

KEYWORDS
Qualitative Research, Triangulation, Supply Chain Audit, Quick Scan, Audit, Field Research

INTRODUCTION

Supply chain management (SCM) concepts continue to be not well-understood, which has led to a call for clear definitions and meaningful conceptual frameworks (Cooper et al., 1997; Croom et al., 2000; Flynn et al., 2010; New & Payne, 1995; Svensson, 2002; van der Vaart & van Donk, 2008).

Although qualitative research methods are being used to acquire the empirical research data needed to support theoretical propositions, such studies remain firmly in the minority. A key purpose of this paper is to motivate supply chain researchers to consider alternative research perspectives so that they might consider incorporating an interpretive stance within a balanced portfolio of supply chain research methods. The authors reflect on some 30 years of academic publications to deduce what currently constitutes valid supply chain discipline knowledge and on some 15 years of experience working with an interpretive, mixed-methods field research methodology. Robust, mixed-methods approaches are advocated that offer a variety of insightful perspectives on supply chain phenomena.

The next section explores the conceptual landscape within which supply chain research is performed. This is followed by description and discussion of a well-established, mixed-methods approach developed and validated for use in the field.
SUPPLY CHAIN MANAGEMENT RESEARCH CONTEXT

The subject of supply chain management is viewed from many different perspectives: purchasing and supply, operations management, relationship management, logistics and transportation, industrial organisation, marketing, or strategic management to name but a few (Croom et al., 2000). Thus as a broad concept, it is perhaps unsurprising that it lacks a single, widely accepted definition (Cigolini et al., 2004; Flynn et al., 2010; Mentzer et al., 2004). Table 1 indicates the relative frequency of supply chain/logistics research methods that have appeared in the publications named in the past 30 years. It is clear that the dominant research methods have long been guided by a dominant world view favouring the positivist/objective research paradigm (Eisenhardt, 1989; Gammelgaard, 2004; Seuring, 2005), in which the researcher subscribes to the view that an ‘objective’ world, or an objective reality exists - and that reality can be understood through the application of such objective/quantitative methods as surveys and statistical analysis.

<table>
<thead>
<tr>
<th>Author</th>
<th>Period</th>
<th>Journal or Topic</th>
<th>Quantitative</th>
<th>Qualitative</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seuring (2005)</td>
<td>1990 – 2005</td>
<td>Sustainable SCM</td>
<td>~ 42%</td>
<td>~ 11%</td>
</tr>
</tbody>
</table>

When attempting to develop well-substantiated supply chain/logistics management theories this world view is a real issue (Stuart et al., 2002) because supply chains are almost always managed within a context of constant environmental change, and involve many layers of complexity, personal relationship nuances, etc. On such ‘shifting sands’ posited generalisations and hypotheses become almost impossible to substantiate.

The fact that supply chain management problems are unstructured and even ‘messy’ (Ackoff, 1998) real-world problems (Frankel et al., 2005; Mentzer & Kahn, 1995; New & Payne, 1995; Seuring, 2005; Westbrook, 1994) requires that a ‘one paradigm, one approach’ perspective (irrespective of its persuasion) should not automatically be the obvious choice (Frankel et al., 2005; Seuring, 2005; Towill and Christopher, 2007). The alternative is an interpretive perspective that emphasises the importance of subjective meanings and social-political and symbolic actions in the processes through which humans construct and reconstruct their reality (Morgan 1983, p. 396). Thus, a strong argument can be made for adopting research methods appropriate to generating valid interpretive knowledge and involving field case studies that examine human endeavours within particular supply chain circumstances and social work settings.

Following on from the ontological belief that reality is socially constructed; the interpretive researcher avoids imposing externally defined categories on a phenomenon. Instead of coming to the field with a well-defined set of constructs and instruments with which to measure social reality; the interpretive researcher attempts to derive constructs from the field by in-depth examination of and exposure to the phenomenon of interest. The categories and themes that emerge out of this approach are intended to closely couple those relevant to the study's participants (Orlikowski and Baroudi, 1991).

A MIXED-METHODS APPROACH TO SUPPLY CHAIN RESEARCH

In the early 1990s a procedure known as the Quick Scan Audit Methodology (QSAM) originated from the Logistics Systems Dynamics Group at Cardiff University in the UK. This was originally created to describe and explain the complexities of a ‘messy’ European automotive supply chain environment via application of multiple, site-centred data collection methods.

QSAM utilises a structured modelling framework. A key characteristic is that it endeavours to achieve an optimum compromise between qualitative and quantitative methods of management theory research, by making maximum use of resources in field-based activities in the search for ‘meaning of evidence’ (Eisenhardt, 1989). In practise it mixes qualitative and quantitative methods when seeking to triangulate information sources (Beach et al, 2001; Berry et al. 1995; Jick, 1979).

QSAM researchers recognise that supply chain-specific issues need to be combined with management practises, such as marketing and strategic management; hence a complete ‘rich’ picture of the focal company situation is obtained through the application of systems thinking/theory. QSAM also provides contingency theory underpinning (Lawrence and Lorsch, 1967; Thompson, 1967) by considering industrial norms and environmental settings (Näslund, 2002).
Theoretical refinement of QSAM has involved untold brainstorming, debate, experimentation, and triangulation for the current format to emerge. It brings together four different key stakeholders having their own interests: the Host Organisation (What’s in it for me?); The Business Community (What can we learn from them?); the Analytic Auditors (How do we rate this supply chain?); and the Research Community (What new knowledge is revealed?). The four parties are shown in a Balanced Scorecard format in Figure 1, which also indicates four feedback loops.

**FIGURE 1**
**QSAM BALANCED SCORECARD – BRINGING TOGETHER FOUR INTERESTED PARTIES**

The *Auditor Competence Loop* is critical, requiring that the auditors are well trained, focused, observant and capable of participation as a member of an academic-industry team. In particular they require an inquisitive mind, good time management skills, should not accept data or opinion at face value and should aim to achieve good data triangulation via different data sources. The *Value Stream Competitiveness Loop* codifies (and ranks) measures of supply chain performance against external benchmarks. A useful consequence of accumulating the QSAM audit results is that they also provide a rich benchmarking source in their own right. The *Academia Peer Judgement Loop* is where the quality of the final research output is assessed. Finally, there is the *Business Principles Enhancement Loop* where the knowledge gained influences real work practices. QSAM researchers need to balance the needs of these stakeholders.

**QSAM PROCESS OVERVIEW**

The research/audit process is typically undertaken by a team of experienced researchers assisted by host organisation supply chain ‘players’ in a structured approach designed to fit around the limited time available to busy managers and staff (Böhme et al., (2008); Naim et al., (2002)). Judgments regarding individual supply chains are based on a combination of case study-type metrics and statistically significant data. In seeking to maintain this standard the researchers aim to exploit knowledge from as many data sources as possible. The various site-based activities are designed to achieve maximum information volume and fidelity. A QSAM is inevitably both time and resource constrained and although data collection and analysis lies at its heart, front-end and back-end activities help to ensure that all participants ‘sing from the same hymn sheet’, and that the host organisation receives maximum benefit from the experience.

Audit data is collected from four distinct sources, which facilitates methodological triangulation and increases internal validity: process maps; attitudinal and quantitative questionnaires; semi-structured interviews; and examination of archival information. The goal of the various data collection techniques is to fully understand the phenomenon being studied, and the accumulation of multiple supporting sources of evidence helps to assure that the facts being collected are indeed correct (Meredith, 1998). Data triangulation also provides stronger substantiation of constructs and hypotheses (Eisenhardt, 1989), and the utilisation of multiple onsite investigators enables the case situation to be viewed from different perspectives, which adds to the richness of the data collected (Eisenhardt, 1989). This also helps to build confidence in the findings and increases the likelihood of surprise findings. In essence, triangulation improves researcher judgment accuracy by providing several sources of verification (Flynn et al., 1990).
A feature of research to build theory from subjective social realities in this manner is the frequent overlap of data analysis with data collection (Eisenhardt, 1989; Lewis et al., 1989). The central idea during the theory building process is to constantly compare theory and data – iterating toward theory that closely fits the data (Eisenhardt, 1989). During the QSAM theory-development process, logic replaces data as the basis for evaluation (Meredith, 1989).

A most critical element of a QSAM audit study concerns how data extracted from the supply chain system is analysed using systems thinking principles. Cause-effect analysis is utilised to reveal: (a) the ‘major pain(s)’ the company is feeling (symptoms of the underlying problems); (b) the supply chain/ process integration barriers; and, (c) the root (initiating) causes of the identified major pain(s).

VALIDATING THE QSAM APPROACH

Because field research is commonly perceived as being prone to construct error, poor internal and external validation, and questionable generalisability (Meredith, 1998) the same quality criteria need to be applied to subjective research as is applied in objective studies. Table 2 outlines how the key quality criteria: internal validity, external validity, reliability, and objectivity (van der Vorst & Beulens, 2002) are achieved during the QSAM audit. From this it may be concluded that QSAM is a robust and rigorous field research method, which continues to evolve as researchers in the field discover further ways to enhance it.

<table>
<thead>
<tr>
<th>Dimension of research quality</th>
<th>Definition</th>
<th>How achieved within the QSAM?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Internal validity – how accurately are cause-effect relationships identified?</td>
<td>Establishing causal relationships between research variables (certain conditions are shown to lead to other conditions)</td>
<td>Use of a team of researchers for data collection (Böhme et al., 2008)</td>
</tr>
<tr>
<td>External validity – can the findings be translated to other settings?</td>
<td>Establishing the domain to which a study’s findings can be generalised.</td>
<td>Comparison against database of previous QSAM applications (such as in Towill et al., 2002)</td>
</tr>
<tr>
<td>Reliability – can the findings be reproduced by others?</td>
<td>Demonstrating that the operations of a study can be repeated with the same results</td>
<td>Process well documented in literature (Böhme et al. 2008; Lewis et al., 1998; Naim et al., 2002) and existence of database (Towill et al., 2002)</td>
</tr>
<tr>
<td>Objectivity – are the results free from bias?</td>
<td>Establishing correct operational measures for the concepts being studied.</td>
<td>Triangulation via process mapping, data analysis, interviews and questionnaires (Naim et al., 2002; Böhme et al., 2008).</td>
</tr>
</tbody>
</table>

Adapted from: Potter & Bowles, 2006; van der Vorst & Beulens, 2002

DISCUSSION

Based on some 15 years of experiences with a particular method, it is the authors’ belief that the supply chain management/logistics discipline would benefit if more researchers would take advantage of methods that generate valid interpretive knowledge; in particular when they involve site-based field case studies of managers within their social settings. The QSAM is an example of a mixed-methods approach that has proven to be extremely valuable for studying messy real-world supply chains, in particular because the researchers are reminded of the need to “understand and acknowledge the extent to which the perspective they adopt will focus their attention on some things and not others, and bias their perception of the phenomena they study” (Orlikowski and Baroudi, 1991, p. 23). Philosophically, its research methods emphasise the importance of subjective meanings and social-political and symbolic actions in the processes through which humans construct and reconstruct their reality (Morgan 1983, p. 396).

Working within a team ensures that QSAM researchers view the same case situation from different perspectives and in divergent ways; particularly when individuals are tasked with using specific methods (Eisenhardt, 1989). A further major strength involves data triangulation to maximise its validity. QSAM enables good practice, poor practice, and trends in performance to be detected (e.g., Childerhouse and Towill, 2004). Overall, QSAM audits have yielded a very
valuable and varied pool of empirical data and the understanding gained has manifestly enabled the development of new management theory and the validation, and more often further refinement, of research ideas (Childerhouse and Towill, 2004).

CONCLUSION

At a time when supply chain management concepts continue to be not particularly well-understood, this article has sought to present the benefits and challenges of interpretive research methods that seek to frame supply chain issues though a variety of theoretical lenses. In reflecting on some fifteen years of application and refinement of a mixed methods supply chain methodology the structured framework, administration requirements and overarching processes were summarised and justified. Guidelines for making sense of ‘soft’ data describing relationships between technology, people, and organisations in the supply chain were also presented.

To-date QSAM research findings have been published mainly as case studies (e.g. Potter et al., 2004) and quantitative value stream comparisons (e.g. Towill et al., 2002). Some 40 experts spread around eight universities worldwide have used the framework and its standard protocols to perform readily comparable assessments of real world supply chains. This team is keen to extend a hand to researchers who are interested in interpretive supply chain research that extends the QSAM research network. It is thus our hope that this paper may serve to motivate researchers to utilise a more balanced portfolio of research methods for studying supply chain phenomena than has been the case until now.

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REORGANIZING LOGISTICS IN THE AUTOMOTIVE INDUSTRY

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ABSTRACT

If we include transportation and services provided by the automotive sector, an estimated 2.4 million people employed in the development, manufacture and sale of cars in France in 2008, nearly 10% of the population active. Automotive production employs approximately 260,000 employees in more than 2200 institutions. Logistics is the heart of the business of the automotive industry (production, commercial sales and after). Growth in this sector was 2.9% in annual average until 1979. After 1980 it dropped to 0.6% per year. Since 2002, growth has stagnated. This inevitably affects the profits and therefore the profitability of manufacturers. In this context, the automakers are reviewing the organization of their units in emerging countries. This article deals with the reorganization of the supplying at the edge of the chain in the automotive industry. Our work revolves around many axes: 1) the elaboration of specifications describing the improvements’ goals of the way of supplies along the chain, 2) this description is detailed according to the organizational, technical, human and economic aspects, 3) the design of logistics service center allows the feeding of the edge of the chain. This is an essential condition to switch into the new mode of supply, 4) the proper use of computers in the automotive industry, and 5) use of the methodological tools for describing the transition from the operational mode of supply to the new one. This study has a double interest: 1) a professional interest: the introduction of the new mode of supply, and the various performance indicators to measure the effectiveness of this mode, and 2) an interest for the applied research: modeling and simulation of the logistics system of an automobile manufacturer for a global optimization goal.

KEYWORDS
Automotive Industry, Integrated Logistics, Supply Chain, Performance Indicators

INTRODUCTION

The problem of the car industry’s efficiency articulates around two axes; the conception of the product “motor vehicle” and the organization of the process of its provision. This process is confidentially connected to the Automotive Supply Chain that we note ASC.

According to Claude Laforgeau [1], four main problems condition the conception of the vehicle; the energy, the environment, the security and the congestion.

- The energy: the production capacity of the majority of the big world car manufacturers is 70 millions cars a year. Within century, the humanity almost exhausted its fossil resources in energy (Coal, oil, gas). So, raw materials and energy go necessarily marked incapacity to make 70 millions cars, as well as fuels to make them drive it.
- Environment: several studies indicate that considerable volumes of CO2 released in the atmosphere cannot be any more absorbed by forests or dissolved in the oceans. They produce the greenhouse effect entailing the global warming and its continuation of disaster.
- Security: the causes of the vehicles’ accidents, we have the driver, the vehicle and the infrastructure; 95% of the accidents question the responsibility of the driver, what brings the builders automobile, for lack of eliminating the driver, to automate most some functions of the vehicle.
- Congestion: the intelligent systems of transport have to allow decreasing the congestion for in a communication between the vehicle and the infrastructure.
- Congestion: Intelligent Transportation systems must reduce congestion through improved communication between the vehicle and infrastructure.

The ASC is now conditioned by the diversity of products. Given this diversity the technical mastery of production processes is no longer sufficient, we need a control variety.

Yesterday, the customer had the choice between two or three varieties. The law of the supply and demand played in favor of the car manufacturers. Long deadlines were accepted by the customers. The investment in advertising was limited. The forecasts were not always an obstacle to the production.

Currently, the manufacturers are subjected to the consumer’s demands. The production is crossed (spent) by a manufacturing limited production to billions of variants. The theoretical number of variants on a recent model, the Kangoo of Renault, amounts in $10^{18}$ [2].

This change puts us in front of several problems:

- Technically: standardize production meanings to accommodate this multiplicity of products, and seek multi-skilled personnel to carry out a large number of varieties.
- In terms of management: the materiel planning of requirements, scheduling and planning will be exposed to a difficulty of control and uncertainty due to the variety of products
- From the point of view of the profitability of the innovations: uncertain evaluations, to see impossible. In the economic optimization, we launch innovative programs without being able to estimate the economic impact on the market.

In this context, the digitization of management functions within the company assisted in the redesign of the organization of the ASC.

Control and monitoring of the ASC therefore requires the use of tools in different logistics flows. The production part is the subject of an application of modelling and simulation to plan and schedule the tasks on resources. Constraints and the size of data to handle make the scheduling problem very difficult. The simulation software is configurable to easily simulate the behaviour of a production unit. It is then necessary to design new simulation systems to describe the specific behaviour of a production. [3]

In a scheduling problem, many choices and decisions are possible. The choices made or not satisfy the performance criteria. The criteria will generally result in optimizing or maximizing an objective function (minimization of cost, timeliness, maximization of profit ...). The number of solutions, often exponentially, rules out the complete list of those it. We must intelligently explore the solution space to find a good solution, not always the best. Several optimization methods are applied to scheduling problems, such as mathematical programming, dynamic programming, graphs, and meta-heuristics.

In a supply chain involving multiple actors, everybody must work together for the good functioning of the chain. The actors exchange information inside and outside of the chain. Traditional communication protocols are no longer valid. It is essential exploit the STIC (Science and Technology Information and communication) to build an adequate information system.

We are interested in the integration of research partners to external capabilities. The organization of the ASC is a growing emergence of flow types based on the concept of family logistics. It relies heavily on blood flow while requiring a pilot developed by information shared among all participants of the ASC (customers, suppliers and various service providers). [4]

An isolated action of a company can improve the overall competitiveness of a product on the market. The finished product depends on the supply chain. This chain is based in particular on the concepts of Just-In-Time (JIT) and Traceability through including PDM System (Product Data Management), which describes the static. Electronic Data Interchange (EDI) can strengthen the establishment of the JIT process and assist in the "Total Quality" and contributes to the dynamics of the ASC.

The problem is to integrate data and systems. This integration creates a synergy from the start of the project. These projects are started growing ahead of the launch of the product by the manufacturer. This prevents loss of relatively serious consequences in terms of technical efficiency, and economic times. This is a new form of project management.
This integration also creates the "corporate memory" on the one hand, and a "product catalogue" to react and respond quickly to customer needs.

The implementation of such integration is accompanied or preceded by the normalization of a number of concepts and rules that govern the company's business and the products it manufactures. The new organization becomes customer-oriented and requires a redesign of the processes that make up the ASC around idea of added value.

So, there is a break between the old and new organizations based project management. [5]

In this article, we treat the case of Renault SA, which was one of the car manufacturers to adopt this new organization. Previously, we described the supply chain at the edge of the new organization of the ASC. We study two examples of the ASC links; SOMACA in Morocco and the PARTSTOK Supply Chain in France.

REORGANIZATION DE LA ASC

Supply chain to the edge.

The diversity of produce we require changes in the logistics strategy in the automotive industry, a strategy based on four basic principals:

1. Stock up just in time body and mechanical assembly plants
2. Stock up just in time body assembly plants and mechanical
3. Distribute the vehicles in the commercial network in accordance with the announced delay to the customer
4. Standardize Processes and Information Systems Logistics

The supplier must contribute to the implementation of this policy strictly in accordance with supply expected to serve the logistics workstation.

To overcome the various shortcomings related to the multiplicity of variants, automakers must begin first by improving their methods of supplying internal and external.

**The mode of internal supply:** the improvement consists in finding a mode of physical management of flows capable of managing the need in components, the breaks in edge of chain (channel) and of avoiding overhangs in edge of chain.

The management passes by the optimization of waiting time at the edge of chain and minimization of the time of handling...

**The method of external supply:** the reorganization allows:
- Define the parameters of the calculation required
- Communicate needs room to suppliers directly from the consumption of packaging.
- To manage incoming and outgoing parts and packaging in stores

It should also monitor the quality of service providers and their logistics performance through a tool to control the incoming stream. The monitoring is done by carrying out audits logistics:
- Analyzing in detail the results of the supplier and his answers after incidents
- Realizing the logistics audit at the supplier
- Defining and leading the implementation of improvement plan logistics provider
- Follow the progress plans logistics providers audited

The standardization of modes of supply differs from one room to another, we cannot, for example, apply the same method of supplying a small room to a room large car, take into consideration different parameters (size, frequency, conditioning ...)

The method of supply depends on the type of flow to manage:
- The pushed flows:
  The flow is said pushed when all the products of the production process is sent to consumer markets. They are therefore expected client and not the actual demands that will be used to plan the dimensioning of inventory, production plan and resources needed to manufacture the products.
The pulled flows:
The flow is said pulled when the production quantities of each reference are defined by the customer's request. So the real customer requirements that will be used to plan the dimensioning of inventory, production plan and resources needed to manufacture the products. The goal is to satisfy the customer as soon as possible and thus minimize costs due to in-process inventory.

synchronous flows:
Flows refer to a method of synchronous flow management coordinating the supply of various components in order of use and time use in the production line. In other words, they are to deliver a type of component to a destination specified in the order of the command sequence.

This delivery is done in a timeframe respecting the hours of assembly of the component and the storage capacity at the foot of the assembly line. The provider may be internal (workshop upstream) or external (supplier). It must be located in against a perimeter close to his client to remain compatible with the possibilities of the range of delivery.

**Logistics Service Centre (LSC)**

In order to facilitate the supply of domestic logistics service center is to contain the consumption of a day. The establishment of a LSC will enable us to:
- Remove the storage area, freeing the area occupied, keep the pieces against degradation, and thus avoid additional charges
- Also delete the zone picking: gain surface and human resource

This mode of operation of logistics service center is to bring the edge of the channel is strictly necessary for the production of parts provided.
To do this, the reasoning is as follows:
1. From the need for production;
2. Look at what is already on the edge of channel;
3. Compare the needs with what is on the edge of chain and deduce what to distribute.

This involves knowing the need for production; this need has to be stable.

In addition, for comparison, the stock level at the edge of chain must be explicit and not shared with the stock now in store.

Finally, to prepare the distributions, it is necessary to have a specific stock and a list providing information on the packaging for this stock at the edge of supply chain.

**CASE OF RENAULT MOROCCO [6]**

Renault Morocco is based on two dimensions: commercial and industrial.

Renault is present in Morocco since 80 ans. It now provides the marketing of Renault and Dacia brands through 14 dealers. Since 2004, the Renault brand is market leader in automotive Morocco. Since 2006, sales reached almost 14,000 vehicles.
Renault has since 2005 almost 80% stake in Moroccan society building cars (SOMACA). The plant Casablanca assembles Dacia Logan, Sandero and Kangoo. SOMACA decided in 2007 to upgrade its standards Renault and its quality. It opens internationally in exporting for the first time in its history, a part of its production of the Logan to France and Spain. She was brought to improve its supply house. The aim was to simplify the complex industrial products.

This new context requires SOMACA not stop only on the competitiveness of prices and costs. It must also consider the ability to present and to adopt different product lines. It must address quickly to disturbances in the supply chain.

In this context, the SOMACA deployed a new mode of supply named CPL1’. This mode is to bring the edge of the channel is strictly necessary for the production of parts provided. As a result, the stock side chain is located in the work station.

In terms of internal flows, once the packages to be distributed at the edge of channel have been identified, the question remains:
- Review the list of packages;
- Prepare physically packages to be distributed;
- The making available of the distributor
- Bring them in on a string;
- Resumption of empty.

To more easily manage the preparation of the order of distribution areas are defined. An area of distribution is a set of work stations located in the same general geographic area of the production line. This division is important because distribution lists are published by following this principle: A list by distribution area. Therefore contains the same list packages from the same geographical area. This will, for example, assign a zone distribution and managing a distributor commitment. By deploying this mode SOMACA could gain in terms of waiting time, previously used for physical inventory, the inventory is now done automatically during retrieval. Also gain storage space along the supply chain because the chain is at the right time.

**CASE PARTSTOK, FRANCE**

PARTSTOK is a subsidiary of Renault since 1971. Located in Saint André de l'Eure (France, Normandy), the company specializes in the Supply Chain World (flow management supply just in time inventory management and information flow) with two objectives: be a logistics hub for Renault and a logistics provider for other clients.

PARTSTOK manages small automotive parts. But it also handles the packaging of parts for after sales and part of the activity of the Aerospace Business Unit. Since 2011, the company is considered an integrated logistics platform at the international level of the Renault group.

**Object of the study**

The study, presented here by the following observations:
- Service level objectives of suppliers and customers not being met.
- Physical flows and information not optimized.

In order to improve these flows, the supply system has been re-designing study. We present a part of this study related to supply two parameters: the batch size and code timing.

**The lot size**: is a multiple of minimum packaging per order. This is used to optimize the management of pallets in an environment of lean

**The timing code**: corresponds to the date PARTSTOK must receive the coins. This date is different to that of the provision of goods by the supplier. This difference influences the rate service provider.

To improve these two parameters, the study considers a number of features (Link, Consumer, lot size original type PARTSTOK lot size, number of rooms per lot size, type range, code timing, and unit price).
**Human and Organizational objectives**

The human and organizational goals are closely linked because they are complementary. Indeed, it takes the organization to manage the human. And no human organization is more complicated. Therefore, two data are important for both objectives:

- The number of emergency messages: changing the size of the lot (preferably a reference to a pallet) will make it easier to receive references to PARTSTOK.
- This flag affects the human objective because it will allow the technician in production management and field operators to save time on the rest of the day.

**Target image of the subsidiary**

From a qualitative point of view, the establishment of lot sizes and the change of calendar codes greatly improves image PARTSTOK to its customers.

This study analyzed two performance indicators:

- *The rate of service provider*
- *The level of customer service*

These indicators are important for the integration of suppliers and customers in the new organizational structure. We give in the following graph the improvement seen after one semester of implementation of the new organization.

**CONCLUSION**

We have discussed in this article of the restructuring of organizational structures in the automotive sector. We considered the case of Renault SA.

We have described one of the most crucial issues raised on the manufacturer, the supply chain to the edge. We have studied two examples of the ASC links; SOMACA in Morocco and PARTSTOK in France. The two examples show the international character of this constructor. They also show the need for logistics integration of the various partners of the Renault group. Through the example of PARTSTOK we see the complexity of the logistics system sucks when the global optimization of the ASC.

PARTSTOK, subsidiary of Renault, is an intermediate in the Supply Chain management for the automotive and aerospace. It manages the procurement and distribution in-time parts direct sides chain for Renault but also for Airbus. If we can consider that its integration into the ASC, what about its integration in the aerospace supply chain? Can I transfer the experience of the automobile to aerospace? These questions can form the rest of this article. Our team is working on a similar case as that presented in this article. This is the supply of two workshops (in France and Morocco) working for the Airbus group. In both studies, the human factor was of utmost importance. T. Ohno (Toyota) said there is 30 years ago: « You are paid not to produce documents but to continually improve the processes that produce parts; factory without a human is condemned because it is no longer capable of progress ».
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A CENTRE OF INTERNATIONAL TRADE AND TRANSPORT LOGISTICS

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ABSTRACT

Achieving superior productivity and growth, and understanding how to best manage cost-efficient, environmentally-friendly modes of integrated transport is of vital importance to a nation's strategic interests. Yet in an era of increasing sensitivities toward greenhouse gas emissions and the 'greening' of business many countries lack educational facilities which are dedicated to understanding multi-modal transport logistics and sustainable supply chains that can extend to international trading partners. This paper explains in detail a proposed centre of excellence concept that was developed for the New Zealand Chartered Institute of Logistics and Transport (CiLT). By facilitating intensive business collaborations and engaging industry directly with teaching specialists, consultants, and researchers it is anticipated that Centre stakeholders would benefit from: 1) industry-relevant, world-class applied research and problem-solving expertise that will directly add value to the NZ national and local economies, 2) shared decision support facilities that bring together industrialists, academics, consultants, and other specialists to work together on the most pressing export trade-related supply chain, logistics, and transport challenges and opportunities, 3) improved, industry-relevant qualifications and programmes that make extensive use of new and innovative teaching and learning methods and which are tailored to the country’s international trade, transport and logistics sectors. This research brings together the views of industry, education providers, students, and governmental stakeholders. It has been informed by first-hand experience, by the literature, by international visits and by acknowledged best practise.

KEYWORDS
Logistics Tertiary Education, Centre of Excellence, New Zealand; Proof of Concept, Thematic Analysis

INTRODUCTION

In a global climate of increased deregulation New Zealand is heavily dependent on its export trades for economic wellbeing. Global supply chains also increase pressure on the maritime haul, on port operations and on inland freight distribution; with structural changes to logistics also being caused by new patterns of freight distribution and new approaches to port hierarchy. On the other hand this presents new opportunities for exporters to differentiate their supply chain products and services, and for port operators to consider new approaches to port governance that extend well beyond the traditional port perimeter (Notteboom and Rodrigue, 2005).

This article reports on two years of research into New Zealand's transport and logistics education requirements, and the nature of the service provision. To avoid creating yet another 'laundry list' of industry needs, stakeholder attention was focused onto a concept for a national centre of excellence that was developed by the authors. This article outlines the concept and summarises the feedback that was received from a wide range of senior managers and regional policymakers.

In addition to discussions with regional and industrial representatives, the concept for a New Zealand Centre of International Trade and Transport Logistics (Deakins et al., 2009) was informed by: acknowledged global best practise; visits to exemplar organisations in Australasia and Europe; the NZ tertiary education strategy (MoE, 2009); and the Western Bay of Plenty regional strategy which identifies transport and logistics as a key area of focus (Bay of Connections, 2008, Page 10). Consequently, the concept presents as a world-class centre of excellence that 'sits between' the current education providers to broker a unique blend of (assured) highest quality
education having characteristics of strong industry collaboration, independent advice, decision support and research for the horticulture, forestry and dairy supply chains among many others.

The following section provides a conceptual overview of the proposed centre of excellence, which is followed by a brief methodology section. The thematic analysis of the interview data is presented in section four. Discussion of the major insights is brought together before final conclusions are drawn.

A CENTRE OF EXCELLENCE

At the heart of the concept is an exciting and innovative education facility designed both to attract the brightest young students and to deliver transport and logistics qualifications that exceed internationally recognised standards. Programmes are delivered by experts working closely with industry to ensure that students of the highest calibre receive needed hands-on experiences, and are actively sought by industry even before they graduate. In order to become the leader in applied transport and logistics research within the Asia Pacific region collaboration with leading international research teams will be focused on investigating and transferring best practise to points of real industry need. Equally important, by engaging industry partners with expert capability and specialist researchers, importers and exporters will benefit from access to industry-relevant world-class research and problem-solving expertise that directly adds value to the NZ national and local economies. Figure 1 indicates how this synthesis of industry, education and research activity facilitated by the Centre, will yield significant synergies.

FIGURE 1
CENTRE OF EXCELLENCE SYNERGIES

(NZITTL: New Zealand Centre of International Trade and Transport Logistics)

Vision, Mission and Value

The overarching vision is to be the premier centre of higher education, scholarship, and industry collaboration in International Trade and Transport Logistics in the Southern Hemisphere. Its associated mission is to provide students with the greatest possible educational experience and to inform and inspire its regional, national and international stakeholders. The centre is dedicated to innovative teaching and learning, and knowledge discovery through leading-edge industrial research. The knowledge gained will be used to transform global supply chain industries and their supporting transport and logistics infrastructures. It will pursue international recognition as a world class research facility with a strong emphasis on partnerships with industry and with leading universities and other world-class education providers. Table 1 provides the seven major values of the centre.
### TABLE 1
VALUES OF THE CENTRE OF EXCELLENCE

<table>
<thead>
<tr>
<th>Value</th>
<th>Definition</th>
</tr>
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<tbody>
<tr>
<td>Excellence</td>
<td>This Centre will be recognised as one that routinely exceeds internationally accepted standards of education, training, and applied research. Highest quality and customer service are non-negotiable.</td>
</tr>
<tr>
<td>Competition</td>
<td>This Centre recognises that it needs to compete on the international stage for the best students, faculty, and support staff.</td>
</tr>
<tr>
<td>Collaboration</td>
<td>This Centre will be the national model for effective collaboration between industry, universities, polytechnics, and ITOs for the benefit of graduates, export industries and other key regional stakeholders. Selected collaborative partnerships will enable the Centre to offer a wide suite of education, training and research options and pathways. A strong team culture of collaboration and mutual support will be fostered.</td>
</tr>
<tr>
<td>Scholarship</td>
<td>This Centre will engage in education, training and applied research activity that directly contributes to increasing the region’s knowledge base. It will be highly regarded as a contributor to international best practice; to which end student and staff exchanges between respected overseas partner institutions will be encouraged, and other types of international linkages will be pursued.</td>
</tr>
<tr>
<td>Innovation</td>
<td>This Centre will actively encourage development of its academic staff and industry stakeholders via a focus on creativity, innovation and support. The Centre will host national and international academic and practitioner conferences and forums. In turn it will be actively supported by its industry partners, who will maintain a strong, continuing onsite presence.</td>
</tr>
<tr>
<td>Inspiration</td>
<td>This Centre will engage with respected researchers around the world for the purposes of inspiring creativity, idea exchange, and knowledge sharing.</td>
</tr>
<tr>
<td>Transformation</td>
<td>This Centre will be a driver of change within the industries it serves, through its strong research programme and the calibre of its high quality graduates. It will conduct education, training and research activities that directly contribute to the industrial knowledge base and raise the standard of professionalism - thereby improving productivity, safety and sustainability. The Centre will present export industries as a highly attractive career choice.</td>
</tr>
</tbody>
</table>

In summary, the Centre is designed to be a world class education/industry collaboration and applied research facility based in the Bay of Plenty. It will predominantly exist to serve the Bay of Plenty region and wider New Zealand society; and the other countries of the world by providing an environment of creative enquiry within which critical thinking, human values, technical competence and practical and social skills, business acumen and a capability for lifelong learning are cultivated, respected, and sustained. The Centre will insist on the highest world-class standards of excellence in all that it does and will also strive to actively complement other institutions’ offerings.

### RESEARCH METHODOLOGY

The proposed centre of excellence was drawn up as a concept document, the chief aspects of which were subsequently converted into a questionnaire which was used as a reference for face-to-face interviews. Figure 2 provides an overview of the research process. Administration of the proposed method was piloted with two industrialists and minor amendments made to the process to ensure that maximum insights would be obtained. Feedback on the concept involved a wide range of stakeholders, including: regional policy/decision-makers and senior managers of companies that handle the largest import/export volumes for the Bay of Plenty region.
FINDINGS

Interview notes were taken and combined with direct annotations made by the interviewees on the (previously circulated) questionnaires. Thematic analysis was then used to allow for the richness of data and for quantitative analysis of the responses. Table 2 highlights the key feedback data.

TABLE 2
FEEDBACK ON THE CONCEPT

<table>
<thead>
<tr>
<th>Reported Concept Positives:</th>
<th>Interviewee Reference:</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sets a (high) standard from the outset</td>
<td></td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Sandbox learning elements having applied, pragmatic problem-solving</td>
<td></td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>One stop integrated education provider</td>
<td></td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Breadth of qualifications on offer; training - doctorate 'staircase'</td>
<td></td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Block release aspect of industry training</td>
<td></td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>International connectedness</td>
<td></td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Cross-pollination/facilitation of the major exporters in the region</td>
<td></td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Governance structure and the Centre's relative independence</td>
<td></td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Impressive building needed if to be used by industry</td>
<td></td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Neutral company spaces</td>
<td></td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Proposed location adjacent to the Port of Tauranga</td>
<td></td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Responsive collaboration/facilitation aspects with industry/academe</td>
<td></td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Quality assurance of others' offerings</td>
<td></td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Also up-skills the Executive</td>
<td></td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Reported Concept Negatives</th>
<th>Interviewee Reference:</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Favours more of a pay-as-you-go arrangement after a low entry fee since hard for my company to find large up-front fees</td>
<td></td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>We may not cope with this number of students placed in our Co.</td>
<td></td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Safety and security issues with students on site</td>
<td></td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Possibility of commercial-in-confidence sensitivities</td>
<td></td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>An aquarium would be more appropriate if the Centre was focusing on marine science... hard to find funding in the Tauranga market</td>
<td></td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Reported Concept Interesting Points</th>
<th>Interviewee Reference:</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Industry think tanks; objective, independent, world-class</td>
<td></td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Ability to offer/broker/coordinate papers that are being taught by the best providers from NZ and elsewhere</td>
<td></td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Increased ability to become knowledgeable of best practises and issues</td>
<td></td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Tourism/regional industry showcase; increased public awareness</td>
<td></td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Designed to be inexpensive ($S and staff/time) yet is scalable</td>
<td></td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>
In essence, there appeared to be very strong consensus around four key elements of the concept:

**Relevance and Independence**

Every interviewee agreed that the Centre needs to be strongly focused on bringing the required expertise and vocational skills to bear directly at the points of real industry need. Several also highlighted the need for students to gain industry experience via intensive onsite learning and block-release programmes. Evidently, educational approach and content need to be closely linked to current (and projected) industry requirements.

"*Customer focus is critical ... we are not interested in yet more costly (generic) courses.*"

Strong agreement was also expressed for a governance structure that would enable the Centre to flexibly align its activities with industrial, regional and educational imperatives. In particular, the need to be independent of the tertiary education providers was affirmed by several interviewees, to maximise responsiveness, impartially, and quality of offerings.

"*Its proposed independence is fundamental to its success.*"

In short, industry stakeholders favour a facility that is (somehow) owned by the region and is independent of undue education provider influences. The prospect of becoming more knowledgeable about current issues and best practises, and being able to contribute to industry think tanks and forums was also welcomed.

**Qualifications**

The intention within the concept to offer well-defined career pathways and stair-cased qualifications from NZQA training all the way through to diplomas, masters and beyond, was well received by the interviewees. Although varying according to individual needs, subjects of interest all fell within the domains of transport, logistics management, and international trade and supply chain management. Regarding quality of the offerings, a large NZ exporter highlighted a desire for national coverage to be achieved by identifying and combining the best available course components into exemplar New Zealand qualifications - an approach that would also reduce capital requirements.

"*The Centre could offer papers that are being taught by the best providers in NZ and overseas, and then it would only need the gaps in these excellent offerings.*"

In essence, industry stakeholders favour creation of a responsive one stop ‘education integrator’. However, the small sample size provided no clear direction on the precise qualifications the Centre should offer.

**Transfer of Best Practice**

Interviewees welcomed the idea of ‘neutral’ shared learning spaces being made available to industry to aid benchmarking activities, for example. There was similar interest in the establishment of shared places of learning and of having expertise on hand to solve industry problems and communicate innovative new practices between and across industries. Although some concern was raised about the number of block release students requiring work experience, interviewees commented favourably on the proposed pragmatic problem-solving approaches and international connectedness for cross-pollination opportunities between the major import/export organisations. Overall, a very generous and collaborative mindset was evident and several interviewees offered their time and expertise to enable knowledge transfer and shared learning. Almost all agreed, in principle, to sponsor the placement of postgraduate students into their own organisations.

**Proposed Location**

Support for the Centre to be located close to the Port of Tauranga was almost unanimous due to the port's significance to New Zealand’s export economy, proximity to primary importers and exporters and its position within the logistical ‘golden triangle’ of Auckland, Hamilton and Tauranga. The Port of Tauranga is also the central node of the region's major supply chains. In particular, interviewees were very enthusiastic about the 'sandbox' learning elements described within the concept, since a wharf-side location integrated directly into the local logistical network would be ideal for creating a relatively compact ‘living learning laboratory’ and having collaborative spaces where business and academe routinely interact.
DISCUSSION

If overseas experience is anything to go by, such a world-class facility would undoubtedly contribute to the national and regional economies and knowledge base and would attract new businesses, bright young students, and a skilled workforce. It was therefore disappointing to also note comments such as, "sustainability of demand for Centre products/services could be an issue", and, 'some of us have been here before... to get them to engage, stakeholders need to have some skin in the game'. Although several interviewees agreed that only industry can drive such a unique (to New Zealand) initiative, so as to bypass academic politics and get what business actually needs, there was a general unwillingness to engage further to help implement such a concept. In contrast, most interviewees were keen to become an 'Associate' once the Centre was up and running.

In summary, the empirical research revealed almost unanimous support for an independent, responsive, one-stop education facility that has national reach and which sets national standards of excellence related to international trade, transport and supply chain/logistics. Every stakeholder agreed that the concept was a compelling one and that it should proceed essentially unchanged from the format being proposed.

"This is an awesome concept - definitely needed. An enthralling read!"

CONCLUSION

There is clear agreement for a world-class and industry aligned education facility that is positioned as an integral part of New Zealand’s industrial productivity base. There is also consensus that this facility should be governed independently of the tertiary education providers to be able to responsively align with changing industry requirements. Consensus was also evident around the potential to address specific industrial needs and the desirability of best practice transfer through action research.

Given such enthusiasm and almost daily calls to improve industry productivity and reverse the 'brain-drain', the real question appears to be: Is there anyone with sufficient will and influence to champion an exciting centre of excellence that will attract the brightest young people and provide them with the education, mindset and industry skills that are required to ensure New Zealand's supply chains are genuinely world-class?

ACKNOWLEDGEMENTS

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REFERENCES


STUDY ON LOGISTICS INTEGRATION IN SINGAPORE

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Tel: +65 6248 2007, Fax: +65 6462 4377
STUDY ON LOGISTICS INTEGRATION IN SINGAPORE

by

Tan Yan Weng
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School of Business, SIM University,
461 Clementi Road, Singapore 599491
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ABSTRACT

Logistics service providers play a vital role in ensuring that the supply chain performance is responsive and efficient. These companies are undergoing many dynamics to remain competitive in their respective industries. Integration is one possible business strategy for these companies to manage their operations in an effective and efficient manner. This paper examines the current extent of integration of logistics companies operating in Singapore and company perspectives on integration. Logistics companies in Singapore were surveyed to find out their views on integration. In addition, personal interviews were carried out to obtain a better understanding of industry perspectives towards integration. The results showed that most companies surveyed did not practice integration. Those that did adopted horizontal integration over vertical integration. The company interviews showed that companies that adopted integration benefited from the advantages brought about by it. Their success reaffirmed that logistics integration are important strategies that could be employed by companies to strengthen their competitive position in the industry.

KEYWORDS
Logistics Companies, Singapore, Horizontal/Vertical Integration, Online Surveys, Company Interviews

INTRODUCTION

The supply chain is an intricate network of organisations involved in the different processes and activities that generate value in the form of products and services to customers. This network comprises raw material suppliers, manufacturers, wholesalers/distributors, retailers and customers (Chopra and Meindl, 2010). Logistics service providers play a vital role in facilitating the smooth physical flow of goods. These companies are undergoing many dynamics to remain competitive in their respective industries.

For supply chain success, individual organisations within the supply chain need to coordinate to optimise their value generation. One possible business strategy to achieve this is through integration. This paper presents some findings on the extent of integration in the logistics industry in Singapore as well as the industry views on integration.

HORIZONTAL AND VERTICAL INTEGRATION

Horizontal integration refers to the management control of different businesses located on the same level of the supply chain; e.g. a warehousing company that acquires another company providing similar services (Figure 1). Vertical integration refers to the management control between businesses located at different stages of the supply chain. Organisations can integrate forward (downstream) towards the retail demand side or backward (upstream) towards the supply side, e.g. a warehousing company can integrate forward with other transport companies to form a distribution centre or integrate backward to foster cooperation with port terminals or freight forwarders.
Caputo and Mininno (1996) examined logistics integration in the grocery distribution business in Italy. They noted that integration between producers and distributors can lead to better physical and information flows, resulting in more efficient inventory control. They concluded that internal integration is the pre-requisite for businesses to achieve high logistics performance and horizontal coordination between institutions is the pre-requisite for high synergy in vertical integration.

Häkkinen et al. (2004) noted that mergers and acquisitions (M&As) have received very little attention in logistics research. They carried out a questionnaire survey on Swedish and Finnish manufacturing companies which had used M&As. Motives for the M&As given by respondents were: possibility to extend into new products or markets, growth by buying out competitors in geographically fragmented markets, and to exploit synergies in logistics. The study found that synergy realisation was most difficult in sales, followed by manufacturing, R&D, sourcing and distribution.

Mason et al. (2007) studied collaboration in the UK and Europe road freight transport industry. Through case study examples, they demonstrated that the approach of combining collaboration with vertical supply chain partners and collaboration on a horizontal basis can improve logistics performance.

There have been a number of publications in the area of logistics integration based on studies in the US, UK and Europe. However, very little information is available on local studies of integration. This study serves to provide an initial step into understanding logistics integration from the Singapore perspective.

**SURVEY METHODOLOGY**

Logistics companies in Singapore were surveyed to find out their views on integration and whether they adopted horizontal or vertical integration as part of their business strategy to remain competitive. Internal integration is not examined in this study. The companies surveyed offered services ranging from warehousing and distribution to total logistics solutions.

The views on integration were gathered through an online survey. Email was sent to the human resource managers of around 300 logistics companies to request their senior management involved with strategic decision-making to participate in the surveys. The survey questionnaire was accessed via the link provided in the email. The responses were collated over a two-month period. The resulting response rate was poor with only 30 companies that responded (10% response rate), despite sending reminder email and following up with telephone calls. The low response rate is considered typical when compared with past surveys on the logistics industry in Singapore.
Following the online survey, face-to-face interviews were conducted with a few of the respondents to obtain a better understanding of industry perspectives on integration. The findings of three company interviews are presented in this paper.

**ONLINE SURVEY RESULTS**

After providing information on the company name and nature of business, respondents were asked to indicate whether the company adopted horizontal and/or vertical integration as part of their business strategy over the past 10 years. Figure 2 illustrates the survey findings. The majority of the companies (21 out of 30) did not adopt integration as a way of synergising their business. Those that did preferred horizontal integration over vertical integration. However, caution should be exercised in interpreting the results due to the low response rate.

**FIGURE 2**

**FINDINGS ON ADOPTION OF LOGISTICS INTEGRATION**

Logistics companies that adopted integration in their business strategy

For the nine logistics companies that adopted integration, they were asked to rate (on a scale of 1-5) each given factor according to its importance in their company’s integration plans. Table 1 summarises the importance of reasons for integration ranked in descending order according to the mean rating. The nonparametric signed-rank test (Myers et al., 2007) was used to test the statistical significance of the results at the 5% level as the ratings are ordinal in nature. The top four factors – “increase market share/power”, “greater profit margins”, “reduce cost” and “improve efficiency and effectiveness of operations” – were found to be statistically significant to companies considering integration.

**TABLE 1**

**PERCEIVED IMPORTANCE OF REASONS FOR INTEGRATION (N = 9)**

<table>
<thead>
<tr>
<th>Rank</th>
<th>Factor</th>
<th>Rating</th>
<th>Signed-Rank Test Result</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Factor</td>
<td>Mean</td>
<td>Std Dev</td>
</tr>
<tr>
<td>1</td>
<td>Increase market share/power</td>
<td>4.50</td>
<td>1.07</td>
</tr>
<tr>
<td>2</td>
<td>Greater profit margins</td>
<td>4.43</td>
<td>1.51</td>
</tr>
<tr>
<td>3</td>
<td>Reduce cost</td>
<td>4.14</td>
<td>1.21</td>
</tr>
<tr>
<td>4</td>
<td>Improve efficiency and effectiveness of</td>
<td>4.00</td>
<td>1.07</td>
</tr>
<tr>
<td></td>
<td>operations</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Achieve economies of scale and/or scope</td>
<td>3.86</td>
<td>1.46</td>
</tr>
<tr>
<td>6</td>
<td>Better control of products and processes</td>
<td>3.75</td>
<td>1.16</td>
</tr>
<tr>
<td>7</td>
<td>Erode threats from competitors</td>
<td>2.86</td>
<td>1.77</td>
</tr>
</tbody>
</table>

Rating: 1 = least important, 2 = less important, 3 = important, 4 = more important, 5 = most important
Signed-Rank Test: One-tailed test at 5% level of significance; Null hypothesis (H₀) μ = 3; Alternative hypothesis (H₁) μ > 3.

The companies were also asked to rate (on a scale of 1-5) how well the same set of factors were realised after integration. Table 2 shows their perception of extent of realisation after integration. All felt that they performed
significantly well for the six factors indicated: the top four factors of Table 1 plus “achieve economies of scale and/or scope” and “better control of products and processes”.

**TABLE 2**
PERCEIVED EXTENT OF REALISATION AFTER INTEGRATION (N = 9)

<table>
<thead>
<tr>
<th>Rank</th>
<th>Factor</th>
<th>Rating</th>
<th>Signed-Rank Test Result</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Mean</td>
<td>Std Dev</td>
</tr>
<tr>
<td>1</td>
<td>Increase market share/power</td>
<td>4.50</td>
<td>0.53</td>
</tr>
<tr>
<td>2</td>
<td>Greater profit margins</td>
<td>4.43</td>
<td>0.79</td>
</tr>
<tr>
<td>3</td>
<td>Improve efficiency and effectiveness of operations</td>
<td>4.25</td>
<td>0.46</td>
</tr>
<tr>
<td>4</td>
<td>Reduce cost</td>
<td>4.14</td>
<td>0.69</td>
</tr>
<tr>
<td>5</td>
<td>Achieve economies of scale and/or scope</td>
<td>4.14</td>
<td>0.69</td>
</tr>
<tr>
<td>6</td>
<td>Better control of products and processes</td>
<td>4.00</td>
<td>0.53</td>
</tr>
<tr>
<td>7</td>
<td>Erode threats from competitors</td>
<td>3.71</td>
<td>0.76</td>
</tr>
</tbody>
</table>

Rating: 1 = worse off, 2 = poor, 3 = neutral, 4 = good, 5 = excellent
Signed-Rank Test: One-tailed test at 5% level of significance; Null hypothesis (H₀) μ = 3; Alternative hypothesis (H₁) μ > 3.

*Logistics companies that did not adopt integration in their business strategy*

For the 21 logistics companies that did not adopt integration, they were asked to rate (on a scale of 1-5) how important the given obstacles were that prevented them from adopting integration as a business strategy. Table 3 shows that the companies perceive the significant concerns to integration were “neglect core competency”, “failure to attain economies of scale in production”, “low level of synergy” and “less flexibility in accommodating customer demands”.

**TABLE 3**
PERCEIVED IMPORTANCE OF OBSTACLES TO INTEGRATION (N = 21)

<table>
<thead>
<tr>
<th>Rank</th>
<th>Factor</th>
<th>Rating</th>
<th>Signed-Rank Test Result</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Mean</td>
<td>Std Dev</td>
</tr>
<tr>
<td>1</td>
<td>Neglect core competency</td>
<td>4.00</td>
<td>1.34</td>
</tr>
<tr>
<td>2</td>
<td>Failure to attain economies of scale in production</td>
<td>3.75</td>
<td>1.12</td>
</tr>
<tr>
<td>3</td>
<td>Low level of synergy</td>
<td>3.60</td>
<td>1.19</td>
</tr>
<tr>
<td>4</td>
<td>Less flexibility in accommodating customer demands</td>
<td>3.53</td>
<td>1.43</td>
</tr>
<tr>
<td>5</td>
<td>Creation of monopolistic situations</td>
<td>2.68</td>
<td>1.38</td>
</tr>
</tbody>
</table>

Rating: 1 = least important, 2 = less important, 3 = important, 4 = more important, 5 = most important
Signed-Rank Test: One-tailed test at 5% level of significance; Null hypothesis (H₀) μ = 3; Alternative hypothesis (H₁) μ > 3.
FINDINGS OF COMPANY INTERVIEWS

Table 4 summarises the views of integration based on the company interviews. For reasons of anonymity, the three logistics companies interviewed are referred to as Companies A, B and C. Companies A and B adopted integration; Company C did not.

### TABLE 4
**VIEWS ON INTEGRATION BASED ON COMPANY INTERVIEWS**

<table>
<thead>
<tr>
<th>Company</th>
<th>Nature of Integration</th>
<th>Reasons for/against Integration</th>
<th>Issues raised</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Subsidiary of a global logistics company with operations in Americas, Asia-Pacific and Europe</td>
<td>• Establish market presence in Asia rapidly • Leverage on each other’s strengths • Widen and enhance scope of services</td>
<td>• Management conflicts • Organisational conflicts (jobs, systems, cultures) • Less flexible in times of change</td>
</tr>
<tr>
<td>B</td>
<td>Vertical integration</td>
<td>• Widen customer base quickly • Leverage on each other’s strengths • Better control of operations and processes</td>
<td>• Who takes charge • How to split the profits</td>
</tr>
<tr>
<td>C</td>
<td>No integration</td>
<td>• Value flexibility to cater to demand fluctuations • Focus on core business • Smaller customer base and lower volume</td>
<td>• More concerned with business profitability than expansion</td>
</tr>
</tbody>
</table>

Integration enabled Companies A and B to penetrate new markets and expand faster compared to organic growth. Company C did not have the business volume to justify the need for integration and was more focussed on remaining flexible with short-term contracts that can be easily scaled to meet changing customer demand. It also felt that integration was more suitable for larger companies with substantial resources to meet the requirements of the integration process.

**CONCLUSION**

This paper examined the current extent of logistics integration in Singapore and views on integration as a possible business strategy to manage operations in an effective and efficient manner. The online survey yielded a low response rate. Most logistics companies surveyed did not practice integration. Those that did adopted horizontal integration over vertical integration.

Companies that adopted integration indicated increased market share/power, greater profit margins, reduced cost, and improved efficiency and effectiveness of operations as significant reasons when considering integration. Those that did not integrate reported neglecting core competency, failure to attain economies of scale in production, low levels of synergy, and less flexibility in accommodating customer demands as the main obstacles preventing them from doing so.

The company interviews showed that companies involved in integration benefited from the advantages brought about by integration. Their success reaffirmed that logistics integration are important strategies that could be employed by companies to strengthen their competitive position in the industry.
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IDENTIFICATION AND MODELING OF KEY LOGISTICS PROCESSES IN THE AGRIFOOD SECTOR

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ABSTRACT

As logistics become a substantial part of a firm's operations, the corresponding processes increase in importance. Identifying key logistics processes using a structured approach will align their outcomes to deliver the business goals, design appropriate measures and allocate sufficient resources for their improvement. This paper proposes a systematic methodology for the identification, categorization and prioritization of logistics processes, using a binary linear programming model. The identified key logistics processes are modeled by creating a number of UML diagrams and document them by the use of a pre-defined template. These processes include both inbound and supply chain-wide logistics activities and have a critical effect on the operational performance of an agrifood business entity. Companies can focus on these key logistics processes in order to optimize their critical aspects such as time and cost issues, resources planning and scheduling, as well as, queues and delays.

KEYWORDS
Logistics Processes, Business Process Management, Supply Chain Management

INTRODUCTION

The success of the supply chain networks highly depends on the effectiveness and efficiency of logistics processes. Companies must identify, model and optimize their logistics processes so as to remain competitive; and not only their inner processes but the common processes that share with the other members of a supply chain. In most business environments, a maximum 12 to 15 functions are considered as key business processes. Some of them may span horizontally and internally across most of the departments of a company, or even externally and across the entire supply chain, while companies may implement different practices for monitoring and assessing them (Quesada and Gazo, 2007). On the other hand, there are processes which have an equal or bigger impact on the organization although they never receive the appropriate attention such as the logistics processes. The identification and prioritization of the business processes has been the main objective of many research initiatives (Kanji, 2002; Kaplan and Norton, 1992, 1993, 1996 and 2000). As logistics become a substantial part of a firm's operations, the corresponding processes increase in importance. Identifying key logistics processes using a structured approach, aligning their outcomes to deliver the business goals, designing appropriate measures and allocating sufficient resources for their improvement is the key to success.
This paper proposes a systematic methodology for the identification, categorization and prioritization of logistics processes, using a binary linear programming model. The identified key logistics processes are modeled by creating a UML diagram (as an example).

The following sections of the paper are organized as follows; Section 2 presents and analyses the proposed methodology and model for the identification and the prioritization of the logistics processes. Section 3 presents the application of the proposed model to the agri-food supply chain as a case study. The findings reveal the priorities that the managers of the examined companies consider about logistics processes. Section 4 presents a UML diagram as an example case. Finally, at the Conclusions part, the findings of the survey are discussed and the scope of further research is provided.

**PRIORITIZATION OF LOGISTICS PROCESSES**

In this paper, a simple methodology and a corresponding mathematical model is proposed for the identification and prioritization of logistics processes. The methodology consists of two (2) steps:

1. **1st step:** Identification and classification of the logistics processes, and
2. **2nd step:** Prioritization of logistics processes.

**Step 1: Identification and classification of the logistics processes.** Generally speaking, a logistics process consists of logically related logistics activities performed together to produce a defined set of results according to a company’s strategy. Since, every company have different strategic objectives, goals and mission, internal logistics processes can differ from one company to another. Thus, it is necessary to identify the internal logistics processes and classified them under a generic framework.

In the literature there are research initiatives regarding the classification of logistics processes (Curran and Ladd, 1999; Radjou, 2003; Malone et al. 1999; Lambert, et al. 1998; Camp, 1995; APQC, 1996; Diaz et al. 2004; Blaik and Matwiejczuk, 2009). There are also a number of business processes models such as the Value Chain Model (Porter, 1984) the QFD model (Westlund, 2001), etc.

After synthesizing the related bibliography we propose eight (8) groups of logistics processes:

1. **Production support:** Planning of primary production, Procurement for production, Harvesting, Production scheduling and materials planning, Production of finished and semi-final products, Production planning, Selection of production machines and lines, Layout planning.
2. **Transportation and Distribution:** Planning of distribution tasks, Planning of distribution network, Planning of transportation management, Control and monitoring of transportation management, Selection of transportation means, Selection of transportation materials, Monitoring and tracing of product, Routing and scheduling of transportation means.
3. **Warehousing and Inventory Management:** Location of warehouse or distribution center, Layout of warehouse or distribution center, Selection of warehousing facilities, Selection of warehousing materials, Coding of products and storage positions, Materials management, Inventory management, Inventory control (monitoring), Demand forecasting, Physical inventory.
4. **Order processing:** Order handling, Management of infrastructure for order handling, Planning of picking, Execution of picking, Order’s packing, Planning of shipment facilities, Shipments management, Execution of shipments, Returns management.
5. **Procurement:** Planning of procurement, Execution of procurement, Monitoring of execution of procurement, Proposals management, Selection of suppliers and assignments, Evaluation of suppliers.
6. **Materials handling:** Planning of inbound materials handling, Forecasting of inbound materials handling, Execution of inbound materials handling, Monitoring of inbound materials handling.
7. **Quality management:** Quality control, Total Quality Management, Quality of services, Traceability and monitoring of production and material handling.
8. **Environment:** Unused final and semi-final products handling, Byproducts handling, Packaging materials handling, Gas emission / pollutants production, Byproducts transportation management, Energy consumption management.

The above processes match supply chain capabilities to demand requirements from the point of origin to the point of consumption (Lambert et al. 1998; Day, 1994).

**Step 2: Prioritization of logistics processes.** In this step, the logistics processes that emerged from the previous step are prioritized. This prioritization is based on specific criteria. The following criteria can be used (Davenport, 1993; Sasazaki et al. 2004; Dervitsiotis, 2006; Madison, 2005; Ioannou, 2005):
• Logistics processes, which are essential for the customer and also for the existence of the company. Businesses are usually based on these processes to attain a competitive edge (for example, the process of picking is critical to the Third Party Logistics).
• Logistics processes, which cost so much.
• Logistics processes that are consuming significant resources (informational, financial, technological, human resources, etc.).
• Logistics processes, which contribute considerably to the added value of services and products.
• Logistics processes, which regularly generate problems, errors and delays.

It is practical that each of the above criteria, for every logistics process, isn’t of the same importance. Managers that involve on the logistics processes consider them of different significance. In the case study we proposed possible values for the evaluation of the importance of the above criteria can range from 1, no significance; to 7, very high significance. The final objective is the estimation of the significance of the process.

MODEL FORMULATION

In this section, we present the proposed model that addresses the prioritization of logistics processes. Below, we provide the related nomenclature:

\( w = 1, \ldots, W \): criteria for the classification of the logistics processes.
\( i = 0, \ldots, I \): group of logistics processes.
\( j = 1, \ldots, J \): logistics processes.

Next, in Table 1 we provide the nomenclature for the decision variables and the parameters of the model.

<table>
<thead>
<tr>
<th>TABLE 1 DECISION VARIABLES AND PARAMETERS OF THE PROPOSED MODEL</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Variables</strong></td>
</tr>
<tr>
<td><strong>Parameters</strong></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

Consequently, the following binary linear programming model is formulated:

Maximize:

\[
\sum_{w=1}^{W} \sum_{i=1}^{I} \sum_{j=1}^{J} c_w \cdot f_{ij}^w \cdot y_{ij} \quad (1)
\]

Subject to:

\[
\sum_{w=1}^{W} y_{ij} \leq N, \forall i \quad (2)
\]

\[
y_{ij} \in (0, 1) \quad (3)
\]

The objective function aims at maximising of the performance of the logistics processes. To this effect, two different constraints have been considered. More specifically, equation (2) provides the maximum number of logistics processes that can be selected in each group. Finally, equation (3) represents binary constraints.
CASE STUDY OF THE PRIORITIZATION OF LOGISTICS PROCESSES MODEL

In order to implement and check the validity of our proposed methodology and the corresponding mathematical model a survey consisting of a cover letter and a questionnaire were mailed from July 2010 to December of the same year, to the managers (CEO’s, Operations and Logistics Managers) of the 40 largest agrifood companies in Greece.

Of the 40 questionnaires distributed, 19 completed questionnaires were returned by those surveyed. The effective response rate was sufficient (48%). A corresponding number of interviews were arranged with the above managers. The main objective of the survey was the assessment of the logistics processes of the examined companies (sample) according to the following four (4) criteria: 1) Logistics processes, which are essential for the customer and also for the existence of the company, 2) Logistics processes, which cost so much and they are consuming significant resources, 3) Logistics processes, which contribute considerably to the added value of services and products, and Logistics processes, which regularly generate problems, errors and delays.

Managers asked to insert their ranks about the criticality of the logistics processes that were presented at Table 1. Managers could choose from 7: Very high significance to 1: Very low significance in order to evaluate the logistics processes that were categorized to 8 groups. Then the averages for each process has estimated taking account the answers of the respondents.

Considering as the 25% of the logistics processes the number of critical processes and based on the results the most critical logistics processes are presented (on descending order) below: 1) Planning of primary production, 2) Production of finished and semi-final products, 3) Quality control, 4) Production scheduling and materials planning, 5) Total Quality Management, 6) Quality of services, 7) Order’s packing, 8) Traceability and monitoring of production and material handling, 9) Planning of procurement, 10) Order handling, 11) Production planning, 12) Harvesting, and 13) Procurement for production. According to the results, the logistics processes that support the production of the Agrifood products are key enablers of the companies’ success. They are essential for the customer, they cost so much, they contribute considerably to the added value of services and products, and they regularly generate problems, errors and delays. Similarly, logistics processes that support the application of the quality practices and approaches are significant. Both findings were expected due to the special needs of the customer and the market. Moreover, managers agree that packing is an important element because it adds value to the products and services and procurement can play a significant role for the management of the expenses.

Then a number of Unified Modeling Language (UML) diagrams were developed and documented based on a specific template. An indicative UML diagram is given below:
FIGURE 1
Tracking and tracing production process [QUAL4] and Tracking and Tracing of end product [DIST7].
CONCLUSION

In this paper a systematic approach for the identification, classification and prioritization of logistics processes was proposed, applied and validated by a case study (survey). The proposed approach includes a step-by-step methodology and a mathematical model.

Based on the findings, most of the key logistics processes belong to the “Production support”, “Quality management” and “Order processing” groups. This result was expected due to the nature of the industry and the specific needs of the products. Agribusiness companies have invested a lot into the production processes / production lines and the corresponding total quality management practices and traceability approaches. Therefore, it is critical for the agribusiness companies to develop a number of performance measurement indexes and metrics for these processes. Moreover, they must to standardize these processes and apply continuous improvements approaches. A number of logistics processes are not appeared on the list. Specifically, processes from the “Transportation and Distribution”, “Materials Handling”, and “Warehousing and Inventory Management” groups. Managers don’t consider them as non-critical processes; most of them present a high average. But, they are focusing on the production and quality issues because they consider them as the processes that support their companies’ competitiveness. Furthermore, most managers consider environmental issues as less significant. This reveals that in most agribusiness companies the focus is on the policies and the strategic level and less on operational level.

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IMPROVED SALES PLANNING METHODOLOGIES FOR STOCHASTIC EVENTS IN THE SUPPLY CHAIN

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ABSTRACT

In many business operations sales planning is rather an experienced based process than a structured one. Know-how of sales employees, their correct “gut feeling” and their relation to clients have been sufficient for many years to guide enterprises successfully through the market. However, the economic crisis in 2008 and 2009 has brought many companies close to bankruptcy or worse, has terminated their existence. This is largely due to the very sudden and unexpected sharp drop in market demand for many products and commodities, which has not been realized in advance and consequently hit companies completely unprepared. Apparently, common practices as described above have failed to foresee a situation like in 2008 and 2009. This paper is now directed to search for alternatives to common practice sales planning. In a first step it was evaluated which methods have been widely used in micro- and macroeconomics to forecast the future so far. Secondly, the authors decided to scan other science fields for planning methodologies. Planning in the sense of predicting the future is pretty common to human behavior and can be found elsewhere, too. The paper also describes in some detail how adequate planning methodologies were detected that seemed to be appropriate to be transferred to business and company requirements. Finally, the most promising potentials are clustered and adjusted to develop a practical approach for industry enterprises. During the analysis and development of the approach some interesting findings occurred. Certain forecasting methods are broadly used in untypical planning areas, whereas their usage in enterprises and research is limited. However, not only bad or false-chosen forecasting methods are reasons for failures in predictions. A crucial factor is that poor macroeconomic forecasts are used as data basis for microeconomic prognosis. The consequence is that businesses have to improve their results on their own without taking macroeconomic predictions too much in consideration. Finally, since companies’ existence depend on their ability to predict influencing factors for their supply chain they need to define which data they use for their analysis. Some analyzed approaches show that forecasters do not have to develop a complex and costly prediction model to obtain good results. We particularly found that social media and the political stock market are sources for forecasting practices that can also be transferred to businesses.

KEYWORDS
Sales Planning, Supply Chain Management, Forecasting, Prediction Model, Stochastic

MOTIVATION

The worldwide economical crisis, which began in 2007 and had its peak particularly in 2008 and 2009, not only affected the financial markets but also production industry. It occurred mostly unexpectedly and hardly anybody could predict its occurrence. This crisis has demonstrated that common and widely accepted planning models are apparently not sufficient to cope with changes that nobody foresees and which might be called “black swans” (Taleb, 2008). Apart from financial institutions those companies suffered worst from it who were neither close to customers nor sold commodity products. Intimacy with customers may help to detect changes in the market earlier. Despite the continuous effort to improve supply chains it is well known that bullwhip effects (Christopher, 2005) exist that decouple enterprises further down the supply chain (towards the suppliers) in a way that they suffer much worse demand fluctuations. Commodity products had a decline through the crisis, which was by far not that bad as the plunge of demand in industry. The global car industry, which is important for world economy because of its size, experienced a sharp drop in sales by 20% and was even worse for Germany, whose industry is particularly strong in car manufacturing. Referring to the situation for commercial vehicles like trucks Germany experienced a plunge by 57% (Piegert, 2010).

Following interventions by politics this downturn in production was softened and turned into a completely unexpected growth at the beginning of 2010 at least in Central Europe. This situation came so sudden that most
companies ran into severe troubles again, just the other way round: production capacities were too low, supply chains were dry and some products and components were absolutely short in the market. What can be learned from this situation is the following:

- The farther companies were down the supply chain (towards suppliers) the harder they were hit
- Companies producing investment products were hit more severely than those delivering commodities
- Despite all efforts in the past enterprises were not flexible enough to cope successfully with these sudden happenings
- Sales planning methodologies are in place but could not provide adequate support and predict what would happen.

This research paper deals primarily with the last of these mentioned findings. It is crucial for enterprises to have adequate means at hand to cope with uncertainty and stochastic events. Existing procedures and methodologies apparently cannot provide adequate assistance, which was the reason in this paper to search for alternatives. So, basically the research can be condensed to the following two research questions (RQ):

RQ 1: Why have forecasts failed in the past and what can be learned out of this?
RQ 2: Which forecasting methods can be derived from other scientific areas and which opportunities will emerge from them?

**BASICS, LITERATURE REVIEW AND APPROACH**

Sales planning is an important part of a structured planning process in enterprises and is usually critical to the quality of planning. It is the input to the planning process and transfers the information from the customers to the company. It combines forecasts, which are predictions of what will happen in future, with definitive customer orders (Ross, 2004) and is a core element for the demand plan (Palmatier, 2003). The demand plan contains the information what is needed from the market together with the intended sales and is regularly prepared by the sales and marketing organization.

Forecasting is core of our interest in this paper, which is the essential part of the planning process. It is always related to uncertainty, which comes from the stochastic nature of future. According to Hellwig et.al. (2005) sales forecasting consists out of qualitative and quantitative methodologies. Quantitative methodologies are based on mathematical and statistical models, which extrapolate historical data into the future by using trends (Pillkan, 2007) or regressions (Makridakis et al, 1980). Qualitative methods, however, are used when the available set of data is too small or too vague and, hence does not allow the application of quantitative methods (Homburg, 2000). Qualitative methods mostly employ the knowledge of experts. The most prominent qualitative methods are Delphi (Makridakis et al. 1980), scenario techniques, relevance tree analysis or morphological methods. Generally, the existing bouquet of alternative qualitative methods is much smaller than for the quantitative ones and sometimes it is hard to distinguish whether the intended method is appropriate for forecasting (as is the intention here) or rather for creativity purposes. They are both closely linked and related.

**Current approaches to forecasting in industries**

There is a wide range of literature that can be found on the various forecasting methods. What is rather limited, however, is the number of studies that deal with implementation of these methods in business settings. For practical reasons in enterprises it is of crucial importance that companies apply these models adequately and even find more promising approaches to tackle stochastic events. It is important to bear in mind that quantitative methods in particular are based on historic data, which are then extrapolated into the future by different ways. Apart from the search for a more promising solution for coping with stochastics it is interesting to see that planning in industry is still not that widely used as assumed. A study from the Institute of Business Forecasting has analyzed the employment of planning as a whole in industry and has delivered interesting, perhaps embarrassing results (Jain, 2007). Planning is not that well established as might be thought and was introduced systematically only a few years ago. From a functional point of view in companies it is supply chain management in most cases (37%) which takes the responsibility for planning. Regarded from a methodical point of view quantitative models outweigh qualitative ones. It is also interesting to see that these mathematical models are mostly enhanced with the tacit and implicit knowledge of the involved persons. Interestingly, as was proven by a study (Fildes, 2009), manual correction improves the accuracy of the information. This might be due to the fact that little knowledge on the proper application of statistics exists in companies and the practice shows that the enrichment of data by experience pays off.
In addition to these findings, De Goojer (2006) has analyzed published literature on planning and found the following:

- In literature, procedures and guidelines hardly exist that help enterprises choose the most promising methods for forecasting.
- Over time, more and more methods have been introduced which are not based on Gaussian distribution. These methods are more robust towards statistic fluctuations.
- It appears that another trend could be a combination of linear and non-linear models. However, only basic research exists so far on this topic.

Research question 1 can now be answered: Planning and forecasting are not that widely used as might be assumed and proper forecasting requires profound knowledge, which does not exist in many cases.

Applied approach

The intention of this paper is to broaden the view on planning with respect to forecasting. Quantitative and qualitative methods as described in the previous chapter are derived from business applications. We wanted to focus on other areas of science and searched for interesting opportunities to transfer planning models from there to business. Practically, we did that by means of creativity sessions and applied the method of brainstorming. The most promising and accessible areas for us seemed to be meteorology with its weather forecasts, election prediction from political sciences and data mining from social media, which has recently been discovered for marketing. We chose these three different areas due to following reasons: the science of weather forecasting has a long history and volatility can be high. Election prediction has also been subject to intensive research for many years and delivers remarkably good results. Social media, however, are generally pretty new and apparently offer the chance to identify opinions early, which could help to detect trends and change in patterns.

ALTERNATIVE FORECASTING METHODS

Weather forecasts

Meteorologists have been dealing with weather forecasts for more than hundred years. It may be assumed that prognosis of weather is a pretty old and established science and findings are well proven and may be transferred to other areas of science. Generally, from many locations above the earth’s surface the atmospheric conditions like air pressure, wind and temperature are measured and then computed to deliver weather forecasts for distinct geographical regions (Lynch, 2008). A breakthrough discovery with weather prognosis was the separation of earth’s atmosphere into small segments. Soon, it was discovered that computing forecasts in every geographical place with the same accuracy is not efficient. This led to significantly reduced computing times and delivered forecasts between rough and very detailed depending on requirements (Al-Yahyaj et.al., 2010). Weather is a chaotic process, which is similar to situation in business. Small changes in input factors (e.g. local atmospheric disturbances) may have significantly different outputs.

Transferred to business models, weather forecasts can be seen as a quantitative, causal (multivariant) method. In a first step sophisticated algorithms solve equations which describe the physics of the atmosphere to deliver results. The robustness and stability of these results is then tested in 51 different scenarios that all have slightly varying input parameters (Lynch, 2008). Comparing this to business, this turns out to be a remarkable difference: in business hardly any forecast is profoundly tested on its stability with varying scenarios. As described above data sources for weather predictions are atmospheric situations at a huge number of distributed weather stations. Nature’s physics deliver values for the data which is different to business. In business it is often hard to determine what the most promising criteria for measurement would be. If promising criteria are found it is often difficult to measure them accurately. Large number of data would help to substitute for single weak inputs and still gain valid and acceptable accuracy. Transferred to microeconomics and individual enterprises this would mean that they should not rely on data from their sales force or marketing only but also use much more extensively sales numbers from competitors or benchmark data.

Election prediction

The prediction of elections is particularly interesting early before voting takes place. It can be divided in micro- and macro-level models. Micro-level models are those that respond to questions like “Why have these persons voted for party x while others voted for party y?” unlike the more general question on a macro-level “Why has party x won and how could it make this difference to y?”. In particular it is interesting to note that candidates are not asked to give their personal intended votes for an election but they are asked what they would expect to be the outcome of the election.
Lewis-Beck et.al. (1999) have proposed a model that voters can purchase shares from their most favored candidates, which is similar to the stock market. The candidate with the highest number of purchased votes is the winner of the election poll. It is interesting to note that the accuracy of this method is high.

The political stock market model (Forsythe et.al., 1992) is similar to the above mentioned model. It compares votes with stock markets in a way that voters can purchase shares of their candidates. It was first used in 1988 at the US President’s election and had an accuracy of more than 99%! The accuracy of this model has been also proven in following elections, which has also raised interest in the past to transfer it to supply chain problems (Hedtrich et.al. 2009). Generally, the balance between efforts to forecast market behavior in supply chains and the gains out of it is not given. This could be overcome by using virtual stocks, however, this model is limited by the necessity to find enough traders, a number which should generally be above 20. Hedtrich (2009) proposes to use this model particularly in agricultural industries and food markets in order to predict raw material prices. Further literature is practically non-existent and a lot needs to be done here.

Election poll models are based on social macro data, which reflect people’s opinions to certain situations. Taking general socioeconomic factors into account for business forecasting is exhausting and requires a lot of effort. However, polling models have the benefit to concentrate just on the opinions of customers without significant worse results. Using customers’ opinions as input to business forecasting could be wise. Although the above described polling models are primarily used in American elections, which usually have only two candidates to elect, it has been shown that they can be used for situations with more alternatives, too. An example might be the Hollywood Stock Exchange (Levmore, 2003), which uses the underlying methodologies to predict the financial results of movies before they make their debut. Transferred to business, companies from the same branch could use the virtual stock exchange with a number of customers to forecast their market shares as a result of the question: “Where will the customers purchase their products in the coming year?”

Social Media

Social media is an excellent source for scientists to detect trends and changes early ahead (Gruhl, 2005). Data mining and intelligence use the power of social network users to predict. Blogging and Twitter are the most common forms of social media which have already been subject to scientific research. Interestingly, despite Facebook being the largest social media forum research on data extraction from Facebook for prediction is still scarce. Similar to methods as described in the chapter before (Hollywood Stock Exchange) is a methodology applied by Asur et.al. (2010) to predict the success of movies from blogging, again before their debuts. Asur found that the Tweet rate, which is the number of Tweets per hour correspond significantly high with the revenue of the movie. An improved version of this Tweet-Rate methodology delivered even better results than the Hollywood Stock Exchange, which has been best so far. O’Connor (2010) used Twitter to prove that Tweets can be a cost effective alternative to costly opinion polls. Prognosis methods based on social media extract information from online platforms and relate them to economic values. Research in this area is still young and all case studies employ more or less the same software to extract social opinions. Using these tools and models might be hard for enterprises since relevant data can be obtained for large, international companies only on one hand and the time horizons are pretty short, just in the frame of a few days.

RESULTS

Referring to research question 2, which asked for methodologies to forecast that can be derived from other scientific areas and the related chances, it was shown that there are a lot of opportunities although not always easily accessible. According to De Gooijer (2006) enterprises lack guidelines to select the most appropriate prognosis tool. Although no hands-on guideline can be provided yet to help companies improve their forecasting ability with particular reference to stochastic, hardly to extrapolate data from the past, it must be clear that starting to implement structured planning processes (which require forecasting as part of it) must be done immediately, despite this sounds so simple.

Related to weather forecasting the definition of the pattern size is essential. Pattern in meteorology determines the border between rough and fine planning and the horizon of planning. Next, macro-data need to be identified and followingy, it is important to verify their validity. As was demonstrated, social media could be a rich source for data that can be extracted, however, research is still young. A large number of individuals can deliver results which are comparably good as those from macroeconomics and in many cases it is much cheaper.
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LOGISTICS REQUIREMENTS AS A KEY TO SUCCESSFUL PRODUCT RAMP-UP PHASES

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LOGISTICS REQUIREMENTS AS A KEY TO SUCCESSFUL PRODUCT RAMP-UP PHASES

by

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ABSTRACT

Companies have generally realized that logistics competence is key to cost-efficient production and meeting market demands. However, market competition gets tougher and tougher caused by increasingly shorter product life cycles, by new technologies entering the market and by globalization, which in turn forces companies to more frequent and successful innovation. Austria is a high cost country with nearly 99,7% of all companies being SMEs (small and medium enterprises), whose success is based on their ability to innovate and produce cost-efficiently. Despite these challenging frame conditions, this research study shows that there is much room for improvement to focus deeper on logistics requirements particularly during the ramp-up phases of new products. Ramp-up phases are parts of the whole innovation cycle, which usually starts with an idea for a new product. Commonly, ideas emerge and are then nursed and brought up to a certain stage when first prototypes are developed and perhaps tested at some customers. Only if these tests are passed successfully next steps are taken which then will lead into a ramp-up process. Basically, the task of the ramp-up process is to bring a prototype to industrial production. Unlike larger companies SMEs do frequently separate their products’ innovation processes from later production, which leads to a negligence of logistic aspects (e.g. market demand versus production capabilities, low inventories to drive short lead times) in early product innovation phases. Although a prototype can be successfully built without taking logistics requirements in consideration, it will negatively impact the subsequent ramp-up process, which should then bring the product from a prototype stadium to industrial production capability: the final product must meet certain budget restrictions, must not exceed defined product costs, must be able to meet customers’ requirements sufficiently and must be at the market on time. These requirements usually contradict each other. So, this paper describes what can be done to shape this ramp-up process in a way that these apparently ambiguous goals (low costs, sufficient quality, fast) can be met best. In order to do so this paper presents the current status in literature on ramp-up processes in its first part. Additionally to theoretical research an empirical research was done that gathered best practices from industry. The results of which are then analysed to give a recommendation what companies may do to make their product ramp-up process faster, more effectively and more efficiently.

KEYWORDS
Innovation, Ramp-up Process, Logistics Management, Empirical Research, SME

MOTIVATION

Innovation is crucial for companies to adapt to changing environments and better cope with the future. Part of innovation and the innovation process is product ramp-up, which is the core part of this research paper. Product ramp-up is the period from finalizing prototypes to full scale production (Wiesinger, 2002).

Innovation is becoming more and more vital for enterprises, particularly in high-cost countries. The market competition gets tougher and tougher caused by increasingly shorter product life cycles, by new technologies entering the market and by globalization, which in turn forces companies to more frequent product innovations. In addition, innovation itself must become a stable, robust and sustainable capability as a foundation to a company’s success. As will be demonstrated later in this article, innovation has been subject to research for a long period of time, however, product ramp-up activities within innovation are not that well investigated. This is particularly true for ramp-up processes in smaller enterprises. Austria is mainly dominated by SMEs (small and medium enterprises), which usually have less than 250 employees and amount to 99,7% of all companies. Many of these companies are excellent in innovating products, which helps them survive in a competitive environment and even gain impressive market shares but they have certain weaknesses in how to transfer their product innovation expertise effectively into the capability of industrializing these products. So, we concentrated on how well these companies were able to combine product innovation with integrating new products into their supply chain. Activities like transferring supply chain know-how from logistics, procurement and
production into this particular phase of ramp-up were elements that had our attention. These activities certainly dominate later production but are found scarcely in early innovation phases, particularly not in the environment of SMEs. This empirical research study investigates common practices in ramp-up processes at leading enterprises, compares these practices to literature and draws certain conclusions from it for academics and practitioners alike to find which practices could be recommended.

A LITERATURE REVIEW ON WHAT MAKES ENTERPRISES INNOVATIVE

Innovation as a the base for sustainable success

In economic theory innovation is generally regarded from two different perspectives: the market and the resource orientation. Market oriented theories (Schumpeter, 1942; Mansfield 1968; Porter 1980 and 1985 and others) regard innovation and the related innovation management basically as a question of price creation and focus on the proper positioning in the market. The resource based approach (e.g. Penrose, 1959; Barney 1986 and 1991; Peteraf 1993) explains innovation as the intrinsic ability of enterprises to gain competitive advantage by employing resources and exploiting capabilities that are hard to copy and make for a sustainable success. The basic thought behind the resource based approach lies in the assumption that companies develop a combination of material and non-material factors that help them build a strong market position and defend it over time (Barney 1991). Since volatility and unpredictability have increased over time the resource based view was modified to become the dynamic capability view (DCV). The DCV (Teece et.al., 1997 and 1999; Wu, 2010) assumes that enterprises continually modify and adjust their internal core competencies in alignment with their external resources and strategic partners (Teece et.al., 1999). A critical factor for success with this approach are business processes that are well under control in combination with organization learning (Argyris, 1978; Senge, 2003).

In the frame of innovation with particular focus on ramp-up processes both theories need to be distinguished. While in the view of market oriented theories innovation is generally initiated by a customer’s demand the situation might be totally different in case of a “technology push”, which is an outcome of the resource based view model. In case customers drive innovation they are mostly involved early in the innovation processes and participate as partners for field tests. This is different in situations of technology push when enterprises intend to bring new products to the market and need to find companies which are interested to collaborate.

Innovation is not always rationally fact-based but has to do with soft, hard to grasp issues. It is a pretty complex activity with different phases and requirements. DCV regards innovation as a complex bunch of abilities, which interact strongly, not always linearly and which are not always visible in their combination by the involved parties. It may be concluded that innovation management is not a trivial field of research, which is well treated in literature. As Teece (1996) states, innovation is a quest into the unknown. Innovation does not always contain knowledge that can be easily seized and transferred but rather employs implicit knowledge and expertise of all involved people.

Product ramp-up phases

Product ramp-up phases do not have that prominent position in literature that they would deserve from their implications in company practice. One reason may lie in many different definitions of product ramp-up and the related ramp-up phases, which can be found in literature and practice alike. Every time new products are placed in the market product ramp-up phases happen. Moreover, this does not necessarily imply that companies have a common understanding on this process and in many cases it is hard to find a company function who feels responsible. Basically, the ramp-up phase is the time period between the finalization of the product development and reaching full capacity in production (Schuh, 2008), see figure 1.
Additionally, there is a differentiation in literature between ramp-up process and ramp-up management (Kuhn, 2002; Wildemann, 2009). While the first rather relates to the definition above, the latter one stretches across the whole innovation process as is indicated in figure 1. Ramp-up management starts simultaneously with the product innovation (which is in most cases a mere idea) and accompanies the whole innovation process until production has started at full capacity. Certainly, the intensity of management attention within this process fluctuates.

What can be observed is the fact that product innovation as an activity is frequently separated from all the tasks that need to be tackled in order to bring the innovative prototype to an industrialized product, which can compete in the market successfully. Innovation without the ability to bring products successfully to industrialized production and deliver high quality is not sufficient. It is proven in literature that weaknesses in order to so cause companies to fail (Wildemann, 2009).

The overall goal of a product ramp-up phase is to optimize the prime success factors time (short time-to-market), cost (the lower the cost for product development the better) and quality (the product must meet the customers’ expectations) in the transition of a vague idea to a successful product in the market (Wildemann, 2009). Research shows that a reduction in time by 40 - 60% decreases related cost for product development by 5 to 30% and besides, the risk of missing the “window-of-opportunity” in the market (Risse, 2003) is also lower.

**EMPIRICAL RESEARCH AND FINDINGS**

We concentrated our empirical research on Austrian companies that seemed to be innovative and leaders in their branches. Austria is a country which is dominated by SMEs and which depends strongly on high-tech industry, in particular on the automotive industry. Many companies supply material as first or second tier suppliers. Requirements in this branch are tough and in order to stay in business these enterprises are forced to establish innovation as a core of their business.

**Methodology**

A former study on early product innovation had already identified companies from automotive industry in Austria. We used the expertise with these companies, selected the 8 most promising from them and enhanced this group with another eight companies from various industries that we expected to be good candidates for an empirical study. At the end, 13 out of these 16 companies agreed to participate in the study. We then designed a questionnaire to execute the research work.

**Findings**

Interestingly, one of the major findings was that the results from our empirical research were pretty similar to those from other studies a few years ago (Schuh, 2005; Schneider et.al, 2002). It might be concluded that companies are well aware of the importance of successful ramp-up processes, they know tools and methodologies but are not really in the position to apply these methods adequately.

Ramp-up as an activity is frequently understood differently. While in some companies product ramp-ups are seen as part of the design engineer’s responsibility we could also identify enterprises that leave the responsibility in the hands of the head of production. This is a broad span across company functions, which troubled us already initially when
we tried to identify the correct partners for our interviews. It was not an easy task and there is apparently not a common understanding across industry who should be responsible for product ramp-ups. What we learned, however, was that ramp-ups are usually easier to manage in case overall responsibility is with those persons who have their functional home in one of the supply chain areas like purchasing, production or logistics. No matter of the ramp-up owner, it is important to fully integrate representatives from purchasing, logistics or the production function itself early enough in the ramp-up phase. Certainly, it would even be better to have these functions already available from the very beginning of the product innovation. Otherwise important aspects of the supply chain are missed. Companies overall show certain weaknesses at managing the information flow across the interfaces between different companies. In most cases customers and important suppliers are not part of this product ramp-up process leading to unnecessary changes later in the production process. Getting the required information right has to do with knowledge management. All the companies which we had in our study are aware of the importance of it, however, many of them do not really use them to the full. Reasons for this are manifold, the primary ones being apparently simple like shortages in time and a tendency to rather preferring hands-on execution to investing a lot of time into reviewing processes and considering improvement opportunities. Sometimes this is even regarded as waste of time.

Working in teams during the phase of product ramp-up is essential. This statement is well founded with the findings in our empirical research. However, the team composition varies from innovation process to innovation process. Companies often lack the ability to transfer knowledge from one project to the next and many of these teams consist primarily out of members from the technical departments. It would be wise to take already those functions into the project teams that are later responsible for efficient and effective production.

Cooper’s stage-gate model (Cooper, 2004) is widely known in industry, which does not mean that it is always applied as intended. Basically, this model is technically not very sophisticated but emphasizes the necessity of employing project management tasks. Project management itself is a structured and disciplined approach that supports companies in arriving on time at agreed goals without exceeding committed resources.

In some companies the ramp-up phase with all its responsibilities ends as soon as industrialization has taken place and products drop off the production line. This is not in line with literature which would rather propose ending the ramp-up phase only a few months after successful start of production. This is important because responsibility then still lies with the ramp-up team in the first few months of production. Unexpected problems or disruption in product and process design, which might occur, are solved by this team before the supply chain organization takes over a product that has proven its capability for production.

A major problem in all companies participating in our empirical research is founded in the horizontal and vertical integration of enterprises. A lack of transparency, standards of processes and definitions which are different between companies, uncoordinated interfaces and late integration of suppliers are common problems. Additionally, product design issues remain unsolved for a too long period of time, which lead to late and unexpected changes in ramp-up processes. The consequence of this are bull whip effects which are well known from supply chain management and which lead to undesired time pressure, disruptions in the process and put the timely introduction of the product at risk.

It may be concluded from our research that product ramp-up activities and the related management must be in the hands of the supply chain organization. This can easily be achieved by choosing a project manager who is not from the innovation or technical side of the company but rather from later supply chain. It is important not to miss representatives of relevant company functions in the ramp-up teams. Besides, generating and managing knowledge is crucial for sustainable success. Part of this is the set up and the maintenance of data bases that provide required information on the product and which store this information, too.
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THE STUDY OF THAI SOLAR THERMAL SUPPLY CHAIN

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ABSTRACT

Solar Thermal industry in Thailand has recently become more popular. The industry was of interest by the government as one of the new sustainable energy resources addressing the traditional energy resource crisis. However, the supply chain of the industry is unknown and therefore cannot be promoted and improved according to the real requirement and constraints of the industry, especially the supply side. Therefore, the study tries to understand Thai Solar Thermal supply chain by investigating 5 case study supply chains. The case study chains include both CKD (Completely Knocked Down) and CBU (Completely Built Unit) cases and in various sizes of the firms. Various logistics and supply chain K were used to indicate weaknesses and room for improvement for the industry. As the result, the supply chain improvement suggestions were made in order to improve Thai Solar Thermal Supply Chain.

KEYWORDS
Solar Thermal Supply Chain, Logistics and Supply Chain

INTRODUCTION

Energy is demanded as the development of the world. Whilst the usage is increasing each year, fossil fuel is expected to run out within 40-year time. In 2010, in Thailand, the total cost of energy is equivalent to 52.13 billion USD and increasing 2.5% from 2009. Where Thailand energy resource is limited, nearly half of the energy must be imported. (Energy Policy and Planning Office - Ministry of Energy, Thai Government, 2009)

Whilst global and Thailand’s energy crisis become more critical, the renewable energy resource is now more preferable. One of the highly recognized alternatives is the solar energy. Where solar energy is free and is considered renewable, it is more stable and more cost effective than other renewable energy sources such as wind and water.

In Thailand, solar usage in terms of Solar Thermal (ST) has long developed as well as other countries, eg, China, Australia and European countries. Technology is no longer new. The safety and effectiveness of the system are well-known.

Geographically, Thailand is located near the equator where there are in high solar intensity, with the rate of 5.05 kWh/m²-day. Together with an area of more than 513,120 sq.km., the potential is high. Say if only 1% of the potential energy is used, it will save up to 700,000 ktoe yearly. )Department of Alternative Energy Development and Efficiency - Ministry of EnergyThai Government ,,2011 )

Today, ST industry in Thailand has been growing. Also the Department of Alternative Energy Development and Efficiency (DEDE), Ministry of Energy, has strongly promoted this industry. Several subsidy projects have been approved. Target group includes hospitals, hotels, schools. For the last 3 years and this year, this DEDE’s ST program aims at installing more than 40,000 sq.m. of ST. This amount will be equivalent to 5.8 million USD worth of crude oil.

However, there are yet to be any study focusing on the supply chain of this industry. Rather, there are only study focusing mainly on the marketing and technology. (The Solar Thermal Market in Thailand, 2011, Thailand, 2011, Solar Thermal Association (STA) Opens in Thailand, 2011, Menke, C., 2007)
SOLAR THERMAL TECHNOLOGY

ST technology is simple. The solar collector, made with heat conducting material fin or tube, is used to collect the heat from the solar rays. Normal water or any medium is used to collect the heat by circulate within fin or tube, pressurized by connecting pumps. Then the hot water is kept in the insulated tank, ready for use. Upon Thailand condition, the water can be heated up to 55-90°C. (Electricity Generation Authority of Thailand, 2010)

FIGURE 1
SOLAR THERMAL MAIN COMPONENT DIAGRAM

High-temperature pipe is used connect each main components together. Temperature control, electrical control and values are used to control the system condition.

Where the system varies in type of collector, materials, coating technology, efficiency and temperature varies so. (Kaygusuz and Kamil, 1999, Lane, 1990, Hasan, 1997) However, the main concept is more or less consistent as discussed.

SOLAR THERMAL SUPPLY CHAIN

There are 2 types of ST use, ie, home-use and industry-use (hotel, industry, hospital, school, etc.) Where it is very simple for home-use cases, the completely built standard unit can be chosen. This home-use ST’s size varies from 100-500 liters/day. This home-use ST can be both Completely Knocked Down (CKD) or Completely Built Unit (CBU).

In case of small-size, home-use CBD set, all parts are assembled oversea and imported as a completed set, ready for installation. Shipping is mostly via sea, approximately 40 set per container. In case of industry-use (size up to thousands of liters/day), it is only the CKD case where components can be procured both locally and overseas.

The supply chain of CBU ST industry can be simply illustrated by Figure 2.

FIGURE 2
SUPPLY CHAIN OF SOLAR THERMAL INDUSTRY - CBU
In practice, the sales department of ST company or its dealer will make a contact to the customer or vice-versa. This depends on cases. The sales personnel will inquire about the system requirement and need. Then the data will be transferred to the design department where the ST system will be tailor-made to the customer. This includes the supporting structure design and modification package at the installation site. The design process may take up to 1-2 weeks depends on the complexity of the project. Then the quotation will be issued to the customer. Once the customer agreed to the arrangement, the ST company will then start to procure each material, if not in their inventory.

Once the bill of material is issued based on the design, the procurement will be made. The components can be imported or produced locally. In most cases, solar collector both fin and tube types are imported from China where the price is more competitive. However, in some company, raw material such as tempered glass, copper tube, aluminum fin, enclosure parts, are procured locally. Then, they are processed, eg, coated and assembled, at the factory.

Accessories, such as pipe, value, control, pump, are mostly procured with the local dealer. However, these parts can be produced locally or again imported.

Whence the components are ready (in the inventory or ready to be delivered by the suppliers), the installation team will install the system at the site. This includes the supporting structure installation. The installation period is depending on the complexity of the system as well as the size of the system.

The case is well different for home-use where the requirement is basic and standard set is pre-designed (and sometimes stocked). The design lead time can be less than a day. However, the supporting structure design may still be required and some inspection at installation site may also be required. The installation is simpler as the set is pre-assembled.

After installation, service warrantee is given. It can be either the whole set or only tanks. The duration of 1-5 years are varied from companies.

**SUPPLY CHAIN PERFORMANCE MEASUREMENT**

The study examine 5 ST case study companies, ie,

1. **Company A**
   - design and installation service
   - both home-use and industry-use
   - 2,000 sq.m. installation in 2010
   - CKD; main components are imported from Chinese supplier

2. **Company B**
   - design and installation service
   - both home-use and industry-use
   - 100 sq.m. installation in 2010
   - Main components are produced locally

3. **Company C**
   - installation service
   - home-use
   - 150 sq.m. installation in 2010
   - CBU; complete set is imported from China

4. **Company D**
   - design and installation service
   - both home-use and industry-use
   - 150 sq.m. installation in 2010
   - Main components are produced locally

5. **Company E**
   - installation service
   - both home-use and industry-use
   - 200 sq.m. installation in 2010
   - CBU; complete set is imported from Australia

It shall be noted that the company name is confidential. Therefore, alias is used for the study. However, these company can represent the industry as they contribute to approximately 10% of overall ST installation in Thailand.
Here, the supply chain are investigated based on 8 logistics and supply chain activities, ie, customer service & support, design process, sourcing, inbound logistics, logistics communication, inventory management, outbound logistics and installation. Where in each activity, related KPIs based on (i) cost, (ii) reliability, (iii) time and (iv) other are compared as follow;

**TABLE 1**

<table>
<thead>
<tr>
<th>KPIs</th>
<th>Company</th>
<th>unit</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A</td>
<td>B</td>
</tr>
<tr>
<td><strong>1. Customer Service and Support</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.1 Time of Inquiry</td>
<td>day</td>
<td>7</td>
</tr>
<tr>
<td>1.2 Data Collection</td>
<td>hr</td>
<td>24</td>
</tr>
<tr>
<td>1.3 Time for Pre-design</td>
<td>day</td>
<td>7</td>
</tr>
<tr>
<td><strong>2. Design Process</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.1 Number of Design Expert</td>
<td>person</td>
<td>7</td>
</tr>
<tr>
<td><strong>3. Sourcing</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.1 (Domestic Sourcing) Order Cycle Time</td>
<td>day</td>
<td>0-7</td>
</tr>
<tr>
<td>3.2 (Oversea Sourcing) Order Cycle Time</td>
<td>day</td>
<td>7-30</td>
</tr>
<tr>
<td>3.3 Accuracy</td>
<td>%</td>
<td>100</td>
</tr>
<tr>
<td>3.4 Payment Lead Time</td>
<td>day</td>
<td>0-60</td>
</tr>
<tr>
<td><strong>4. Inbound Logistics</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.1(Domestic Supplier) Delivery Lead Time</td>
<td>day</td>
<td>3</td>
</tr>
<tr>
<td>4.2(Oversea Supplier) Delivery Lead Time</td>
<td>day</td>
<td>7-30</td>
</tr>
<tr>
<td><strong>5. Logistics Communication</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.1 Order Accuracy Rate</td>
<td>%</td>
<td>100</td>
</tr>
<tr>
<td>5.2 On-Time Delivery</td>
<td>%</td>
<td>90</td>
</tr>
<tr>
<td>5.3 DIFOT</td>
<td>%</td>
<td>100</td>
</tr>
<tr>
<td>5.4 Order Processing Cycle Time</td>
<td>day</td>
<td>0-30</td>
</tr>
<tr>
<td><strong>6. Inventory Management</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6.1 (Raw Material) Inventory Turn-over Rate</td>
<td>day</td>
<td>30</td>
</tr>
<tr>
<td>6.2 (Finished Product) Inventory Turn-over Rate</td>
<td>day</td>
<td>15</td>
</tr>
<tr>
<td>6.3 Inventory Accuracy</td>
<td>%</td>
<td>100</td>
</tr>
<tr>
<td><strong>7. Outbound Logistics</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7.1 Mode of Transportation</td>
<td>3 (truck, train, air)</td>
<td>1 (truck)</td>
</tr>
<tr>
<td>7.2 Delivery Lead Time</td>
<td>day</td>
<td>3</td>
</tr>
<tr>
<td>7.2 Shipping Error</td>
<td>%</td>
<td>0</td>
</tr>
<tr>
<td><strong>8. Installation</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8.1 (Home-Use) Installation Period</td>
<td>day</td>
<td>1</td>
</tr>
<tr>
<td>8.2 (Industry-Use) Installation Period</td>
<td>day</td>
<td>90-150</td>
</tr>
<tr>
<td>8.3 Testing Period</td>
<td>day</td>
<td>7-10</td>
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**SUMMARY & DISCUSSION**

It can be seen that each company has difference logistics and supply chain performance. Where Company A, biggest company with home-use and industry-use, mainly uses CKD parts, however, with a big volume, the delivery lead time is short (3-day locally and 7-30-day oversea), in comparison to Company C and E. Inventory turnover rate is also short at 15-day for raw material and only 15-day for finished product. Compared to Company B, the order cycle time and (domestic supplier) delivery lead time are long. Inventory turn-over rate of the finished product is also considerable long. Company C, on the other hand, uses CBU complete set. Order cycle time is long and the delivery lead time is also long. This is investigated and it is found that because the oversea supplier is a very big factory and the company’s order is small in volume. The sourcing power and priority are therefore small. The inventory turn over rate of Company C is also long at 30 days. Company E which imported ST complete set from Australia also has a long lead time in delivery (60 days) and order processing (60 days).
The study reviews logistics and supply chain status of Thai Solar Thermal industry and it indicates room of improvement. Delivery lead time and inventory turnover seem to be a big issue. Another key observation made by authors are that these companies have not concern on their own logistics and supply chain performance. Several logistics KPIs are unknown and has never been collected or observed. They seem to be neglected. Here, such limitation of the information can result in the mis-led development direction that is unpreferable.

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ON SUPPLY CHAIN INTEGRATION MODEL FOR THAI FOOD PRODUCT IN JAPAN MARKET

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ABSTRACT

The study focuses in how to integrate Thai food products’ supply chain into Japanese supply chain. Here, frozen fresh and semi-cooked shrimp product is used as the example of the product exported from Thailand to Japan. In order to understand the relationship and the connectivity of the members on Thai and Japanese partners in the supply chain, the Supply Chain Integration Model (SCI Model) is used. The model is constructed by 4 major criteria, ie, infrastructure, institutional, businesses and people. The comparison were made on Thai and Japanese sides and the gap can be seen. The results indicate the weakest links of the chain and therefore lead to the improvement suggestions both public and private stakeholders.

KEYWORDS
Supply Chain Integration Model, Thai Food Products in Japan Market

INTRODUCTION

Thai food has been very popular around the world due to its special characteristics, ie, spicy and suave. Also, a large variety and completion of taste in one dish brings its fashionable style in to the table. CNN has recently ranked Massaman curry (Thai curry dish) as the 1st rank in Top 50 Foods from CNN along with Tom Yum Kung (Shrimp in hot and spicy soup) in 8th, Nam Tok Moo (Mince pork salad) in 19th and Som Tum (Papaya salad) in 46th (Top 50 Foods from CNN, 2011). Also, Hotelclub website has ranked Thai food as 5th most tasty cuisine (Top 10 Most Tasty Cuisines in the World, 2011). With currently more than 6,000 Thai restaurants around the world have been registered to Thai government database as the evident of the case. (Thai Food … Global Top 5, 2011)

Moreover, to promote Thai food, the “Kitchen to the World” and “Thai Food Good Taste” by Thai government has been launched (Thailand – Kitchen of The World, 2011). Together with the potential of being a source of food, Kitchen to the World means not only the food and restaurant but also raw material and ingredients to other international dishes. Thai government has declared that Thailand has exported more than 18 billion USD worth of raw material for cooking in 2010. Top importers are China, Japan, USA, Malaysia and South Korea.

In this study, Japanese market is of interest. As it said that Japanese market is one of the highest quality in the world, shall one can export to Japanese market, one can export to anywhere in the world.

Upon Thai Customs Office statistics, Thailand exports more than 3 billion USD worth of food raw material yearly. Majority of food products exported to Japan are processed frozen and canned seafood (shrimp, tuna, squid) and processed frozen chicken at 33% and 21% gross respectively.

The study is therefore focusing on understanding the relationship and the connectivity of the members on Thai and Japanese partners in chain of Thai food products in Japan market. Hence improvement room, indicated by the weakest links of the chain, can be identified. This will suggest Thai exporter and Thai supplier to improve their supply chain operation to meet customer satisfaction. Moreover, the findings would inspire the new comers or potential company to Japanese market.
SUPPLY CHAIN OF THAI FOOD

Upon literature and interview with Thai exporters and Japanese imported, the supply chain model of the case study product ie, frozen fresh and semi-cooked shrimp product, can be demonstrated in Figure 1. Figure 2 shows Thai shrimp products in Japan market.

FIGURE 1
FROZEN SHRIMP SUPPLY CHAIN

The supply chain of processed frozen Vannamei shrimp (as an example of the processed frozen and canned seafood) starts from hatchery farms where Vannamei nauplius is imported from USA. These farms are controlled under the virus quarantined and GAP (Good Aquaculture Practices) and CoC (Code of Conduct Shrimp Hatchery) code. After 20 days, these shrimp will be transferred to nursery farm with again GAP and CoC code of practice. The shrimp will grow 3-4 months prior to the collection. Here, random quality inspection may be made. Movement Document (MD) and GAP are among the requirement of the transfer.

The shrimp middle man or middle market would then collect shrimp from farmers and transfer to the processing factory. Here, quality control and speed of the delivery are the key to the good quality of the products.

Whilst arrived to the processing factory, processes including the inbound logistics, sizing, cleaning, cooking or processing, packaging and outbound logistics, must be done under Hazard Analysis Critical Control Point (HACCP) and Good Manufacturing Practices (GMP).

Then the exporter must again quality control the products in terms of required Thai export and Japanese import protocols, especially the safety of the product, traceability and Codex Alimentarius Commission (CODEX) including GMP, HACCP, Movement Document (MD), Health Certification, and other documents (Customs Department and Department of Fisheries, etc.)
Whence arrival to Japan, Japanese importers will perform any clearance and distribute the products to the customer via variety of distribution channel. This include cold chain inbound logistics, chilled warehouses and outbound logistics to the retailers.

**SUPPLY CHAIN INTEGRATION MODEL**

Supply Chain Integration Model (SCI Model) is designed and developed, adapted from the model used to study the connectivity between international supply chain (Banomyong et.al., 2011), as well as other related studies (Gunasekaran et.al., 2001, Melnyk et.al., 2004, Mentzer et.al., 1991), to benchmark supply chain components of 2 trading countries in order to indicate rooms of improvement as the concept of “the supply chain is as strong as the weakest link”. Whilst component in both producing-exporting country and importing-consuming country result in quality, price and lead-time as well as reliability and flexibility of the product consumption, the weakness in the chain must be improved.

Here, SCI Model comprise of 4 main criteria, ie, infrastructure, institutional, businesses and people. Within main criteria, sub-criteria are included. Figure 3 illustrates the structure of SCI Model.

![FIGURE 3 SCI MODEL](image)

Whilst in some sub-criteria, it may be constructed of several KPIs such as Reliability sub-criteria under the Business criterion which comprises of KPIs, ie, forecasting accuracy, return rate, delivery capability.

**SUPPLY CHAIN INTEGRATION THAI-SIDE AND JAPAN-SIDE BENCHMARKING**

In the study, benchmarking within each criterion is made. Information from literature and interview are used. Here, the 5 mark scoring is used where “5” indicates the most preferable or the outperformed and “1” indicates the unsatisfied or the underperformed.
From the benchmarking, it clearly indicates that Japan-side supply chain performs better in most criteria. Whereas 1-2 score differences are mostly found in the comparison, this indicates that Thai-side supply chain are less satisfied. However, these differences are found to be not critical. For example, the transportation network sub-criterion, where Japan, scored 5, are better in terms of road network, road condition, road facilities and seaport facilities than Thailand, scored 3, but Thailand’s transportation network are more or less sufficient and can satisfy the overall standard. Likewise in cost sub-criterion, where transportation, inventory and holding costs in Thai-side may be unsatisfied, scored at 3. Japan-side’s cost are also high where Japanese business perform slightly better and have moderately more efficient in terms of these logistics activities. Japan-side is scored 4 in this cost sub-criterion.

The only big gap in this benchmarking is the Reliability sub-criterion. Where it comprises of forecasting accuracy, return rate and delivery capability, Thai-side is scored 1 whilst Japan-side is scored at 5.

If investigating into the detail of this factors, the 1 score results from the overall performance that is the weakest link within the chain.

### TABLE 1

**THAILAND’S RELIABILITY SUB-CRITERION**

<table>
<thead>
<tr>
<th>KPIs</th>
<th>Farm and Hatchery</th>
<th>Middle-Man</th>
<th>Processing Factory</th>
<th>Exporter</th>
<th>Overall Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forecasting Accuracy</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Return Rate</td>
<td>1</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>Delivery Capability</td>
<td>1</td>
<td>4</td>
<td>5</td>
<td>5</td>
<td>1</td>
</tr>
</tbody>
</table>

From data, even though middle-man, processing factory and exporter are good in terms of return rate and delivery capability, farm and hatchery, on the other hand, are weak in terms of forecasting accuracy, return rate and delivery capability. In fact, they do not have any forecasting and therefore the forecasting accuracy gains score at 1. The return rate is very high as the quality of the products is mostly not up to the standard. Therefore, they gain score at 1 on the return rate factor. Also, most of the time, the farmer cannot deliver the products on time. Therefore, they again get score at 1.

The score is based on the weakest member. Therefore in this sub-criterion, Thai-side supply chain get a score at 1 and it is the weakest link of the supply chain integration.
DISCUSSION

It is indicative from the study that the weakest link in the supply chain is at upstream, ie, farmer and hatchery. Most obvious indication is, as discussed, as the reliability is low.

In addition, there are several weaknesses in other sub-criteria studied. For example, they suffer from high inventory, holding and transportation cost. Information sharing within supply chain, especially, between farmers and other supply chain members, are also lacked. Moreover, they cannot access to the necessary information, production knowledge and related news. Communication and networking within the farmer group do not exist. These issues all contribute to the weaknesses of the upstream of the supply chain. Therefore, the improvement scheme can be suggestive as follow:

1. Related government agencies should support upstream in terms of knowledge, production technology and Japanese requirement and demand.
2. Related government agencies should continuously support the firms that currently export to Japan in terms of promotion, facilitation and funding.
3. Farmers and hatcheries should build network and share necessary information in order to strengthen the production. This also increase the relationship and negotiation power to other supply chain members.

These are the examples of the suggestion for the development of the shrimp industry in Thailand where it will increase the supply chain efficiency, resulting in better integration to Japan market.

SUMMARY

The study demonstrates the method of indicating the weakness and therefore suggest the development scheme for better integration in the import-export supply chain between 2 countries. Supply Chain Integration Model (SCI Model) is used where 4 main criteria, ie, infrastructure, institutional, businesses and people, are used. The study benchmark Thai-side and Japan-side in various perspectives. Where there are small gap in most factors of interest, which Thai are under developed however the gap is small and not critical. The only big gap is “Reliability” which of the weakest link, the upstream facing forecasting accuracy, return rate and delivery capability problems. Other issues are also raised such as the information sharing limitation, high logistics cost, communication and networking. Therefore the development scheme is suggested. This will expectedly increase the supply chain integration in the case of Thai shrimp exporting to Japan.

REFERENCES


A CASE STUDY OF LOGISTICS IMPROVEMENT IN HEALTHCARE INDUSTRY

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A CASE STUDY OF LOGISTICS IMPROVEMENT IN HEALTHCARE INDUSTRY

by

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ABSTRACT

Traditionally, healthcare industries in Thailand pay little attention to the logistics management. Some of the healthcare professional staffs such as physician, pharmacist and nurse, spend workload on logistic tasks which should be handled by logistics expertise or the use of information technology. This paper studies the issue of improving on logistics process and eliminating some unnecessary logistics processes in healthcare industry by implementing the technology and computer to aid the information management. The study simulates the real scenario in a hospital in Thailand with traditional management and a new scenario representing the processes with the implementation of management technology. The number of customers, the hospital’s resources and the size of the hospital are varied. The means flow time are compared and used to evaluate the performance of the original system and the proposed system. The results show that the management technology will benefit the hospital in case of the expansion of the hospital, and the break-even point is 2 years and 2 months. Therefore, the hospital should look into a possibility to implement software for their expanding plan in the near future.

KEYWORDS
Healthcare, Logistics, Management Technology, Simulation

INTRODUCTION

Logistics is the process of planning, implementing and controlling the efficient, cost-effective flow and storage of raw materials, in-process inventory, finished goods and related information from point of origin to point of consumption for the purpose of conforming to customer requirements

In hospitals, logistics cover not just support services such as purchasing, stores and the pharmacy, but also health care services such as patients and documentations. Many activities that could be carried out by support personnel are often on the list of duties performed by healthcare personnel. This reduces the performance of healthcare personnel which can trouble the healthcare process. Logistics is a complex process. The people involved vary with the type of products in question: for example, stores manage medical and office supplies; the pharmacy looks after pharmaceutical products; and food services manages the procurement and processing of food products.

Therefore, logistics work should be handled by a logistics expertise and healthcare work will be handled more efficiently by healthcare personnel.

According to the problem, we will focus with internal logistic of organization. The project will study about those problems by collecting a data from hospital, which is our case study, then created the simulation model to simulate the way of solution. The model will base on the real situation in the hospital and added some of scenarios to determine the better result from the model. However, the investment of improve the performance will be good enough or not depending future explanation of hospital.
LITERATURE REVIEW

There are several papers concerning with the problem. The followed paragraphs are summarized examples of literatures. Adams (1995) highlighted that healthcare costs are under attack by the public because healthcare information management systems are merging and consolidating. Alt (1997) clarifies that the increase in healthcare cost and inefficiencies are due to inadequate and tedious purchasing procedures and purchasing information systems, and inefficient delivery of healthcare.

The current status of IT implementation, outsourcing opportunities, inventory reductions, just-in-time applications, and restructuring are identified for the healthcare industry in Singapore.

Vasoo (2000) believes the reengineering model provides a more efficient solution with fewer staff, resulting in a cost reduction of 60 percent in Singapore hospitals. Singapore hospitals still need to have full confidence that integrating logistics concepts in their systems would result in reduced costs. The approach put the emphasis on helping hospitals to improve their logistics by better coordinating purchasing and procurement. Supply manager make decision such as when each employee should work, when should visit the care units, etc. Unfortunately, the mathematical models need further development to accomplish.

Costing of services provided by the healthcare industry has become more significant in current years. Orloff, etal (1990) said however, hospitals have become more involved in cost reduction to improve profitability. Houston (1992) suggests that cost could be reduced when activities are closely evaluated and eliminate non value-added activities. One of these non value-added activities is related to the cost of carrying inventory, which can be reduced by using the JIT inventory system. The results shows the U.S. are more developed in logistics, level of partnership with suppliers and effort in cost reduction. While the French shows higher motivation in inventory reduction than the U.S.

According to Booth (1999) most management attention has been paid to drug discovery and sales and marketing (the extreme ends of the supply chain), but now much more attention is being paid to supply chain optimization as a means of delivering value. A pharmaceutical supply chain is considered a complex process including capacity planning, risk management, plant design and improving decision making. After developed the testing model, the pharmaceutical supply chain improves customer satisfaction. By means, this can service more customers and gain more money to the business.

Tunga, etal (2008) states that electronic logistic information system is one of the approaches to reduce the operational expense in the hospital. The paper discusses the model to determine acceptance of the HIS in the medical industry. They combine TAM and IDT with additions of two new parameters, trust and perceived financial cost to purpose HTAM. The new hybrid technology acceptance model is strongly accepted by the data gathered from nurses via questionnaire.

Villa (2009) discusses the “patient flow logistics” from three cases of hospital redesign in the Italian Healthcare System. The purpose of the study is to be able to understand what can changes of patient flow logistic do with patient-centered model, and what is needed for the implementation. There are 3 important factors: spaces, wards, and hospital workload in redesigning. After the study, restructuring patient flow logistic can reduce average hospital length of stay, increase bed occupancy rate, increase in hospital case-mix complexity and reduction in turnover ratio.

Maruster and René (2005), The knowledge-management perspective is least of used for simulation of any process in business than Maruster and René will using the information of patient from hospital to apply into simulation because of different treatment of patient need. From the situation can bring to better patient care by improve the quality service of hospital staff.

PROBLEM STATEMENT

The using of healthcare staff to conduct the logistic processes in the healthcare industries leads to two problems, insufficient of region healthcare profession, and hospital cannot achieve the best performance due to low quality logistic processes. In addition, Thailand is still lack in the consideration on building logistic profession, despite the fact that it is very useful science. Some actions have to be done to solve those problems. Thus, some hospitals try to consider on logistic processes by implementing the logistic assisting technology.

However, the making decision of implementation is quite difficult. The different size of hospitals will have different amount of patients and, therefore, different in the benefit that can be obtained from technology implementation.
Moreover, the cost of investment is high so hospitals are more aware whether the implementation will worth the money or not.

The project will study the logistic processes for its importance, and try to estimate the benefit of implementing logistic technology, and to state that those technologies will worth the investment or not based on hospital size. However, it is impossible to do the estimation for all hospitals. In this case, three hospital samples will be chosen according to their sizes. In addition, it is difficult to study all the logistic chains in the hospital. Therefore, a specific chain will be studied. Note that, the chain will be studied within hospital processes only (start and finish in the hospital).

**METHODOLOGY**

*Definition and notation used*

**Definition**
- IPD = Inpatient Department
- OPD = Outpatient Department
- Gold Card = the right that government give Thai citizens to be cured by hospital without paying

**Notation for the appendix section**
- D = Diagnosis Department
- R = Registration Department
- O = Others
- P = Pharmaceutical Department

*Source of information*

DoctorPanya Hospital is chosen as a case study for the project by two main reasons.
1. The hospital main goal is to serve gold card patient, which will benefit to the quality of life of everyone, rather than focusing on rich people.
2. The hospital is in private sector, which is willing to invest in order to improve its performance but lag of information to make decision.

*Current process of the hospital*

**TABLE 1**

<table>
<thead>
<tr>
<th>Division</th>
<th>Description and Responsibility</th>
<th>Staffs</th>
</tr>
</thead>
</table>
| Registration | Check patient’s gold card right (R1)  
                 Register patient (R2)  
                 BP, Weight, Height Measurement (R3) | 1 Right checking staff  
                                          5 Registration staff  
                                          2 Nurses                  |
| Diagnosis  | Diagnosis patient (D1)  
                 Correct Prescription if error occurs (D2) | 4 Doctors                |
| Pharmaceutical | Fill in drug information to software (P1)  
                         Prepare drug (P2)  
                         Check prepared drug (P3)  
                         Drug conciliation (P4) | 2 Pharmaceutical staff  
                                              2 Pharmaceutical technician  
                                              2 Pharmacist              |
**Improved process of the hospital**

<table>
<thead>
<tr>
<th>Support</th>
<th>Document transfer (O1-O4)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Do Laboratory (O5)</td>
</tr>
<tr>
<td></td>
<td>IPD (O6)</td>
</tr>
<tr>
<td></td>
<td>2 transfer staff</td>
</tr>
<tr>
<td></td>
<td>3 Laboratory staff</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>TABLE 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>IMPROVED PROCESS OF THE HOSPITAL</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Division</th>
<th>Description and Responsibility</th>
<th>Staffs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Registration</td>
<td>Check patient’s gold card right (R1)</td>
<td>1 Right checking staff</td>
</tr>
<tr>
<td>Registration</td>
<td>Register patient (R2)</td>
<td>5 Registration staff</td>
</tr>
<tr>
<td>Registration</td>
<td>BP, Weight, Height Measurement (R3)</td>
<td>2 Nurses</td>
</tr>
<tr>
<td>Diagnosis</td>
<td>Diagnosis patient and fill in drug information to software (D1*)</td>
<td>4 Doctors</td>
</tr>
<tr>
<td>Diagnosis</td>
<td>Correct Prescription if error occurs (D2)</td>
<td></td>
</tr>
<tr>
<td>Pharmaceutical</td>
<td>Prepare drug (P2)</td>
<td>2 Pharmaceutical technician</td>
</tr>
<tr>
<td>Pharmaceutical</td>
<td>Check prepared drug (P3)</td>
<td>2 Pharmacist</td>
</tr>
<tr>
<td>Pharmaceutical</td>
<td>Drug conciliation (P4)</td>
<td></td>
</tr>
<tr>
<td>Support</td>
<td>Do Laboratory (O5)</td>
<td>3 Laboratory staff</td>
</tr>
<tr>
<td>Support</td>
<td>IPD (O6)</td>
<td></td>
</tr>
</tbody>
</table>

**Simulation model explanation**

The simulation model is created with Arena Simulation software version 12.00, by Rockwell Automation Technologies, Inc. There are 2 models, current process model (CP1) and improved process model (IP1). CP1 represents the current situation of the hospital. IP1 represents the expected situation of the hospital after the process is improved by implementation of computers and software.

**Validation method, Number of replication determination, and Comparison method**

To compare the result between current model and improved model, the output of both models flow times are compared by Arena’s output analyzer with T-test mean comparison command with 95 percent confident interval. If the interval contains 0, it fails to reject hypothesis. That means the means are not different.

**Scenario of models**

To be able to compare the current process and improved process, ten scenarios are introduced in order to compare each situation.

<table>
<thead>
<tr>
<th>TABLE 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>MODEL SCENARIOS</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Type of model</th>
<th>Arrival rate</th>
<th>Resource and distance</th>
</tr>
</thead>
<tbody>
<tr>
<td>CP1</td>
<td>Current process</td>
<td>0.019</td>
<td>Same current process</td>
</tr>
<tr>
<td>CP1A</td>
<td>Current process</td>
<td>0.017</td>
<td>Same current process</td>
</tr>
<tr>
<td>CP1B</td>
<td>Current process</td>
<td>0.015</td>
<td>Same current process</td>
</tr>
<tr>
<td>IP1</td>
<td>Improved process</td>
<td>0.019</td>
<td>Same current process</td>
</tr>
<tr>
<td>IP1A</td>
<td>Improved process</td>
<td>0.017</td>
<td>Same current process</td>
</tr>
<tr>
<td>IP1B</td>
<td>Improved process</td>
<td>0.015</td>
<td>Same current process</td>
</tr>
<tr>
<td>IP2</td>
<td>Improved process</td>
<td>0.038</td>
<td>Multiply by 2</td>
</tr>
<tr>
<td>IP3</td>
<td>Improved process</td>
<td>0.057</td>
<td>Multiply by 3</td>
</tr>
<tr>
<td>CP2</td>
<td>Current process</td>
<td>0.038</td>
<td>Multiply by 2</td>
</tr>
<tr>
<td>CP3</td>
<td>Current process</td>
<td>0.057</td>
<td>Multiply by 3</td>
</tr>
</tbody>
</table>
CP1 and IP1 are the base models, to represent the current situation and improved situation of the hospital. CP1A, CP1B, IP1A, and IP1B are scenarios that the model is increased arrival rate but the resources and distance parameters are fixed. CP2 and CP3 are the models that are magnified arrival rates, resources and distances by 2 and 3 respectively. We introduce CP2 and CP3 by the assumption that the increase in demand of the patient will be proportional to the size of the hospital, which means distance between departments, will be higher, and also there will be more staffs to serve patients.

RESULT AND DISCUSSION

Number of replication and validation of the model

The model is terminating system with 48 replications. The mean flow time of CP1 model is 0.9631 hour, compare to the data provided by DoctorPanya hospital is 1.047 hour. There is 5 percent error, which is acceptable. Thus, the model is valid with the real situation.

Mean flow time of patient comparison (CP1 and IP1)

Mean flow time of patient in hospital is used to represent the performance of the hospital because patients always want to spend time in hospital as less as possible. After simulation, the average flow time of the hospital is increased from 0.9631 hour (CP1) to 0.9904 hour (IP1). From two-sample T test comparison by Arena’s output analyzer, means flow time of these two are not equal in statistical test. In other word, implementation of computers and software reduce the performance of the hospital.

Mean flow time of patient comparison (CP1, CP1A, CP1B and IP1, IP1A, IP1B)

From the comparison, difference in mean flow time of patient of CP and IP increases as the arrival rate of the patient increases. That is, if the resources of the hospital is fixed, CP will always better than IP.

<table>
<thead>
<tr>
<th>Patient mean flow time (hour)</th>
<th>-</th>
<th>A</th>
<th>B</th>
</tr>
</thead>
<tbody>
<tr>
<td>CP1</td>
<td>0.9631</td>
<td>2.0585</td>
<td>2.741</td>
</tr>
<tr>
<td>IP1</td>
<td>0.9904</td>
<td>2.3321</td>
<td>3.264</td>
</tr>
</tbody>
</table>

As we know, IP will benefit the system when, the distance between divisions in hospital is significant large. That is, the data fill in time will be less than transportation time of the document. In this case, the result can be described that, for this hospital, the distances between departments are small, so IP has higher mean flow time than CP.

Utilization rate of staffs’ comparison (CP1, IP1, CP1A, IP1A, CP1B, IP1B)

From the utilization comparison, IP1 registration staffs utilization increases from 0.535 to 0.650, and doctor utilization increase from 0.341 to 0.60. In addition, pharmaceutical technician and pharmacist utilization rate reduce from 0.634 to 0.631 and 0.682 to 0.671 respectively. Other staffs have only minor change in their utilization rate.
### TABLE 5
**UTILIZATION OF STAFF COMPARISON OF CP1, IP1, CP1A, IP1A, CP1B, IP1B**

<table>
<thead>
<tr>
<th></th>
<th>CP1</th>
<th>IP1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Right checking staff</td>
<td>0.133</td>
<td>0.135</td>
</tr>
<tr>
<td>Registration staff</td>
<td>0.535</td>
<td>0.650</td>
</tr>
<tr>
<td>Doctor1</td>
<td>0.343</td>
<td>0.597</td>
</tr>
<tr>
<td>Doctor2</td>
<td>0.340</td>
<td>0.601</td>
</tr>
<tr>
<td>Doctor3</td>
<td>0.339</td>
<td>0.601</td>
</tr>
<tr>
<td>Doctor4</td>
<td>0.342</td>
<td>0.603</td>
</tr>
<tr>
<td>Nurse</td>
<td>0.055</td>
<td>0.566</td>
</tr>
<tr>
<td>Pharmaceutical staff</td>
<td>0.524</td>
<td>-</td>
</tr>
<tr>
<td>Pharmaceutical technician</td>
<td>0.643</td>
<td>0.631</td>
</tr>
<tr>
<td>Pharmacist</td>
<td>0.682</td>
<td>0.671</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>CP1A</th>
<th>IP1A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Right checking staff</td>
<td>0.167</td>
<td>0.145</td>
</tr>
<tr>
<td>Registration staff</td>
<td>0.650</td>
<td>0.763</td>
</tr>
<tr>
<td>Doctor1</td>
<td>0.406</td>
<td>0.619</td>
</tr>
<tr>
<td>Doctor2</td>
<td>0.404</td>
<td>0.622</td>
</tr>
<tr>
<td>Doctor3</td>
<td>0.404</td>
<td>0.623</td>
</tr>
<tr>
<td>Doctor4</td>
<td>0.405</td>
<td>0.627</td>
</tr>
<tr>
<td>Nurse</td>
<td>0.069</td>
<td>0.060</td>
</tr>
<tr>
<td>Pharmaceutical staff</td>
<td>0.655</td>
<td>-</td>
</tr>
<tr>
<td>Pharmaceutical technician</td>
<td>0.804</td>
<td>0.674</td>
</tr>
<tr>
<td>Pharmacist</td>
<td>0.854</td>
<td>0.717</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>CP1B</th>
<th>IP1B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Right checking staff</td>
<td>0.175</td>
<td>0.147</td>
</tr>
<tr>
<td>Registration staff</td>
<td>0.702</td>
<td>0.776</td>
</tr>
<tr>
<td>Doctor1</td>
<td>0.417</td>
<td>0.625</td>
</tr>
<tr>
<td>Doctor2</td>
<td>0.416</td>
<td>0.626</td>
</tr>
<tr>
<td>Doctor3</td>
<td>0.418</td>
<td>0.623</td>
</tr>
<tr>
<td>Doctor4</td>
<td>0.417</td>
<td>0.628</td>
</tr>
<tr>
<td>Nurse</td>
<td>0.073</td>
<td>0.064</td>
</tr>
<tr>
<td>Pharmaceutical staff</td>
<td>0.687</td>
<td>-</td>
</tr>
<tr>
<td>Pharmaceutical technician</td>
<td>0.846</td>
<td>0.686</td>
</tr>
<tr>
<td>Pharmacist</td>
<td>0.896</td>
<td>0.730</td>
</tr>
</tbody>
</table>

The implementation of computers and software system will eliminate the use of pharmaceutical staffs, and transfer staffs. However, the work that those staffs must do is shift to another type of staffs. As we can see, the registration staffs increase their utilization rate since they have to fill in data to the software to transfer between departments, instead of let transfer staffs to carry documents. The doctors have to fill in drug data into the software, instead of let transfer staffs to fill in.

**Patient waiting time comparison (CP1, IP1, CP1A, IP1A, CP1B, IP1B)**

Table 6 shows waiting times of documents in different divisions. From the comparison between CP and IP, waiting time of registration document and prescription document of CP are lower. In contrast, waiting time of laboratory document of CP is higher than IP.
TABLE 6
PATIENT WAITING TIME COMPARISON OF CP1, IP1, CP1A, IP1A, CP1B, and IP1B (hour)

<table>
<thead>
<tr>
<th>Waiting time</th>
<th>Registration document</th>
<th>Prescription document</th>
<th>Laboratory document</th>
</tr>
</thead>
<tbody>
<tr>
<td>CP1</td>
<td>0.5634</td>
<td>0.0351</td>
<td>0.0400</td>
</tr>
<tr>
<td>IP1</td>
<td>0.8878</td>
<td>0.0677</td>
<td>-0.0018</td>
</tr>
<tr>
<td>CP1A</td>
<td>0.7119</td>
<td>0.0361</td>
<td>0.0420</td>
</tr>
<tr>
<td>IP1A</td>
<td>1.4811</td>
<td>0.0664</td>
<td>-0.0018</td>
</tr>
<tr>
<td>CP1B</td>
<td>1.1229</td>
<td>0.0366</td>
<td>0.1400</td>
</tr>
<tr>
<td>IP1B</td>
<td>2.4048</td>
<td>0.0640</td>
<td>-0.0018</td>
</tr>
</tbody>
</table>

We can say that, the distance between registration division and diagnosis division, and diagnosis division and pharmaceutical division are small. Therefore, the software data fill in time is more than transfer staff document transfer time. In contrast, the distance between diagnosis division and laboratory division is large, so the waiting time is negative, which means documents reach the division before patient.

Mean flow time of patient comparison (CP1, CP2, CP3 and IP1, IP2, IP3)

The comparison of models bases on assumption that hospital will try to increase their supply in order to meet the demand. From the result, CP1 has higher performance than IP1, CP2 has higher performance than IP2, and CP3 has lower performance than IP3.

TABLE 7
MEAN FLOW TIME OF PATIENT COMPARISON (CP1, CP2, CP3 and IP1, IP2, IP3)

<table>
<thead>
<tr>
<th>Patient mean flow time (hour)</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>CP</td>
<td>0.9631</td>
<td>1.5635</td>
<td>2.3339</td>
</tr>
<tr>
<td>IP</td>
<td>0.9904</td>
<td>1.6355</td>
<td>1.6358</td>
</tr>
</tbody>
</table>

Computers and software implementation will benefit the hospital if the size of hospital is significant large that is when the size of the hospital is more than 2 times of the current size.

Investment Analysis

The total investment for software and equipment for the new method is at 700,000 baht whereas the salary of the transfer staff and assistant pharmacist are at 7000 baht and 6500 baht respectively. Thus, the break even of the project that can reduce the transfer staffs by 2 and assistant pharmacist by 2 is at 700,000/(6500*2+7000*2)=25.9 months, which is about 2 years and 2 months.

CONCLUSION

From the model, shifting from current method to software implemented method increase the flow time of the patient, which reduces the performance of the hospital because that software can help in reducing transportation when the distance between department is significant large. Therefore, there is no point in investing in this project despite the fact that the break even of the project is at 2 years and 2 months.

However, if the project is considered as long time investment, from the magnification analysis, the software implemented method will have the same performance with current system with lesser resource when the arrival rate is 2 times more, and will outperform the current model when the patient arrival rate is 2.2 times more. The project is worth investment if the hospital is considering on expanding the hospital.

The assumption of magnification analysis is just an approximate method representing expansion of the hospital. However, if the hospital really considers on expanding, the data of travelling distance layout and expected demand of the patient is available; hence, the simulation will be more accurate for decision making.
ACKNOWLEDGEMENTS

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LOGISTICS MANAGEMENT IN INDIAN AUTOMOTIVE COMPONENT INDUSTRY

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LOGISTICS MANAGEMENT IN INDIAN AUTOMOTIVE COMPONENT INDUSTRY

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ABSTRACT

Many of the leading firms in the Indian automotive component industry have an efficient logistics management system. Having an efficient logistics management system is no longer a choice but a necessarily for these firms considering the global opportunities that have opened for this industry. The Indian automotive component industry has shown tremendous growth over the last decade. Today it has 480 companies, employees more than 250,000 people and has an estimated turnover of approximately Rs 45,000 crore (US$ 10 billion). On export front also, the industry has grown by leaps and bounds, generating an overseas sales of to Rs. 8,190 Crores (US$ 1.8 billion) in 2005-06, which is nearly three times of what it exported in 2001-02 (US$ 578 million)1.

KEYWORDS
Logistics, Employees, Automotive, Management, Employees

INTRODUCTION

The Indian automotive component industry has shown tremendous growth over the last decade. Today it has 480 companies, employees more than 250,000 people and has an estimated turnover of approximately Rs 45,000 crore (US$ 10 billion). On export front also, the industry has grown by leaps and bounds, generating an overseas sales of to Rs. 8,190 Crores (US$ 1.8 billion) in 2005-06, which is nearly three times of what it exported in 2001-02 (US$ 578 million)1. The tremendous growth in the automotive component sector over the last few years is shown in table 1:

<table>
<thead>
<tr>
<th>FY2004</th>
<th>Production</th>
<th>Y-O-Y change</th>
<th>Exports</th>
<th>Y-O-Y change</th>
</tr>
</thead>
<tbody>
<tr>
<td>FY2005</td>
<td>120317</td>
<td>14935</td>
<td></td>
<td></td>
</tr>
<tr>
<td>FY2006</td>
<td>129967</td>
<td>126585</td>
<td></td>
<td></td>
</tr>
<tr>
<td>FY2007</td>
<td>163559</td>
<td>25.8</td>
<td>18330</td>
<td>16.9</td>
</tr>
<tr>
<td>FY2008</td>
<td>178569</td>
<td>9.2</td>
<td>27065</td>
<td>47.7</td>
</tr>
<tr>
<td>FY2009</td>
<td>216021</td>
<td>21.0</td>
<td>28019</td>
<td>3.5</td>
</tr>
<tr>
<td>FY2010</td>
<td>255354</td>
<td>18.2</td>
<td>34965</td>
<td>24.8</td>
</tr>
<tr>
<td>FY 2010</td>
<td>306400</td>
<td>20.0</td>
<td>45000</td>
<td>28.7</td>
</tr>
</tbody>
</table>

Compiled by INGRES
Source: http://www.fadaweb.com/iacl.htm

The automotive industry manufactured components fall under six broad product categories according to Automotive Component Manufactures association (ACMA). These are given in table 2.
TABLE 2
CLASSIFICATION OF AUTOMOTIVE COMPONENTS ACCORDING TO ACMA

<table>
<thead>
<tr>
<th>Product Group</th>
<th>Products</th>
<th>Share* (%)</th>
<th>Some of the Key Players</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electrical Parts</td>
<td>Starter Motors and Generators</td>
<td>7</td>
<td>Motor Industries Company, Denso, India Nippon Electrical</td>
</tr>
<tr>
<td>Drive Transmission and Steering Parts</td>
<td>Gears, Clutches, Axles</td>
<td>14</td>
<td>Rico Auto Industries, Sona Koyo Steering Systems, Automotive Axles, GKN Driveshafts, Bharat Gears, Rane (Madras), Clutch Auto, CeeKay Daikin</td>
</tr>
<tr>
<td>Suspension and Braking Parts</td>
<td>Brakes, Leaf Springs, Shock Absorbers</td>
<td>11</td>
<td>Brakes India, Sundaram-Clayton, Munjal Showa, Gabriel India, Rane Brake Linings, Sundaram Brake Linings, Jamna Auto</td>
</tr>
<tr>
<td>Equipment</td>
<td>Headlights, Dashboard Instruments</td>
<td>8</td>
<td>Premier Instruments &amp; Controls, Lumax, Motherson Sumi Systems</td>
</tr>
<tr>
<td>Others</td>
<td>Sheet Metal Parts, Pressure Die Castings, Tyre Tube Valves and Cores</td>
<td>36</td>
<td>Jay Bharat Maruti</td>
</tr>
</tbody>
</table>

Source: ACMA
Segemental market shares of the organized sector in FY2003 in rupee terms
Compiled by INGRES

THE HISTORY OF THE INDIAN AUTOMOTIVE COMPONENT INDUSTRY

The Indian Auto Component Industry had its small beginnings in the 1940s. If the evolution of this industry is traced in India, it can be classified into three distinct phases namely:
1. Period prior to the entry of Maruti Udyog Ltd (1940s to 1984).

The period prior to the entry of Maruti Udyog Ltd was characterized by low technology and assured business for most of the auto-component manufacturers who used to supply to a handful of players in the Indian automobile market like Hindustan Motors, Premier Automobiles, Telco, Bajaj, Mahindra & Mahindra etc.

With the entry of Maruti in the 1980s, the auto ancillary industry in the country showed a spurt in growth. This period witnessed the emergence of a new generation of auto ancillary manufacturers who were required to meet the stringent quality standards of Maruti's collaborator Suzuki of Japan. The good performance of Maruti resulted in an upswing for the domestic auto ancillary industry. It was also during this period that auto components from India began to be exported.

With the liberalization of the Indian economy in 1991 and coming of many foreign automobile manufacturers like Hyundai, Daewoo etc., the auto ancillary industry witnessed huge capacity expansions and modernization initiatives in this period. This also led to a tough competitive scenario, which saw a lot of consolidation, technological collaborations and equity partnerships within the industry and with leading global players abroad.

Today, many international and local automotive players are increasingly sourcing components from Indian automotive component manufacturers. As the demand for manufactured automotive components with the tag "made in India" increases, the automotive companies have to further enhance the quality of their products and operations as global players require quality components at reasonable prices and at precise time durations. This has made the automotive component manufacturers in India to be under severe pressure to meet such onerous demands. Hence, to meet such demands, today all the major players in this industry are having one or the other logistics management system.
UNDERSTANDING LOGISTICS MANAGEMENT

Logistics is the organized movement of materials and, sometimes, people. The term was first associated with the military but gradually spread to cover business activities. Logistics Management is defined as a business planning framework for the management of material, service, information and capital flows. It includes the increasingly complex information, communication and control systems required in today's business environment. Logistics management includes a whole gamut of processes like planning, procurement, transportation, maintenance, distribution and replacement of personnel and material.

The process of logistics management differs from one firm to another. In some firms, all these activities are placed within a single logistics department; in others, they are shared among the departments. The firm may also go in for what is called third-party logistics, which is a contract with an outside party to perform specific logistics services.

The following indicative list gives some of the functions that a firm's logistics management system is supposed to perform

1. **Customer Service**: All the activities that are done to keep the existing customers satisfied come under the gamut of customer service.

2. **Demand Forecasting**: This process includes various statistical measures that enable the firm to estimate the demand in the future, which in turn helps in proper demand management.

3. **Documentation Flow**: This process covers the movement of the paperwork that accompanies the movement of physical product.

4. **Interplant Movements**: This is only applicable to those firms where production process is accomplished in more than one plant, requiring the movement of semi-finished products from one plant to another.

5. **Inventory Management**: Inventory management requires a cost effective maintenance of stocks of goods and materials.

6. **Order Processing**: Order processing starts with the receipt of an order from a customer and ends when the order is ready for packaging.

7. **Packaging**: Packaging is done mainly to protect the product when it is being transported from the source to the destination. It can also be used for promotional purposes.

8. **Parts and Service Support**: This covers the whole after-sales service process.

9. **Plant and Warehouse Site Selection**: This function is carried to determine where the plant and the warehouse are going to be located, keeping cost-benefit analysis in mind.

10. **Production Scheduling**: This function's task is to balance demand for products with the existing plant capacity and availability of inputs.

11. **Purchasing**: This is a very important function in the logistics management as the quality of inputs that are purchased determines the quality of the finished product. Vendor selection is an important sub-process of this function.

12. **Returned Products**: There are many categories of returned products. A few are subjects of product recalls, meaning that a safety defect or hazard has been discovered. E.g. laptop battery recall by Dell. These products are removed from the shelves, and both retailers and consumers attempt to return them to the manufacturer. This is a form of reverse distribution, with goods moving in the opposite direction of their usual flow.

13. **Salvage Scrap Disposal**: How a firm takes care of its waste material is covered in this function. The firm might recycle its waste or sell the waste to various processors who specialize in recycling it.

14. **Traffic Management**: All the transport requirements needed to move a firm's freight is known as traffic management.
15. Warehouse and Distribution Centre Management: This logistics activity involves management of the locations where the firm's inventories are stored.

LOGISTICS MANAGEMENT PRACTICES IN LEADING INDIAN AUTOMOTIVE COMPONENT MANUFACTURERS

* Sundaram Clayton Limited (SCL): Sundaram Clayton uses comprehensive TQM (Total Quality Management) practices that enable it in being a competitive world-class manufacturer in terms of quality, cost and timely delivery of products. SCL uses cellular manufacturing, which gives it the flexibility to respond in tune to customer needs. It does comprehensive integration of the supply chain through implementation of ERP (Enterprise-Wide Resource Planning) programme.

* Bharat Forge Limited (BFL): Bharat Forge has been effectively leveraging information technology as an important tool for reducing costs in the field of logistics management. In 2000-01, the company implemented SAP enterprise resource planning package. Bharat Forge is moving at full speed to build e-commerce applications with SAP as a backbone for BFL legacy systems and other collaborative softwares like SCM (Supply Chain Management), PLM (Product Lifecycle Management), etc.

At Bharat Forge, SAP also provides in-built capabilities like CRP (Capacity Resource Planning), BPR (Business Process Re-engineering) and thus offers a powerful link between the entire value chain extending from the customers to the suppliers.

The company has also set up an integrated supply chain management system, which enables real-time visibility of material requirement and inventory throughout the value chain, and provides decision support at all stages of operations. It also assists the company in awarding contracts to vendors on current and competitive terms and ensures better execution of contracts. Majority of the company's suppliers have been logged into its supply chain and with Bharat Forge e-enabled with its customers, the company has a real time total demand management system in place.

A virtual private marketplace has been created for Bharat Forge through which the company engages in e-procurement and reverse auctions. The company has already started selling scrap online.

* Exide Industries Limited: Exide has eight manufacturing plants producing world class products. Exide factories are located strategically around the country to provide logistic support for its production of over five million batteries per annum. Exide's R&D is engaged in projects embracing process technology aimed at improving the product quality & consistency, production efficiency and material utilization. Exide employees Total Quality Management programme in its office and factories to set higher standards for itself at every step of its "customer-service route". "Zero-error" benchmarking, and delivering quality orientation throughout operations has led Exide to get the coveted DIN ISO 9001 certification by RWTUV of Germany.

* Sundaram Fasteners Ltd. (SFL): SFL makes just-in-time (JIT) supplies for various Original equipment manufacturers (OEMs) throughout the country. It has an effective Inventory Management system. Currently, in order to enhance its logistics management; and with the aim of achieving high quality and low cost in its operations, it is using Total Productive Maintenance program (TPM), which was initiated in 1995 in consultation with JIPM (Japan Institute of Plant Maintenance).

* Shriram Automotive Products Ltd: This Company has tried to improve its logistics management by establishing, implementing and maintaining a quality system in accordance with the requirements of ISO 9002. It tries to adhere to customer delivery schedules through adequate planning and monitoring and tries to bring down non-conformities by strictly monitoring the effectiveness of corrective and preventive measures.

* India Pistons Ltd (IPL): India Pistons Limited strives to maintain a comprehensive system of professional logistics management designed to identify possible defects right from the initial phases of development, hence, preventing problems that could potentially cost the organization dear. In all IPL locations, systems & procedures based on TPM, TQM and Lean Manufacturing are used to ensure that Quality levels are on par with the best in the world. All its plants are QS 9000 certified.

* Premier Instruments & Controls Limited (Pricol): As a part of its logistics management policy, Pricol gives lot of emphasis on procurement quality through systematic vendor development, quality plan, vendor upgradation through Vendor Center of Excellence, process capability, vendor quality audit, inspection and training.

* **Sona Koyo:** Sona Koyo is moving on the path of Total Quality Management (TQM) by developing its core competence and aligning objectives at all levels to realize synergy in its operations. It has adopted Total Productive Maintenance (TPM) to improve performance through the philosophy of prevention of accidents. All these measures help it to have a robust logistics management system.

* **Munjal Showa:** Munjal Showa is a TS-16949 & ISO 14001 company which aims at providing highest customer satisfaction, cost competitiveness, continuous improvement, on-time delivery of products and direct on-line system by having an enviable logistics management system.

Besides the firms that have been mentioned above, other major automotive component manufacturers like Rico Auto, Sumi Motherson, Cluth Auto etc. too realize the importance of stringent inventory management and delivery requirement and hence have their own state of the art logistics management systems in place.

**SUGGESTIONS FOR FURTHER IMPROVEMENT IN THE LOGISTICS MANAGEMENT SYSTEMS IN THE INDIAN AUTOMOTIVE COMPONENT INDUSTRY**

The Indian Automotive Component Industry can further improve its competitiveness, but the Association of Indian Automotive Component Manufacturers and the Indian government have to work hand in hand to address some of the problems that are being faced by this industry – like inefficient infrastructure in terms of ports, roads, etc; unutilized capital equipment available in the industry, government led bureaucratic hurdles and many more such speed breakers that can curtail the speed of growth that this industry is witnessing today.

Some of the steps that can further improve the logistics management system being used by various firms in the Indian Automotive Component Industry are:
* Improving productivity of suppliers by technology transfer and funding.
* Further reducing inventory buffers and supply chain bottlenecks.
* Using latest technological initiatives to enhance the existing quality levels and streamlining the processes further.
* Using softwares like Supply Chain Event Management or SCEM that monitor forecasts, orders, manufacturing schedules, inventories, and shipments etc.

**CONCLUSION**

The more competitive the Indian automotive component industry becomes in the global arena, the more inseparable will the principals of logistics management become to its success and future growth. Though many of the leading automotive component manufacturers in India are having some sort of logistics management system in place, there are still a number of problems that the automotive component industry is facing on the logistics management front. In order to make a bigger mark in the global arena of automotive components, these problems have to be addressed and solutions implemented at the earliest.
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SUPPLY CHAIN COLLABORATION AND INNOVATION OF AUTOMOTIVE AND ELECTRONICS INDUSTRY IN DEVELOPING COUNTRIES: THE CASE OF THAILAND

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ABSTRACT

The main objective of this study is to investigate the factors influencing the innovation in the automotive and electronics manufacturing sector established in Thailand specifically within greater Bangkok area. The factors considering includes a firm’s characteristics: size, type of capital structure, amount of assets, technology transfer, technical assistants, human resources, an establishment’s relationship with external organizations. Both automotive and electronics industries are now one of the most important industrial sectors of the country due to the high volume of exported products during 2001-2010. In this study, it is important to understand the relationship between the innovation capabilities and supply chain collaboration in both industries. Case studies were selected for the in-depth interviews which include assembler, tier 1, and tier 2 suppliers and its capital good supplier. The selected firms are local-owned company and branch office in order to understand how the different architectures of global value chains shaped the innovation progress of subsidiaries in the country. For each firm, case material was gathered on each of the nine dimension of technology, including numbers of R&D, engineering and technician staff, types of equipment used, the main focus of production activities, relationships with parent firm, tools and frameworks for analyzing technology, links with local institutions and suppliers, the decision-making process with respect to technology, future strategies and areas of technical strength and weakness.

KEYWORDS
Supply Chain Collaboration, Innovation, Automotive Industry, Electronic Industry

INTRODUCION

Automotive and electronics has been expanding within the industrial sector of Thailand. Especially the automotive industrial since there was a shortage of parts after the natural disaster in Japan. In 2011, the industry sector contributes up to 45.6% GDP comparing to agriculture and service sector (Central Intelligence Agency, 2011). Automotive and electronics industries have played an important role in Thailand, in terms of exporting. For the past five years, electronics industry has the highest export value from Thailand, and the second is automotive industry (Department of export promotion, 2010).

The innovation is important to the organization for making value created to retain the market share and increase profitability (Tidd et al., 2010). Therefore, firms recognize to innovate and develop the products and processes to compete in the market. Moreover, the innovation in product and process improve the quality, flexibility, efficiency, and cost reduction which enhance to the firm performance (Gunday et al.,2011; Wanga et al.,2009). The innovation can be enhanced by collaborations with various partners, including customers, suppliers and R&D organizations (Von, 1986). Thus the companies rethink about the ways they do business and move forward for building more collaboration with others.
SUPPLY CHAIN COLLABORATION AND INNOVATION

Supply chain collaboration

The collaboration is the recent trend in supply chain management (SCM). The supply chain composes of all party involved from the upstream through downstream. The supply chain collaboration is the network activity along the business partners in the chain. The collaboration allows members to jointly gain a better understanding of future demand and planning. Soosay et al. (2008) proposed that collaboration can be best described as an inter-organizational relationship type in which the participating parties agree to invest resources, mutually achieve goals, share information, resources, rewards and responsibilities as well as jointly make decisions and solve problems. Sahay (2003) studies on a framework for customer-supplier collaboration that facilitates effective and efficient supply chain operation. It shows that the supply chain collaboration is a driver force of effective supply chain management (SCM). Simatupang et al. (2005) studies on the collaboration index that affects to the supply chain collaboration activities. The researchers suggest that members in the supply chain attempt to build collaborative to seek opportunities to improve overall performance of their firms. There are many activities focused on the supply chain collaboration which are information sharing, decision synchronization, resource sharing, incentive alignment, and joint investing (Sahay, 2003; Simatupang et al., 2005; Soosay et al., 2008).

Innovation

The innovation is one of the key success drivers for the organization. It is how the firm can mobilize knowledge, technological skills, and experience to create novelty on its product/service. The enterprise that has the innovation is more successful than non-innovative firm. It is the ability that firm understands the opportunities of innovation and creates new ways to exploit them (Tidd et al., 2010). According to the environmental changing, the new product development helps firms to retain the market share and increase profitability (Baden-Fuller, 1996).

Joseph Schumpeter (1950) states that the technological innovation; new product, new service, or new process; help an entrepreneur to get the strategic advantage to its company. Innovation is strongly related to the introduction of new products, processes, or ideas in the organization (Koc et al., 2007). It comes from the combination between knowledge and creation to introduce products or services in the market which make profit with minimum cost (Szeto, 2000). The innovation can be considered as a complex phenomenon including technical; for example, new products and new methods; and non-technical aspects; for example, new markets and new forms of organization (Armbruster et al., 2008). The degrees of novelty can classify by incremental or radical innovation. The incremental innovation is how to improve quality and productivity through sustain incremental change. The radical innovation means how to create something new or a whole new design which involve in a high level of novelty (Tidd et al., 2010).

Rush, Bessant, and Hobday (2007) used nine key dimension of the management technology to describes the development of a technology assessment. The technological capabilities assessment tool was used to identify the strength and weakness of firm. Moreover, it can provide appropriate policies and organizational development strategies. The nine key dimensions of technological capabilities include the ability to awareness of technology in competitiveness, the search ability to monitor external technology and trends, the building of distinctive core competence, the development of a technology strategy to support the business, the ability to assess/select the suitable technological, the technology acquisition, the ability to implement and effective use of the technologies, the ability to learn and knowledge from the experience, and the ability to form and exploit linkage with member networks (Hobday et al., 2003; Rush et al., 2007; Cetindamar et al., 2009).

CASE STUDIES

There are 4 firms selected for interview in this case study in order to investigate on the different innovation factors and supply chain collaboration activities. The firm characteristics are summarize and shown in the Table 1 below.
<table>
<thead>
<tr>
<th></th>
<th>Company A</th>
<th>Company B</th>
<th>Company C</th>
<th>Company D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type of industry</td>
<td>Electronics</td>
<td>Electronics</td>
<td>Automotive</td>
<td>Automotive</td>
</tr>
<tr>
<td>Firm characteristics</td>
<td>1st Tier supplier, Thai-owned company</td>
<td>1st and 2nd Tier, MNC</td>
<td>Thai-owned, Assemble and 1st Tier company</td>
<td>1st Tier supplier, Thai-owned company</td>
</tr>
<tr>
<td>Year of established</td>
<td>1995</td>
<td>1951</td>
<td>1967</td>
<td>1977</td>
</tr>
<tr>
<td>Number of employee</td>
<td>2,200</td>
<td>2,000 (10 in Thailand)</td>
<td>900</td>
<td>4,222</td>
</tr>
<tr>
<td>From of innovation</td>
<td>Product, process</td>
<td>Product, process</td>
<td>Product, process</td>
<td>Product, process</td>
</tr>
<tr>
<td>Type of innovation</td>
<td>Radical, incremental</td>
<td>Radical, incremental</td>
<td>Radical, incremental</td>
<td>Incremental</td>
</tr>
</tbody>
</table>

**Company A**

Company A is a Thai-owned company, which produces Microelectronics Module Assembly (MMA) and Integrated Circuit packaging (IC). The IC package is also used in the automotive industry to measure the pressure of tires and part of the airbag system. The company itself has other branches located in USA, Germany, Taiwan, and Japan. The company was located in the Free Zone in Bang Pa-in, Ayutthaya, Thailand.

This firm has collaboration activities with suppliers and customers. Company A shares information among the chain such as forecasting with its suppliers to produce and prepare the parts on time. There are some joint developments with customers for example, co-design of new products. Company A has strategic partners with major hard disk manufacturers in the Free Zone area which benefit the firm to trade without tax and benefits for cooperating. The company A has incentive alignment with suppliers and customers in order to reduce the risk and cost of investment such as buying new capital goods or machines. Company A employee transferred know-how from the equipment maker. Moreover, there is some collaboration with research institutes for the quality of product testing.

Company A won the Best Innovation Award in 2003 in Thailand with the machine separating the rice grains for the rice mill. It was the innovation from the company owner who also has the rice mill and the R&D team developed a new machine based on the existing technology. In general, the factor that drives the innovation is the market trend. It forces the company to develop the product and better process to achieve the better performance and cost reduction. The firm has in-house R&D to study the market trends and develop products to satisfy the customer need. Engineering team was sent to overseas conferences to study new materials, technology, and equipment. Moreover, customers also play an important role in challenging the firm to improve the product and reduce the cost.

Figure 1 displays the overall technological capability assessment which is the strengths and weaknesses in technological capability in company A. It shows that the firm has high awareness, acquiring technology, and learning which drive the innovation for competitive advantage in the company.

**FIGURE 1**

THE TECHNOLOGICAL CAPABILITY OF COMPANY A
**Company B**

The company B was established in Israel and has a manufactory in USA. It expanded its manufacture to Singapore in 2000. It is a global leader in the design and manufacture of semiconductor assembles equipment. This firm is one of the major suppliers of the capital goods for many manufacturers in Thailand which is 67% of the market share in 2011.

Company B has collaboration with its customer in order to maintain the customer satisfaction in terms of producing new machine. The firm share knowledge and train customer how to use the machine. However in the terms of innovation, within the capital goods industry, it is usually done through in house R&D and market trend is the main factor that influences the innovation.

Nonetheless the market factor still governs the way in which the product is being innovated. The challenge of Company B is to response the customer criteria by providing higher productivity, higher quality, fewer defects, and lower cost. Tax incentive for importing capital goods that help the firm to supply advance machines to customer which response to the customer need.

The overall assessment which shows in Figure 2 is the strengths and weakness in technological capability in company B. It concludes that the firm has high awareness, core competence, strategy, assessment/selection, and learning which drive the innovation for competitive advantage in the company.

**FIGURE 2**

**THE TECHNOLOGICAL CAPABILITY OF COMPANY B**

**Company C**

The company C activities are the design and development of motor vehicles and automotive parts, design and manufacture of dies and jigs, manufacture of automotive parts and vehicle assembly. The main profit that the company earns from producing automotive parts is around 50% of all products. This firm received many recognized excellence award which can guarantee the performance and product innovation.

There are some collaboration activities that the firms focus on. The firm has collaboration network with both suppliers and customers. The company transfers the knowledge of technology with its alliance. Firm C was interested to joint venture with the major automotive assemble to develop products and fit special accessories for special purpose vehicles which can drive this firm to enhance more innovation. Moreover, firm collaborates with the university and research institute in order to consult for the product testing and product development.

The innovation that the company C focuses on is producing the automobile that create from Thai engineer for Thai users and enhance the product to the international standard. The manufacturer always develops and improves the product to build customer satisfaction through world-class and service. The firm produces the product with the lower price than the foreign company. The firm develops and improves the products in order to response the customer need and the market trend. Company C has in-house R&D in order to develop processes and products by its own. On the other hand, the top management also supports employees to have innovation and initiative to motivate the employee’s skill and performance.
The overall assessment which shows in Figure 3 is the strengths and weakness in technological capability in company C. It can conclude that it has high core competence, technology strategy, and assessing and selecting which drive the innovation for competitive advantage in the company.

**FIGURE 3**  
THE TECHNOLOGICAL OF COMPANY C

![Diagram](image)

**Company D**

The company D and group of companies are one of the major part manufacturers in Thailand for the automotive and motorcycle. The products of company group are well accepted among the industries. The customers include all famous automotive assemblers both local companies and foreign companies in Thailand.

The organization shares the information with their suppliers and customers such as the demand. The organization has the sharing process with customer. The company is trained by the customer about the production process and using new technology. Moreover, the firm collaborates with university and research institute to develop curriculum for management level. The R&D department corporate with Thailand Automotive Institute/Government agencies for some helps in technology project such as training program, process development, software and testing.

Most of innovation in company D is process innovation. Since top management realized the important of the organization improvement thus, management team stimulates many activities in order to upgrade the organization to be the leader in automotive part supplier. The major motivation for innovation is the change in demand of product or production style from customer that force the company to generate new idea and production method that match with the changed design and also reduce cost of production. Management team sent the engineer to oversea to observe and learn new technology trend and process. Company D continually develop themselves by developing internal R&D and implementing SAP program. The firm encourage employee to be innovative and improve their performance in order to gain better capabilities.

The overall assessment which shows in Figure 4 is the strengths and weakness in technological capability in company D. It can conclude that it has high core competence, technology strategy, and assessing and selecting which drive the innovation for competitive advantage in the company.
CONCLUSION

In conclusion this research found that the collaboration and innovation are the drivers of successful in the organization. This research studies on the supply chain collaboration activities and innovation factors that affect to the automotive and electronic manufacturing sector established in Thailand specifically within greater Bangkok area.

From interviewing, it shows that there are supply chain collaboration activities with both customers and suppliers. Firms share information and make a decision together. Firms have joint investment with their customers or suppliers such as invest on machine and technology in order to improve the product and process to match with activities in their chain. There is some collaboration between clients and suppliers in term of sharing the knowledge such as the technical training team program. The organizations collaborate with the academics and institution for the product testing.

Moreover, the innovation also plays an important key in the organization. The most important factor of innovation in these 4 firms is the market trends. The market trends drive the organizations to improve and develop new product and process to response the customer need. The innovation is influenced from in-house R&D because it has to create and improve new products and processes in order to satisfy the customer need and the market changed. Top management support is one of a key to support the innovation in the organization.

The technological capability shows the strength and weakness of firm. This case study implies that the building of core competencies, the development of technology strategy, and assessing and selecting the suitable technology in the firm are the main strength to the firms.

ACKNOWLEDGEMENTS

This paper benefited greatly from the interview. Our sincerest gratitude goes out to all interviewers from all company who generously devoted their valuable time, kindly allow us to interview and access to internal information. Therefore, we would like to express our gratitude to this contribution. All the information is use for educational purpose.
REFERENCES


SUPPLY CHAIN LOGISTICS MODEL DEVELOPMENT FOR MICRO AND SMALL ENTERPRISE TEXTILE INDUSTRY CENTER IN BANDUNG

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ABSTRACT

Bandung is known as an attractive city in Indonesia with culinary and textile appeal. Bandung has several well-known textile products, such as knitted textile, fabric, jeans and t-shirt. The aim of this paper is to develop supply chain logistic model of micro and small enterprise (MSEs) of textile products in Bandung. This research is focused on four MSEs textile industry centers in Bandung, those are Binong Jati knitted center, Cigondewah fabric center, Cihampelas jeans center and Suci t-shirt center. This study employs survey and observation to the four MSEs textile industry centers. We also conduct SWOT Analysis to offer best strategies for strengthening industrial competitiveness challenge in facing an increasingly competitive industry. This study results in four specific models of supply chain management for four well known textile products. The MSEs observed face several problems, including supply of raw materials (upstream side), quality and continuity of production (from production side) and distribution to customer (downstream side). This paper also offers a strategy that can be employed by each MSEs textile industry center in Bandung.

KEYWORDS
Supply Chain, Supply Chain Logistics, Textile, Micro and Small Enterprise (MSES)

INTRODUCTION

Competitiveness is a key issue for the industry in an open world market. World trade has expanded rapidly over the past decades (Chatzipanagioti, Iakovou, Vlachos and Hajidimitriou, 2011). By the capabilities and competitive advantages, industrial products will be able to compete on international competition. Patterson (2005) stated that competition is not just firm versus firm, but chain versus chain. In Indonesia, micro and small enterprises (MSEs) are the largest segments of the national economic actors. The number of MSEs constantly increases from year to year. Data of 2009 from Indonesian Statistics Institute (BPS) shows growth in the number of businesses, the workforce, the value of GDP and export value of MSEs. This growth can be purely due to economic growth or the existence of another driving factor. In this case, that is the increasing number of layoffs due to the many industries that go bankrupt. The decline of domestic industry because of the decline of competitiveness is potential for the increasing unemployment and the poor.

Ranking of competitiveness of Indonesia so far does not improve significantly. It is shown by the report of the World Economic Forum (WEF) 2009-2010. Hult, Ketchen & Arrfelt (2007) stated that for many firms, supply chain as a competitive weapon has become a central element of strategic management process to compete in the competition. The study here focuses on developing supply chain logistics model for four MSEs textile industry centers in Bandung. Bandung is known as an attractive city in Indonesia with culinary and textile appeal. The four MSEs textile industry centers in Bandung are Binong Jati knitted center, Cigondewah fabric center, Cihampelas jeans center and Suci t-shirts center.
LITERATURE REVIEW

Supply Chain Logistics is the flow of materials, information and money between companies (Frazelle, 2001). The difference is that supply chain is a network of facilities that starts from the supplier to the customer while logistics is what happens on the supply chain. Fluctuations in the global economy have increased the pressure on industries. Supply chain operations are challenged to provide the best, efficient, effective cost and on-time delivery. Now, cycles of product life become increasingly short; Market supply and operations become more progressive. Industry Week 2003 survey results show that supply chain is an important key to survive and thrive. The survey results show: (1) Increased outsourcing and partnerships in the supply chain demonstrates a significant challenge in managing demand and supply, as well as inventory control, (2) Timely and accurate information is essential to meet the needs of customers level service, (3) Reduced pure product innovation, (4) Performance of an innovative supply chain is indicated by stable demand. The survey shows many companies which are accelerating the functional advantages to horizontal integration process by concentrating on a single value chain process. There is also some progress in collaboration with external supply chain partners. Newman, Hanna, Gattiker & Huang (2009) proposed a framework that describes the boundary spanning supply chain management initiatives that consists of four factors: understanding, design, improvement, and coordination.

Logistics consists of five activities of the mutual influence of customer response, inventory planning and management, supply, transportation and warehousing (Frazelle, 2002): (1) Customer Response said to be optimal when the Customer Service Policy (CSP) produces the lowest cost of total sales, cost storage and distribution costs, (2) Inventory Planning and Management (IP & M) is to establish and keep inventory levels low to meet the needs of the Customer Service Policy (CSP), (3) Supply is to establish the inventory according to targets set in the Inventory Planning. The purpose of Supply management is to minimize the Total Acquisition Cost (TAC) which meets the availability, response time and quality requirements specified in Customer Service and Inventory Policy Master Plan, (4) Transportation goal is to deliver point-to-point with the lowest cost, (5) Warehousing, existence of which is in the number 5 of the logistics activities because good planning can eliminate the need for warehousing or can be outsourced.

RESEARCH METHODOLOGY

This research focuses on the development of four MSEs textile industry centers in Bandung. This type of research is descriptive research using survey. Research is conducted in 2010. The data used in this study are primary data and secondary data. Primary data is obtained through observation and using questionnaires from MSEs in the Binong Jati knitted center, Cigondewah fabric center, Cihampelas jeans center and Suci t-shirt center. Secondary data is collected from the association and relevant government agencies.

Firstly, we collect the information from the MSEs and association in four MSEs textile industry centers in Bandung. We also confirm the information with the secondary data from relevant sources. Secondly, we design the model for each industrial center. Thirdly, further analysis is conducted using SWOT analysis. With the SWOT analysis, it is expected to obtain recommendation strategies to enhance the competitiveness of textile industry centers in the future.

MODEL

Binong Jati Knitted Center

Binong Jati knitted center consists of 350 manufacturers. Monthly production is 87,500 dozens with a total value of production (in thousand dollars) is Rp 323,736,000.00. Suppliers from around the region and outside the region. Suppliers outside the region come from Purwakarta and Tangerang. Availability of raw materials is relatively a little. Manufacturers have less insight in designing of knitted products, so practice is to do with modifications of existing designs on the market. 87% of producers have their own warehouses. These areas absorb labor force population of 8,000 workers.

Consumers in this region are consumer retailers and wholesalers. The market is not sustainable. Every month there are about 37 wholesalers from Tanah Abang who pick up the products. The rest are sold for national market. For delivery of finished goods, nearly 70% of business actors entrust third parties, while the remainder committed by business actors. With a delivery system that is not done alone, it provides a significant constraint for merchants and consumers who receive it, including the delivery time constraints that are sometimes not on time, the transport cost that is quite expensive and damage of goods during transportation. For the national market, the product is sold to traders in Pasar Tanah Abang Jakarta, which will be forwarded to the traders in a particular area or directly to retailers in certain areas. Figure 1 shows the supply chain logistics model of Binong Jati Knitted Center.
Cigondewah Fabric Center

Cigondewah fabric center consists of 690 units. Main products of this region are fabrics for clothing and curtains. Raw materials for the MSEs come from fabric factory in Bandung. Total number of sales per month on average is Rp 902,810,000.00. Suppliers are near the Cigondewah area. Frequency of ordering to suppliers quite often with nominally small orders. Cigondewah has absorbed 2,688 workers. The majority of the workers, which is about 70%, come from Cigondewah and have family relationships. Average monthly sales of 300 units to 600 units (1 unit = 1 piece = 16 yards) or the average monthly sales of Rp. 60 million to Rp. 120 million per month.

The condition relatively decreases sales due to consumer demand for most entrepreneurs convection reduces the purchase, because of the declining purchasing power. As for how products are marketed through word of mouth information, individual agents or sold itself directly. The products are sold at the local, regional (Bandung, Cianjur, Cirebon, Indramayu, Soreang), and national through intermediaries. According to the business at the current market, the condition is still open or is a large market opportunity. Figure 2 shows the supply chain logistics model of Cigondewah Fabric Center.

Cihampelas Jeans Center

Cihampelas jeans center consists of 152 stores, 2 mall, 11 restaurants, 5 and 4 pieces of fruit supermarket hotels. This area is a special area where there are several fashion commodity merchant groups which have unique characteristics. The majority of goods come from Jakarta (80%) and the rest (20%) come from Bandung area. Goods sold are quite diverse. Most of the suppliers have more than 10 customers. The scale of business and the supplier market is quite large with average sales turnover of more than Rp 100 million per month. 75% of products are originated from textile industry, while 25% of them are from garment company.

Conditions of sales at Jeans products are relatively stable. The product are marketed orally, through an agency/official institutions (cooperatives) or sold themselves directly. Jeans are market products for the local market, sold to traders who passed to the distributions (distribution outlet) in the region and surrounding Cihampelas. Figure 3 shows the supply chain logistics model of Cihampelas Jeans Center.

Suci T-Shirt Center

Suci t-shirt center, which consists of 269 stalls/shops, is located along the Surapati Street. MSEs in Suci t-shirt center is a community of entrepreneurs engaged in business printing, design, and artistic creations t-shirts or banners. The overall business turnover ranges is between Rp. 5-7 Billion per month. This effort alone has been initiated long ago in 1982. Most of the delivery of finished goods that have been ordered by the customers themselves performed by entrepreneurs (80%) and small percentage that use third-party assistance (20%). Raw material suppliers of shirts, those are shirt fabric, yarn and silk screening paints, are almost 100% from Bandung.

Products are marketed orally, through an agency/official institutions (cooperatives) or sold themselves directly. The products are sold on local, national (Tangerang, Banten, Serang, Cianjur, Cirebon, Indramayu, Bengkulu, Palembang, Jakarta), and International (Singapore, Malaysia, Australia). The majority of businesses in the t-shirt product have attended exhibition in the country and abroad. Figure 4 shows the supply chain logistics model of Suci T-Shirt Center.

DISCUSSION AND CONCLUSION

After obtaining supply chain logistics model, this study performed a SWOT analysis on each MSEs industry center to obtain a picture of the various opportunities, constraints, challenges, and threats that occur both in backward linkage (supplier-manufacturer) and forward linkage. From the results of SWOT, it is known that the MSEs textile industry centers facing challenges with various limitations. There are similarities of barriers faced by each industry center. In the upstream, the barriers are quality and quantity of supply of raw materials. In the production side, they are product quality, availability and sustainability. In the downstream, the barrier is distribution to consumers. In the future, all of MSEs in each industry center and government is expected to pay attention to these things in order to improve competitiveness.
REFERENCES


Figure 1. Supply Chain Logistics Model of Binong Jati Knitted Center

Figure 2. Supply Chain Logistics Model of Cigondewah Fabric Center
Figure 3. Supply Chain Logistics Model of Cihampelas Jeans Center

Figure 4. Supply Chain Logistics Model of Suci T-Shirt Center
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DEVELOPMENT AND VALIDATION OF A MEASUREMENT FOR SUPPLY CHAIN COMPETITIVENESS

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ABSTRACT

In this era of globalization, fierce competition in the marketplace has extended the competition among the firms to the supply chains. This study intends to develop and validate the measurements for supply chain competitiveness. 380 sets of questionnaire were distributed and 103 responses were received with response rate of 27%. The factor analysis shows that the components of supply chain competitiveness are comprised of supply chain competitiveness inputs, environment and outputs. The findings also show that reasons for the researched firms to strive for supply chain competitiveness are (i) fierce competition in the market has forced them to do so in order to compete with the competitors; (ii) increased globalization; (iii) due to top management’s instruction. This indicates that the manufacturing firms in E&E industry in Malaysia have been driven by the competition in the marketplace, globalization, as well as top management’s instruction to achieve supply chain competitiveness.

KEYWORDS
Supply Chain Competitiveness, Malaysia

INTRODUCTION

The supply chain management (SCM) is seen to play a positive role in the growth of business performance because many literature reviews have proved that supply chain principles can improve the competitive position [1, 2, 3, 4, 5, 6 & 7]. In other words, many studies have often concluded that companies can improve business performance simply by adopting SCM. Management teams across the industry have been making huge investments in supply chain infrastructure and systems and, in many cases, have already significantly improved their services and products. Consequently, most of these firms have progressed well beyond mere incremental gains. The ability to work with closer relationships across the entire supply chain line in a seamless way, however, is required. This is important for integration of the business systems, resources, and capabilities so that business success can be achieved in a win-win situation among the various channel partners [8].

According to [9], SCM has emerged as the major component of competitive strategy, to enhance organizational productivity, profitability and competitive success. Globalization transforms the way products are manufactured and moved around the world for the competitive advantage. During the same period, a new structure called Supply Chain Competitiveness is developed to take advantage of the benefits, such as lower labor cost and efficient delivery offered by various developing countries around the world [10]. Supply chains competitiveness provides opportunities to create a sustainable competitive advantage [11]. This new structure when coupled with supply chain process is able to tap into the comparative advantage offered by countries around the world. By strategically dispersing the value-adding activities of a supply chain, and with proper co-ordination, a firm would be able to achieve competitive advantage over the competitors [12]. According to [13] to stay competitive, business enterprises are responsible to manage a network of upstream firms (suppliers) that provide inputs and a network of downstream firms (customers) that deliver products and services.

As been argued by [9], SCC is gaining importance for the reason that organizations will survive, in this global competitive environment, if they are competitive enough from both supply chain as well as customers satisfaction point of view. Researchers are trying to describe SCC for the long time and a wide range of strategies have been considered for example; mass customization, information and communication, process capabilities, operational effectiveness, operations strategy, coordination, cooperation, collaboration, flexibility, and strategic partnerships/alliances. [14] emphasized that mass customization can gain competitiveness of supply chains through increase in variety and customization without sacrificing efficiency, effectiveness or low cost. [15] recommended that process capability is a strategic weapon for supply chain competitiveness. In addition, reference [16] claimed that operations strategy is considered as the basic
competitive tool which concentrates upon two common themes: process and content. The important role of operations management and operations strategy for SCC is well documented by [17] and [18].

Even though the importance of SCC is proven for company to be sustained, it still necessitates further research especially in the relation to extent of it among firms in Malaysia. This study is primarily motivated by the question on “What extent is supply chain competitiveness in the context of electrical and electronics firms in Malaysia”? This paper, therefore, investigates the extent of SCC in Malaysia and develops and validates the measurements for SCC. It provides some empirical study on the extent of supply chain competitiveness. Subsequently, the paper describes the literature review on SCC, methodology used and descriptive and factor analyses. The paper ends with the conclusion from the study.

**LITERATURE REVIEW**

Numerous researchers have attempted to define supply chain competitiveness (SCC) for some time. During their research, they have described SCC based on various strategies. [19] states that mass customization increase the level of choices and customization. It is done with effectiveness and efficiency while maintaining the low cost. Pine’s research describes mass customization as the strategy to achieve supply chain competitiveness. According to [20], process and content is the two basic competitive tools in operations strategy. These two competitive tools play an important role in operations strategy which leads to SCC [20, 21&22]. On the other hand, [23] describes operational activities as the basis for achieving competitive advantage. The firm’s operational effectiveness is directly linked to SCC and increase in market share. In order to operate efficiently, the firm must be agile and flexible. This can only be achieved with the coordination of the entities in the supply chain [24]. Flexibility is also stated by [25] of playing the important role in SCC. Beyond flexibility, agility is viewed as the competitive factor in achieving SCC [24].

Supply chain competitiveness is becoming more important to many firms as they globalize their supply chain activities like manufacturing, sourcing, distributing…etc. These firms encounter greater challenges in global environment. [26] emphasize on the strategy of cooperation and collaboration relationships with suppliers and customers. They argue that firms may compete efficiently if they are able to develop these relationships with their supply chain partners and manage them well. According to [27], information and communication are the enablers of cooperation and collaboration strategy. These enablers are the most influencing changes which affect the SCC and the firm as a whole. [28] also describe information, intelligence and expertise as the firm’s unique resources for gaining competitive advantage.

According to [29], the closeness in the relationship between supplier and customer affects the achievement in supply chain competitiveness. The concept of “Advanced Supplier Partnership” is introduced in the research. The essence of this concept is material management and pre-agreed (between supplier and customer) provision systems for price adjustment. This partnership is further enhanced by the exponential growth of information technology and accessibility of internet. This rapid growth has vastly improved the connectivity among the partners in the supply chain. [30] claimed that the flows management in the supply chain is as important as the products sold in gaining competitive advantage. He states that there are twelve drivers which are important for the supply chain’s competitive advantage. According to him, these drivers are essential for gaining the supply chain competitiveness for a firm. The firm defines its competitive strategy in relation to its competitors. It satisfies customer needs by delivering product and services that are acceptable for the customers. [9] have proposed the framework for SCC as illustrated in Figure 1.
Referring to Figure 1, this framework can be divided into three sections, namely SCC inputs, SCC environment and SCC outcomes. SCC inputs consist of the supply chain activities such as partners collaboration, mass customization, customer orientation...etc which are performed at various levels of supply chain. These activities are essential in achieving supply chain competitiveness [9]. The next section of supply chain competitiveness framework is SCC environment. It consists of the competitive environment that the supply chain operates in. Competitive environment consists of business environment and global environment. Business environment can be further categorized as competitor’s strategies, customer demands fluctuation, financial factors, government policies...etc. On the other hand global environment includes global scenario, behavioral forces, economic conditions, foreign trade policies...etc [9].

The last section of Supply chain competitiveness framework is SCC outcomes. When the SCC inputs are perform efficiently and the SCC environment is conducive for the supply chain to perform well, the SCC outcomes are the achievement of the supply chain. Some of the outcomes are customer satisfaction, value to customers and profitability to the firm [9]. The following sub-sections of literature review elaborate further on the framework of supply chain competitiveness’ inputs, environment and outcomes.

**METHODOLOGY**

The manufacturing firms in the electrical and electronics (E&E) industry are deemed to be independent from each other, and the conclusion of this study is drawn at the firm or organizational level. The unit of analysis [31] in this study is the firm or the organization. This study focuses on the population of manufacturing firms in the electrical and electronics industry in Malaysia. According to the Federation of Malaysian Manufacturers (FMM)’s directory (41st edition), there are 380 manufacturing firms in the electrical and electronics (E&E) industry throughout Malaysia to-date. These firms are categorized as E&E manufacturing firms based on the guideline that the major type of products they manufactured must be related to E&E. The survey in the form of questionnaire is sent out to the Supply Chain Manager/Production Manager/Operations Manager of respective firms via post mail. The post mail method is employed in this study as it covers wider geographical area within reasonable time and minimum cost [32].

In today’s global business environment, the firms’ operations has changed dramatically due to increasing customer expectations, competition on a world-wide scale, time and quality based competition etc. Modern competition is among firms and their supply chains rather than the competition among enterprises only [9]. A supply chain is competitive if it is able to create and deliver value for its customers and suppliers. The important measurements of supply
chain competitiveness (SCC) this study focuses on is SCC inputs, SCC environment and SCC outcomes. SCC input includes activities to be performed at different levels such as flexibility in production capacity, cooperation within the firm, coordination and collaboration with suppliers and customers, being customer orientated, and agility on adapting to changing customers demands.

SCC environment consists of business and global environment. Business environment encompasses factors like competitor’s rivalry, fluctuating customer’s demands, economical forces etc. While global environment consists of global trends, behavioral forces, foreign trade policies etc. Performing activities in SCC inputs leads to the gaining of SCC. Outcomes of the SCC are improvement in the optimization of the production capacity utilization, better product quality, responsive to quick changes, and all of these factors lead to customer satisfaction. Ultimately, this improves the firm’s profitability. The three measurements of supply chain competitiveness are summarized in Table 1. A 5-point Likert scale ranging from 1 = Strongly Disagree to 5 = Strongly Agree has been used to measure the variables.

<table>
<thead>
<tr>
<th>No</th>
<th>Supply chain competitiveness (SCC)</th>
<th>Item Surveyed</th>
<th>Authors / Year (Adapted from)</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>SCC inputs</td>
<td>• Flexibility</td>
<td>Verma &amp; Seth (2010); La Londe &amp; Bernard (1997); Vokurka &amp; Fliedner (1998); Mentzer (2004); Miller &amp; Roth (1998).</td>
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<td></td>
<td></td>
<td>• Customer orientation</td>
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<td>• Coordination within firm</td>
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<td></td>
<td></td>
<td>• Cooperation and collaboration with suppliers and customers</td>
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<td></td>
<td></td>
<td>• Agility</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>SCC environment</td>
<td>Monitoring of the following:</td>
<td>Verma &amp; Seth (2010); Pine (1993); Fuller et al. (1993); Levi et al. (2005).</td>
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<tr>
<td></td>
<td></td>
<td>• Competitors</td>
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<td>• Customers demand</td>
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<td>• Government policies</td>
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<td>3</td>
<td>SCC outcomes</td>
<td>Improvement of the following in last three years:</td>
<td>Mentzer (2004); Verma &amp; Seth (2010); Hitt et al. (1999); Vokurka &amp; Fliedner (1998); Hayes &amp; Wheelright (1984).</td>
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<td></td>
<td></td>
<td>• Optimum utilization of production facilities</td>
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<td>• Quality of products</td>
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<td>• Overall profitability</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Customer satisfaction</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Responsiveness</td>
<td></td>
</tr>
</tbody>
</table>

RESULTS

380 sets of questionnaire were distributed and 113 responses were received. However, among the 113 sets of questionnaire collected, only 103 sets could be used for the data analysis. Therefore, the response rate based on the number of researched firms is 27%. The male respondents consist of 71.8% and female respondents stand at 28.2%. The respondents of the survey are from the age group between 25 years to above 55 years old. The survey results shows, around 26.2% of the respondents fall under the age group of 25 - 34 years, 55.3% of the respondents fall under the age group of 35 - 44 years old, 11.7% of the respondents fall under the age group of 45 - 55 years old and 6.8% of the respondents fall under the age group of above 55 years old.

The descriptive analysis of department reflects that 23.3% of the respondents for this survey are attached to the Operations department, followed by supply chain and production department which are tied at 11.7%. Both departments have equal number of respondents. Only 7.8% of the respondents are from department of management information system. MD’s Office, Services, Business Management and Administration departments are also having the same number of respondents at 4.9% each.

Firms with less than 250 employees consist of 34% and firms with more than 250 employees consist of 64% of the total researched firms. Firms with more than 250 employees are considered as large firms. Majority of the researched firms have been established for more than ten years (68.9%) and the rest (31.1%) have been established for less than
eleven years. 67% of these firms are foreign owned, 25.2% are wholly owned by Malaysian and 7.8% involve in joint venture. These firms are mainly producing industrial products (56.3%) and 26.2% of them are producing consumer products. 17.5% of these firms manufacture products categorized as others which include silicon wafer, wire trunking, actuator…etc.

47.6% of the firms researched state that fierce competition in the market has forced them to strive for supply chain competitiveness in order to compete with the competitors. There are also firms which strive to achieve supply chain competitiveness due to top management’s instruction (24.3%). Increased globalization has also been a concern for 28.1% of the firms researched. There are relatively more opportunities now for the firms to sell internationally and source from low-cost countries [33]. This has made the marketplace crowded with more players who can offer competition with lower price. This is one of the reasons majority of the researched firms are citing fierce competition in the market as the reason to achieve supply chain competitiveness.

Factor analysis is performed to examine the validity of the variables in Supply Chain Competitiveness. The result in Table 2 show that items in supply chain competitiveness factorized well into three factors. The total variance explained is 81.25%. KMO of measure of sampling adequacy is 0.817 indicating sufficient inter-correlations among the variables and the Bartlett’s test of sphericity is significant (p<0.001. The factor loading ranges from 0.739 to 0.931. All items in Supply Chain Competitiveness Inputs loaded in factor F1, Supply Chain Competitiveness Environment in F2 and Supply Chain Competitiveness Outcomes in F3.

<table>
<thead>
<tr>
<th>Item no.</th>
<th>Description of item</th>
<th>F1</th>
<th>F2</th>
<th>F3</th>
</tr>
</thead>
<tbody>
<tr>
<td>F1: Supply Chain Competitiveness Outcomes</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CO1</td>
<td>Significant improvement in terms of optimum utilization of the production facilities.</td>
<td>.870</td>
<td>.137</td>
<td>.239</td>
</tr>
<tr>
<td>CO2</td>
<td>Significant improvement in terms of quality of products.</td>
<td>.895</td>
<td>.138</td>
<td>.204</td>
</tr>
<tr>
<td>CO3</td>
<td>Significant improvement in terms of firm’s overall profitability.</td>
<td>.889</td>
<td>.138</td>
<td>.261</td>
</tr>
<tr>
<td>CO4</td>
<td>Significant improvement in terms of customer satisfaction.</td>
<td>.859</td>
<td>.214</td>
<td>.245</td>
</tr>
<tr>
<td>CO5</td>
<td>Significant improvement in terms of responsiveness.</td>
<td>.931</td>
<td>.125</td>
<td>.167</td>
</tr>
<tr>
<td>F2: Supply Chain Competitiveness Environment</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CE1</td>
<td>My firm watches the competitors closely.</td>
<td>.227</td>
<td>.806</td>
<td>.179</td>
</tr>
<tr>
<td>CE2</td>
<td>My firm analyses the changing demands of the customers periodically.</td>
<td>.175</td>
<td>.885</td>
<td>.138</td>
</tr>
<tr>
<td>CE3</td>
<td>My firm monitors the market condition closely</td>
<td>.075</td>
<td>.926</td>
<td>.197</td>
</tr>
<tr>
<td>CE4</td>
<td>My firm monitors the economical factors such as level of employment, interest rate, inflation rate etc closely.</td>
<td>.110</td>
<td>.887</td>
<td>.033</td>
</tr>
<tr>
<td>CE5</td>
<td>My firm monitors the government policies closely.</td>
<td>.112</td>
<td>.894</td>
<td>.040</td>
</tr>
<tr>
<td>F3: Supply Chain Competitiveness Inputs</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CI1</td>
<td>My firm is able to change the processes to adapt to the requirements of the customers cost-effectively.</td>
<td>.128</td>
<td>.005</td>
<td>.739</td>
</tr>
<tr>
<td>CI2</td>
<td>My firm is customer oriented.</td>
<td>.262</td>
<td>.096</td>
<td>.762</td>
</tr>
<tr>
<td>CI3</td>
<td>My firm is coordinated within the firm.</td>
<td>.221</td>
<td>.154</td>
<td>.897</td>
</tr>
<tr>
<td>CI4</td>
<td>My firm has cooperation and collaboration with suppliers and customers.</td>
<td>.205</td>
<td>.179</td>
<td>.840</td>
</tr>
<tr>
<td>CI5</td>
<td>My firm is able to change according to the changing demands of the customers as quickly as possible.</td>
<td>.226</td>
<td>.167</td>
<td>.907</td>
</tr>
</tbody>
</table>

KMO 0.817
Bartlett’s Test of Sphericity 1762.150*
Eigenvalues 4.292 4.088 3.807
Percentage of Variance Explained (%) 28.616 27.255 25.379
Total Variance (%) 81.25

Note: *p<0.001
DISCUSSION

The findings from the study show that reasons for the researched firms to strive for supply chain competitiveness are (i) fierce competition in the market (47.6%) has forced them to do so in order to compete with the competitors; (ii) increased globalization (28.1%); (iii) due to top management’s instruction (24.3%). This indicates that the manufacturing firms in E&E industry in Malaysia have been driven by the competition in the marketplace, globalization, as well as top management’s instruction to achieve supply chain competitiveness. The results from the descriptive analysis indicate that stakeholder relationship management has the most influence on supply chain competitiveness, while business planning and simulation and business consolidation are almost equally as influential on SCC. This concurs with [30] who states that firms that fail to satisfy the customers would not have competitive advantage. In order to gain customer satisfaction, the firm must manage the relationship with the customers properly.

According to [26], cooperation and collaboration among the partners in the supply chain is important for the supply chain to achieve competitiveness. These cooperation and collaboration can only happen with well managed relationship among the partners in the supply chain. This again highlights the importance of stakeholder relationship management. The descriptive analysis also identifies SCC environment as the component of SCC which concerns the researched firms the most compares to SCC outcomes and SCC inputs. This is highlighted in the responses from the firms researched which rank the market condition and globalization as the top two reasons to achieve SCC. According to [9], the competitive environment which consists of business environment and global environment can be a driving factor for the firms to achieve SCC. Therefore, it is vital for the firms to put more attentions in the competitive environment which they operate in.

CONCLUSION

The results of the supply chain competitiveness’ measures in this study are obtained internally from the employees of the firm. However, this might not been the true competitiveness of the firm because the external parties might perceive the situation differently. The competition is extending beyond the firm and among the supply chains [35]. Therefore, future research can expand the scope of the study by exploring the supply chain competitiveness of the whole chain including the firm and also its suppliers and customers. A recommendation of future research would be to study each SCC input and it’s contribute towards achieving SCC.

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DETERMINANTS AND PERFORMANCES OF GREEN INNOVATION ADOPTION AMONG AUTOMOTIVE LOGISTICS INDUSTRY IN MALAYSIA

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by

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ABSTRACT

The purpose of this study is therefore to investigate the extent of existence of green innovation adoption among automotive logistics industry in Malaysia, the determinants that influence the adoption of green innovation, and the actual performances of adoption. The survey questionnaires were sent out to all the firms in Malaysian automotive logistic industry with response rate is 29.2%. The results of the survey found that all the three determinants (regulations, market demand, and firm internal initiative) have a positive impact on the green innovation adoption (green product innovation and green process innovation). The study also showed that two types of green innovations (green product innovation and green process innovation) have a positive effect on the three categories of performances (environmental, social, and economy). Furthermore, the three of the control variables (firm ownership, firm size, and status of ISO certification) were found to have no significant effect at all on green innovation initiative. The implication of the study highlighted that firm internal initiative, regulations and market demand play an important role in motivating firms to adopt green innovation. By adopting the green innovation, it will help in turn the improvement in environmental, social and economy.

KEYWORDS
Determinants, Performance, Green Innovation Adoption, Automotive Logistics Industry

INTRODUCTION

Recently, eco-efficiency has become the most talked about global topic by various parties towards global sustainability issue as the above statement given by Alex Krauer, Chairman and CEO from Ciba-Geigy (Milmo, 1995). Consequently, the importance of the eco-efficiency agenda for the industry has been rising dramatically. World Business Council for Sustainable Development (2006) defines eco-efficiency as follows: “Eco-efficiency is achieved by the delivery of competitively-priced goods and services that satisfy human needs and bring quality of life, while progressively reducing environmental and ecological impacts and resource intensity throughout the life-cycle to a level at least in line with the earth’s estimated carrying capacity.”

Among all industries, perhaps the automotive industry tops the list of industries that have visibly suffered a strong demand for higher environmental performance based on the amount of wastages produced annually. According to Vergragt (2006), this industry have enjoyed years as the main source of employment and economic growth for countries such as America, China and Germany and still have a strong political influence; nevertheless, today it is being singled out as one of the major contributors to air pollution in urban centers. For that reason, environmental and ecological concerns have been brought to the company for innovation initiative. Innovation is a primary key in driving the automotive industry, and automotive industry is constantly looking for ways to innovate in order to gain competitive advantage revolutionary (Mena, Christopher, Johnson & Jia, 2007). In the past, most of the innovation activities are focusing on meeting the customer need, however the focus has shifted it focal point in recent years and required to respond to the environmental and social demand. Thus, the way companies integrate environmental concerns into their strategies while consolidating their competitive advantage is through environmental innovations or green innovations (Kuik, 2006).

Given this situation, green innovation in the automotive industry has a promising area of study that has the potential to provide significant practical benefits to the firms. Consequently, the study tries to investigate the determinants of green innovation and its effect towards performances in the aspect of environmental, social and economy in the automotive industry. The paper starts with this introductory section which gives general idea about the research
topic and problem of the study. The paper also provides literature review that explains green innovation, determinants and performance. Next, the paper portrays the methodology of the study and its analysis. The paper ends with discussions and conclusions.

**LITERATURE REVIEW**

**Automotive Logistics Industry**

One of the big challenges faced by the industry at present is creating a long-term sustainable green society with the least possible negative environmental impact during the production (Lin & Ho, 2008). The claim made by Lin and Ho (2008), however, was focusing more on the logistics industry than the production process. They added that in response to this increasing pressure of green technology being applied in automotive industry, a new approach of green innovations emerged in the early 2000s, which went beyond the standard logistical imperatives for efficient, effective, and fast handling and movement of goods, and took into account of measures for protecting the earth's environment from further damages, sometimes it is referred to green logistics approach.

Automotive logistics is an important part of automotive enterprises, and also is an activity with high complexity. Comparing to other logistic activities, automotive logistics have characteristics of capital-intensive, technology intensive and knowledge intensive entities in it (Chang & Qin, 2008). With rapid development of our automotive industry and fierceness of competition of automotive market after entering WTO, automotive logistics play a much more important role in automotive industry, or else automotive cost will go up through the roof. With regards to the green automotive logistics, Chang and Qin, (2008) refer it as the plan, control, management and implementation of the logistics system through the advanced logistics technology and environmental management, aiming to reduce the pollutant emissions. Therefore, they have recommended the evaluation criterions of enterprise green automotive logistics as follows:

1. **Green transportation.** The green transportation refers to use a kind of fuel with the least pollution as the power to try to implement the multi-transportation and allocation mode. Correctly arrange the transportation can we reduce the pollution, lower the cost and raise the allocation level.

2. **Green storage.** The green storage refers to adoption the mechanized operation in the process of goods-storing to save the manpower cost, adoption the environmentally-friendly products to sterilize the storage goods, adoption the method of centralized-stock to reduce the radicalization to the surroundings and reduce the adverse effect of the warehousing on the environment.

3. **Green packing.** The green package refers to a kind of commodity package that will not cause the environmental pollution. The packing materials should save the resources and reduce the packing waste, moreover, it is supposed to be recycled and regenerated after using, as well as occupies little land while burying in order to be decomposed easily.

Liu et al. (2010) refer automobile logistics as the automotive supply chain of raw materials, spare parts, vehicle parts and after-sales in all aspects of the process flow between the entities (refer Figure 1).
Currently the automotive sector is characterised by several industry participants across the entire value chain. According to the Malaysia Automotive Association (MAA), there are 4 passenger and commercial vehicle manufacturers including Proton and Perodua. There is one motorcycle manufacturer which is Motosikal dan Enjin Nasional Sdn Bhd (MODENAS). In addition, there are 9 motor vehicle assemblers and there are 343 motor vehicle components and parts manufacturers, of which 23 are Tier 1 status to support the manufacturers and assemblers. Malaysia has started invention in the automotive industry since 1960s, apart to develop the local automotive industry and to encourage vehicles to be assembled locally. PROTON and PERODUA, has transformed Malaysia from a mere motor car assembler into a car manufacturer.

Based on the survey done by KPMG International Cooperative (2009), the innovation for local automotive industry is basically focused on the process and product innovations. Millions of dollar is invested on purchasing the machinery, casting, etc to improve the productivity in order to meet its economics of scale. Malaysia New Economic Model (NEM, 2011) reported that Malaysia is at the frontier of the global environment and climate change debate as Malaysia has made a significant commitments to deliver a 40% of carbon dioxide emission by year 2020 compare to emission level that achieved during 2005. This new challenge enforce all parties to carefully consider and carry out the implementation plan to achieve it. Besides that, firm also aggressively working on transferring the technical knowledge to local manufacturing to acquire the necessary of core competence. Accordingly, the Technical Transfer Agreement signed between Malaysia companies and their foreign technology partners also provide the right of protecting licensing and patent, service, sales, marketing and distribution.

**Green Innovations**

The word innovation comes from the Latin root ‘nova’ meaning ‘new’ and many have associated innovation with creativity, R&D and technology (Pawanchik & Sulaiman, 2010). In essence, innovation is the use of new technical and administrative knowledge to offer a new product or service to customers (Afuah, 1998). Based on the Global Innovation Index 2008/2009 conducted by European Administration and Development (INSEAD), Malaysia is recorded at 25th position with scored 4.06 among Asian Countries for innovative performance. Singapore and Korea were ranked among the top ten most innovative economies with scores of 4.81 and 4.73 respectively (Table 1). Despite of the ranking, Malaysia is now in transition to a new economic model based on innovation, creativity and high value-added activities to lift us into a high income nation within a decade. To further drive the innovativeness of Malaysians, the Government has consistently emphasised the importance of technological progress in the country. The Government has also declared year 2010 as the ‘Year of Innovation and Creativity’. The launch is a move towards nurturing a culture of innovation to enable the community to improve the economy and be more competitive (www.miti.gov.my).
**TABLE 1**

**GLOBAL INNOVATION INDEX 2008/2009**

<table>
<thead>
<tr>
<th>Economy</th>
<th>Rank</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Malaysia</td>
<td>25</td>
<td>4.06</td>
</tr>
<tr>
<td>Top Performing Countries</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- USA</td>
<td>1</td>
<td>5.28</td>
</tr>
<tr>
<td>- Germany</td>
<td>2</td>
<td>4.99</td>
</tr>
<tr>
<td>Selected Asian Countries</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Singapore</td>
<td>5</td>
<td>4.81</td>
</tr>
<tr>
<td>- Korea</td>
<td>6</td>
<td>4.73</td>
</tr>
<tr>
<td>- Japan</td>
<td>9</td>
<td><strong>4.65</strong></td>
</tr>
<tr>
<td>- Hong Kong</td>
<td>12</td>
<td>4.59</td>
</tr>
</tbody>
</table>

Source: www.miti.gov.my

Green innovations, on the other hand, can be simply defined as all innovations that have a beneficial effect on the environment regardless of whether this effect was the main objective or not (Chen, Lai & Wen, 2006). According to them, green innovations are different from other innovations; this is due to green initiatives not only producing the spill over effect typically of most of the research and development efforts but also produce positive externalities in and of themselves. The typical example will be reducing the external environmental cost of production or product cost.

As stated by Lin, Ho, Chiang (2009), green innovation successfullness are depending on learning new technology by training and educating the workers to become environmental conscious workers. They added that there are three factors that influence the adoption of green innovation which are management skills, organizational encouragement for innovation, and support of innovation resources. While, Lin and Ho (2008) study found that environmental practices, organizational encouragement, quality of human resources, environmental uncertainty and governmental support exhibit significant influences on the willingness to adopt green innovations among logistics service providers.

**Green Initiatives in Automotive Industry**

The automotive industry is considered as the single largest manufacturing sector around the world with the employment of more than 10% of total workforce. In Malaysia, it is considered as one of the most important and strategic industries in the manufacturing sector and has been earmarked to boost the industrialization process so that Malaysia can be developed nation by year 2020. With the growing concerns of the global warming continue to increase; the automotive industry is facing tremendous pressure to reduce vehicle emissions such as nitrous oxide (NOx), carbon dioxide (CO2) and particular matter (PM) due to the harmful effects of these gases to the environment.

There are previous studies concerning benchmarking of automotive companies for environmental issues. Rothenberg et al. (2005) suggest an approach to environmental benchmarking for automakers involving four categories: regulatory compliance, gross emissions, efficiency and life-cycle analysis. Hahn et al. (2008) have assessed 16 automotive companies (groups) based upon the sustainable value methodology. Their results show the Toyota and BMW groups as leaders and ahead of other competitors. OECD (2005) that categorized the green innovation initiatives into five different types of innovation, which are product innovation, process innovation, organizational innovation, marketing innovation and service innovation.

Green product innovation and green process innovation can be distinguished by referring to the explanation from OECD (1997). OECD (1997) defines green process innovation as the improvement in the production process resulting in reducing the environmental impacts, for instances, closed loops for solvent, material recycling or filter. As for green product innovation, it aims at reducing environmental impacts during a product’s entire life cycle as the environmental impact of many products are stemmed from their use and disposal. For example, the CO2 emissions of car and the fuel consumption using the usage, in addition to the heavy metals in batteries when disposed. According to Triebwetter and Wackerbauer (2004), product innovation changes the final product, for instance changing the overall design and substitution of plastic for metal, whereas process innovation is concerning on the way cars are being produced. This involves using water-solvent paints and changes in motor technology to gas or hydrogen type.
Determinants for Adoption of Green Innovation

In the study of Horbach (2008), the determinants of green innovation are grouped into supply side, demand side, institutional and political influences. However, the academic research on green innovation generally focuses on three types of explanatory variables which are regulation, market and firm internal condition (Bernauer et al., 2007). Chen et al. (2006) found that organization adopt environmental management as a result of the environmental consciousness customers and the international regulations of environmental protection such as Montreal Convention and Kyoto Protocol. Based on the finding from the literatures, it can be conclude that regulations appear to have significant factor as key determinants for green innovation initiatives, followed by firms’ internal initiatives and market demand.

Regulations

According to OECD (1997), the definition of regulations is broad and they include the full range of legal instruments such as constitutions, parliamentary laws, subordinate legislation or constraint imposed by the government institutions. Differ from regulations, environmental regulations are those environmental-related regulations that include the consideration of the impacts to environment (Kemp, 1998). There have been a number of decades that the automotive industry is subjected to environmental regulation, for instance, the 1970 Clean Air Act was set by US government in the late of 1960s to have reduction standards for the emissions of conventional air pollutants from cars (Kuik, 2006). Traditionally, environmental regulation is often viewed as a burden to a firm as it incurred higher expenses and has negative impact on productivity and competitiveness. If given a choice to invest, firm would enforce R&D expenditure in a more profitable area, such as the core business rather than R&D for cleaner technology (Gray & Shadbegian, 1995).

Consumer Demand

The rise of consumer environmentalism is another determinant driving company to engage in environmental management (Chen et al., 2006). A lot of efforts have been carried out in automotive industry to seek for a new path of technology developments, which includes hybrid, electric, components reuse and fuel cell vehicles in order to cope with the enlarged market demand for global climate protection. Toyota is the first to develop the hybrid system that offers 100% improvement in fuel efficiency, 50% reduction in carbon dioxide (CO2) emissions, and, important is the development of this hybrid system was shaped more by market force (Lee et al., 2004). It is argued that green products which besides the public benefits have private environmental benefits for the customers (e.g., energy saving) will generate stronger consumer demand and thus constitute the firm’s motivation to implement those innovations in the first place (Kammerer, 2009).

Firm Internal Initiative

In order for firm to successfully adopt and practicing green innovation initiatives, firms’ internal initiatives play a very important role in order to drive the whole organization to make a change and adopt in this new “green” concept as the inertia for initial adoption are always high inside the organization. From the strategic management point of view, the literature provides the strong evidence for firm-internal conditions and firm strategies. The firm-internal factors are always related to evolutionary theory and resource-based view theory in the context of the firm environment (Barney, 1991). The resource-based view strategy is focus on the valuable resources in the firms’ environment; such resources may include firm internal strategy, organization structure, and also core capabilities to improve the firms’ competitive advantages. Barney (1991) further group the resources into tangible, intangible and personnel based group, tangible group such as firms’ financial and intangible group may include reputation or brand’s image of company and personnel-based include culture, and training of resources. It is clear that all these resources are crucial for firms that plan to initiate green innovation. Therefore, in conclusions, based on the discussion above, it is clear that firm internal initiative has a significant high extend on contribute to green innovation initiatives besides for firms to obtained competitive advantages.

Outcomes of Green Innovation

Green innovation outcomes are the direct positive results or consequences that are actually realized and enjoyed by the automotive companies in Malaysia from green innovation initiatives adoption. By investigating the outcomes, majority of them are bringing the same kind of performances, thus they can actually categorized into environmental, social and economy performances by using the definition defined by the previous study. According to Bernauer et al. (2006), environmental performances refer to the extent of green innovation can bring benefits to the natural environmental. Such performances include the minimization in emission of hazardous substances or waste, consumption of energy and materials which will in turn help in compliance to environment regulations and improve the overall environmental situation. In term of social performances, it is regarded as the contribution of the firm’s daily activities towards the society, including the safety, welfare, health and protection in which the firm operates (Carter, 2005;
Kassinis & Soteriou, 2003). Lastly, economy performances referred to the impact of green innovations on the firm’s business performance especially the financial performance such as the growth in market share, sales, productivity, profitability and cost reduction (Eidat, Kelly, Roche, Eyadat, 2008). Therefore, this study will investigate the performances of green innovation based on environmental, social and economy.

Framework

The theoretical framework as shown in Figure 3 is designed to be an antecedents-outcomes study in which the green innovation initiatives are the focus of the study. Through literature review, the study has identified two types of green innovation initiatives, which are product innovation and process innovation for further investigation. Apart from that, this study also investigates the effect of the three identified key determinants (regulations, market demand, and firm internal initiative) towards the adoption of green innovation initiatives among the Malaysia companies in automotive logistic industry. Subsequently, the research investigates the effect of green innovation initiatives on the designated three types of outcomes or performances (environmental, economic and social performances). The control variables selected for this framework are ownership, size and ISO certification of the firm.

**FIGURE 2**
THEORETICAL FRAMEWORK OF STUDY

![Theoretical Framework Diagram]

The Direct Effect of Determinants on Green innovation Initiatives

This study assumes that the three key determinants (regulations, market demand and firm internal initiatives) have direct positive effect on green innovation initiatives adoption among the firms in Malaysia automotive logistic industry. Previous study and research have shown that the three determinants can have considerable effect in inducing firms to adopt green innovation initiatives in an organization. Accordingly, this study hypothesizes that the three determinants positively affect adoption of the two types of green innovation initiatives (product innovation and process innovation), thus, leading to the following general hypotheses.

**H1:** The determinants have positive impact on green innovation initiatives.

Outcomes or Performances of Green Innovation Initiatives

Previous study and research have shown that green innovation initiatives are associated with better environmental performance (such as reduction of hazardous pollutants, wastes and material use), economic performance (such as reduction of cost, increase in sales growth, market share and return on investment), and social performance (such as improved customer loyalty and satisfaction, green image of firm). Thus, the following general hypothesis is derived.

**H2:** Green innovation initiatives have positive effect on environmental, economic and social performances.
METHODOLOGY

Research Design

A single industry, which is the automotive logistic industry, was chosen as opposed to wider range of manufacturing industries in order to limit the scope of the study. The restriction to only one single industry permits the control of several variables that always vary between industries, including the scope and complexity of environmental concerns. The individual firm will be the unit analysis of the study. The firm here refers to companies or individual units or sites within companies. The sampling frame will be the list of all elements in a population (Sekaran, 2003). The sampling frame of this study consists of all the firms in Malaysia automotive logistics industry. The automotive logistic industry includes those firms that are related to automotive producer’s raw materials, components, vehicles and spare parts.

The sampling list was obtained from the website of Malaysia Automotive Association Federation (MAA). Currently, there are 4 passenger and commercial vehicle manufacturers which including Proton, Perodua, Naza and Modenas. In addition, there are nine motor vehicle assemblers and 343 components or parts manufacturers in Malaysia. With that, the total number in the list is 356 firms. Due to the small sampling frame of the study and the likeness of low response from mail survey (Sekaran, 2003), the survey questionnaire will be sent to all the respondents of these 356 firms. Therefore, census sampling method was applied for this research. The respondents of the questionnaires consisted of engineers, manufacturing managers, operation managers, production managers, quality manager, executive directors, and managing directors in Malaysia automotive companies. They are chosen as the respondents of the study because they directly involved in the process, thus, have the first hand knowledge and experience of all the operating and activities in their companies. The author believes that it is crucial to investigate and find out from those who have an understanding and practical experience in green innovation implementation and adoption.

Development of the Survey Instruments

Items for Green Innovation Initiatives

Chen, Lai, and Wen (2006) define green innovation as innovation of hardware or software that is related to green product or processes which including the innovation in technologies that are involving in energy-saving, pollution-prevention, waste recycling, green product designs or corporate environmental management. Thus, the green innovation is divided into green product innovation and green process innovation. The green innovation initiatives are measured using 5-point Likert scale ranging from 1 (not at all exist) to 5 (very high extent).

This study utilized the definition of Chen et al. (2006) that defined green product innovation as the product innovation related to environmental innovation, which including the innovation in product that are involved in energy-saving, pollution-prevention, waste recycling, no toxicity, or green product designs. The measurement of the green product innovation is adapted from Chen et al. (2006) and consisted of 4 items. This study utilized the definition of Chen et al. (2006) that defined green process innovation as the process innovation related to environmental innovation, which including the innovation in process that are involved in energy-saving, pollution-prevention, waste recycling, no toxicity. The measurement of the green process innovation is adapted from Chen et al. (2006) consisted of 4 items.

ANALYSIS

Response Rate

A total of 356 questionnaires were mailed to the respondents. After two reminder letters in addition to telephone calls and e-mails, 104 respondents completed answering and returned the questionnaires with 6 respondents’ results are rejected due to incomplete answering. The response rate is 29.2%. The response rate of 29.2% is still considered acceptable with the expectation of low response from mail survey (Sekaran, 2003). For comparison, a survey on lean manufacturing implementation in Malaysian automotive industry done by Nordin, Baba and Dzuraidah (2010) managed to receive response rate of 24.4% (total of 61 respondents out of 250 target respondents), while Lin and Ho (2008) received 153 completed questionnaires out of 500 questionnaires which lead to response rate of 30.6% during the survey on the green innovations adoption among the logistics service providers in Taiwan. Therefore, it can be said that response rate of 29.2% obtained from this study is still considered acceptable.
**Profile of Sample Firms**

The first aspects to be investigated were the general background of the firms and respondents. The factors investigated were the ownership, ISO certification, size, annual sales, age, types of product, and market of the firm. The table shows that nearly half of the respondents firms have local ownership (41.3%), whereas 36.5% of the total respondent firms are fully foreign-based ownership and the remaining 22.1% have joint venture between local and foreign. Regarding of quality system qualification (status of ISO certification), almost all the respondents firms are ISO certified (92.3%) and only minority of the firms are still without ISO certification (7.7%). Among the common ISO certifications achieved in Malaysia automotive logistics industry are ISO/TS16949, ISO14000 and ISO9001.

By examining the number of employees, it depicts that respondents are considered mostly from large companies with more than 200 employees (75%) and more than half of the firms are having annual sales turnover more than RM200 million (65.3%). The table also shows that more than half of the firms involved in this study are categorised as old firms with 54.8%. Here, the study defined the old firms that were established more than 15 years and they are considered well established. Less than 10% are newly established firms in the sample (less than equal to 5 years) and remaining of 35.6% are intermediate firms that have been established between 6 to 15 years. Regarding of the types of product, the data shows that about half are focusing on industry products (49%), 36.5% of the samples focus on consumer products and majority of the targeted market of the sample firms are global.

**Goodness of Measures**

**Factor Analysis of Green Innovation Initiatives**

The factor analysis starts with measuring the appropriateness of the data. The KMO measure of sampling adequacy should be at least 0.6 and Bartlett’s test of sphericity should be significant (P<.01) to indicate sufficient number of statistically significant correlations in the matrix for factor analysis (Hair et al., 1998; Pallant, 2003). Table 1 shows the KMO measure obtained is 0.79 which is higher than 0.6 and the Bartlett’s test of sphericity is significant (P<.01). This indicates that the data were adequate for factor analysis. From the table, all items for green product innovation and green process innovation loaded in factor 1 and 2, respectively, are with main loading value above the specified limit of 0.45 and cross loadings below 0.35. Thus, all the items are relevant to their factors and no item is to be excluded from the analysis. The table also indicates that green innovation initiatives items loaded into two factors with eigenvalues exceeding 1, which exceeding the standard criteria for the factors to be considered valid. Hence, the two extracted factors matched the two conceptualized types of green innovation initiatives. These two factors explain 78.07% of variance in the data which is greater than the minimum value of 60% recommended by Hair et al. (1998).

**TABLE 1**

<table>
<thead>
<tr>
<th>Items: My company……</th>
<th>Component</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>F1: Green Product Innovation</strong></td>
<td></td>
</tr>
<tr>
<td>Selects raw materials of the product that produce the least amount of pollutants when conducting product development or design</td>
<td>GP1 .919 -.054</td>
</tr>
<tr>
<td>Selects product that comprises the fewest raw materials when conducting product development or design</td>
<td>GP3 .914 .156</td>
</tr>
<tr>
<td>Selects raw materials of the product that consume the least amount of energy and resources when conducting product development or design</td>
<td>GP2 .868 -.084</td>
</tr>
<tr>
<td>Would circumspectly deliberate whether the product is easy to recycle, reuse, and decompose when conducting product development or design</td>
<td>GP4 .848 .125</td>
</tr>
<tr>
<td><strong>F2: Green Process Innovation</strong></td>
<td></td>
</tr>
<tr>
<td>Reduces the consumption of water, electricity, coal, or oil during the manufacturing process</td>
<td>GM3 .091 .916</td>
</tr>
<tr>
<td>Recycles waste and emission that allow them to be treated and re-used during the manufacturing process</td>
<td>GM2 -.074 .866</td>
</tr>
<tr>
<td>Effectively reduces the emission of hazardous substances or waste during the manufacturing process</td>
<td>GM1 .011 .845</td>
</tr>
<tr>
<td>Reduces the use of raw material during the manufacturing process</td>
<td>GM4 .105 .847</td>
</tr>
<tr>
<td>Kaiser-Meyer-Olkin, KMO (λ = 562.040)</td>
<td>794</td>
</tr>
<tr>
<td>Eigenvalues</td>
<td>3.178 3.068</td>
</tr>
<tr>
<td>Total Variance Explained (78.07%)</td>
<td>39.727 38.352</td>
</tr>
</tbody>
</table>

Note: Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization. N=104. **p<0.01
Factor Analysis of Green Innovation Initiatives Determinants

Table 3 summarizes the result of the factor analysis done for testing the validity measures used in measuring the determinants for green innovation initiatives. The table shows that the items are appropriate for factor analysis given the KMO measure of sampling adequacy is 0.8 (more than the recommended value of 0.6) and the Bartlett’s test of sphericity is significant (p<.01).

From the table, it also reveals that all items of regulation, market demand and firm internal initiatives are loaded appropriately on factor 1, 2, 3, respectively, with main loading values above the minimum level of 0.45 and cross loadings below 0.35. Therefore, all items were to be remained in the measures of determinants for green innovation initiatives. The items for green innovation initiatives determinants that loaded into three factors are having eigenvalues exceeding 1 and the total variance explained by these three factors is 72.90%. This shows that the extracted three factors are corresponding to the conceptualized three determinants: regulations, market demand and firm internal initiatives.

### Table 2

<table>
<thead>
<tr>
<th>Items</th>
<th>Component</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>F1: Regulations</strong></td>
<td></td>
</tr>
<tr>
<td>The government sets environmental laws that contain stringent standard for my company to comply with</td>
<td>RG1</td>
</tr>
<tr>
<td>The environmental regulations are effective in tackling environmental problems directly in my company’s industry</td>
<td>RG2</td>
</tr>
<tr>
<td>Environmental regulations in other countries such as United State and Europe induce my company to adopt green innovations</td>
<td>RG5</td>
</tr>
<tr>
<td>Government frequent inspects and audits my company to ensure that company is in compliance with environmental laws and regulations</td>
<td>RG3</td>
</tr>
<tr>
<td>Government offers financial supports such as R&amp;D subsidies, grants and tax reduction through regulation to motivate my company to adopt green innovation</td>
<td>RG4</td>
</tr>
<tr>
<td><strong>F2: Market Demand</strong></td>
<td></td>
</tr>
<tr>
<td>High pressure from customers, public authorities, pressure groups such as industry or trade association that influenced my firm for green innovation</td>
<td>MD3</td>
</tr>
<tr>
<td>Consumers are willing to pay higher price for green innovation (eco-friendly) product</td>
<td>MD4</td>
</tr>
<tr>
<td>Large potential customer benefits (eg. Energy saving and fuel efficient) attribution motivated my company to adopt green innovation</td>
<td>MD5</td>
</tr>
<tr>
<td>Increasing of environmental consciousness of customers with regards to environmentally friendly product in the market place to adopt green innovation</td>
<td>MD2</td>
</tr>
<tr>
<td>Increasing trend of social awareness of the customers’ need for clean production in the market place induced my company to adopt green innovation</td>
<td>MD1</td>
</tr>
<tr>
<td><strong>F3: Firm Internal Initiative</strong></td>
<td></td>
</tr>
<tr>
<td>My company encourages and supports employees to learn green information and practices</td>
<td>FII2</td>
</tr>
<tr>
<td>My company has the accumulation of technology available to support the development of new products and processes</td>
<td>FII3</td>
</tr>
<tr>
<td>My company has the accumulation of human capital (high skill labour force) to develop new products and processes</td>
<td>FII4</td>
</tr>
<tr>
<td>My company has perceived environmental innovation as an important and effective component strategy towards green</td>
<td>FII6</td>
</tr>
<tr>
<td>My company has the existence environmental management systems, practices and tools to support environmental innovation</td>
<td>FII5</td>
</tr>
<tr>
<td>Kaiser-Meyer-Olkin, KMO (χ= 1522.454)</td>
<td></td>
</tr>
<tr>
<td>Eigenvalues</td>
<td></td>
</tr>
<tr>
<td>Total Variance Explained (72.90%)</td>
<td></td>
</tr>
</tbody>
</table>

Note: Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization. N=104. **p<0.01**
Factor Analysis of Green Innovation Initiatives Outcomes or Performances

Table 3 illustrates the result of factor analysis for the items measuring the performances from green innovation initiatives. The table shows that KMO measure of sampling adequacy is 0.829 (above the recommended level of 60%) and Bartlett’s test of sphericity is significant (p<.01) which indicates that the matrix meets the conditions of factor analysis and can be used for further analysis.

### TABLE 3
**ROTATED FACTOR LOADINGS FOR OUTCOMES OR PERFORMANCES**

<table>
<thead>
<tr>
<th>Items: My company has …..</th>
<th>Component</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>F1</td>
</tr>
<tr>
<td><strong>F1: Environmental Performances</strong></td>
<td></td>
</tr>
<tr>
<td>Substantially minimized the consumption of direct or indirect usage of material</td>
<td>ENP3</td>
</tr>
<tr>
<td>Substantially improved its overall environmental situation</td>
<td>ENP5</td>
</tr>
<tr>
<td>Substantially minimized the emission of hazardous substances or waste</td>
<td>ENP1</td>
</tr>
<tr>
<td>Substantially minimized the consumption of energy</td>
<td>ENP2</td>
</tr>
<tr>
<td>Substantially minimized the consumption of hazardous materials</td>
<td>ENP4</td>
</tr>
<tr>
<td>Substantially improved the compliance to environmental regulations and standards</td>
<td>ENP6</td>
</tr>
<tr>
<td><strong>F2: Social Performances</strong></td>
<td></td>
</tr>
<tr>
<td>Substantially enhanced its green image</td>
<td>SP3</td>
</tr>
<tr>
<td>Constantly paid important concern on the health and safety of the society</td>
<td>SP4</td>
</tr>
<tr>
<td>Constantly paid important concern on the society well being in all operation</td>
<td>SP5</td>
</tr>
<tr>
<td>Constantly paid important concern on how the society response towards firm’s action</td>
<td>SP6</td>
</tr>
<tr>
<td>Substantially improved the overall customer satisfaction</td>
<td>SP1</td>
</tr>
<tr>
<td>Substantially improved the overall customer retention</td>
<td>SP2</td>
</tr>
<tr>
<td><strong>F3: Economy Performances</strong></td>
<td></td>
</tr>
<tr>
<td>Substantially increased the market share and growth rate</td>
<td>ECP1</td>
</tr>
<tr>
<td>Substantially increased the level of productivity</td>
<td>ECP3</td>
</tr>
<tr>
<td>Substantially increased the growth in profit margin</td>
<td>ECP2</td>
</tr>
<tr>
<td>Substantially increased the growth in sales</td>
<td>ECP4</td>
</tr>
<tr>
<td>Substantially lower the cost of production or production cost per unit</td>
<td>ECP5</td>
</tr>
<tr>
<td>Kaiser-Meyer-Olkin, KMO ((\chi=1759.517))</td>
<td></td>
</tr>
<tr>
<td><strong>Kaiser-Meyer-Olkin, KMO ((\chi=1759.517))</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Total Variance Explained (81.01%)</strong></td>
<td>5.269</td>
</tr>
<tr>
<td><strong>Total Variance Explained (81.01%)</strong></td>
<td>30.993</td>
</tr>
</tbody>
</table>

Note: Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization. N=104. **p<0.01

The main loading values for all items are above minimum value of 0.45 on one factor and the cross loadings are below 0.35 on other factors. The eigenvalues for the items loaded on three factors are above 1 show that all the constructs in the scale were measuring the same factor. The three factors cumulatively explained 81.01% of the total variance in the data which is above the recommended value of 60%. This reflects that all items for environmental, economy and social performance are relevant to their factor 1, 2, 3, respectively.

Reliability Analysis

Variable with the coefficient of Cronbach’s alpha equal or more than 0.70 was considered to have sufficient level of reliability and will be used for further analysis, whereas variable with Cronbach’s alpha lower than 0.7 shall be rejected due to unreliable and will be excluded from regression analysis (Nunnally, 1978). From the reliability test results as illustrated in Table 4, all the variables are having Cronbach’s alpha well exceed the minimum value of 0.7 that is ranging from between 0.85 and 0.972. It indicates that the sampling results are reliable (Nunnally, 1978). Hence, no variable is to be excluded and the measures have acceptable level of reliability.
### TABLE 4

**CRONBACH’S ALPHA FOR VARIABLES UNDER STUDY**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Number of Items</th>
<th>Cronbach’s Alpha</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regulations</td>
<td>5</td>
<td>.850</td>
</tr>
<tr>
<td>Market Demand</td>
<td>5</td>
<td>.867</td>
</tr>
<tr>
<td>Firm Internal Initiative</td>
<td>6</td>
<td>.960</td>
</tr>
<tr>
<td>Green Product Innovation</td>
<td>4</td>
<td>.911</td>
</tr>
<tr>
<td>Green Process Innovation</td>
<td>4</td>
<td>.892</td>
</tr>
<tr>
<td>Environmental Performance</td>
<td>6</td>
<td>.972</td>
</tr>
<tr>
<td>Economy Performance</td>
<td>5</td>
<td>.909</td>
</tr>
<tr>
<td>Social Performance</td>
<td>6</td>
<td>.945</td>
</tr>
</tbody>
</table>

### Hypothesis Testing

**Effect of Determinants on Green Innovation Initiatives**

The first hypothesis is three determinants (regulations, market demand, and firm internal initiatives) have positive influence on green innovation initiatives (green product innovation and green process innovation). A two-step hierarchical regression analysis was carried out to test this hypothesis. In step one, the analysis tests the effect of control variables (firm ownership, number of employees and status of ISO certification) on dependent variables. The control variables act as an isolator to the effect of the factors other than those under investigation that may affect the dependent variable. In step two, the analysis includes and tests the marginal effect of the independent or predictor variables on the dependent variable.

Table 5 displays the result of the two-step regression analysis of control variables and determinants on green product innovation. The result from the step one shows that there is no significant effect of the three control variables (firm ownership, ISO certification and firm size) on green product innovation and only able to explain 1.7% of the variance in green product innovation and the model as a whole is not significant ($F=0.58$). Adding the determinants in step two provide additional explanation of 39.8% of green product innovation. By examining the value for the three determinants, it shows that firm internal initiative has the most significant effect on green product innovation ($\beta=.424$, $p<0.001$), followed by regulations ($\beta=.417$, $p<0.001$), and lastly market demand ($\beta=.165$, $p<0.05$). The result supported the hypotheses H1.1a (regulations positively impact green product innovation), H1.2a (market demand positively impact green product innovation) and H1.3a (firm internal initiative positively impact green product innovation).

### TABLE 5

**MULTIPLE REGRESSION RESULT FOR EFFECTS OF CONTROL VARIABLES AND DETERMINANTS ON GREEN PRODUCT INNOVATION**

<table>
<thead>
<tr>
<th>Variables</th>
<th>DV: Green Product Innovation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Step 1 (Model 1)</td>
</tr>
<tr>
<td></td>
<td>Std. Beta</td>
</tr>
<tr>
<td><strong>Control variables:</strong></td>
<td></td>
</tr>
<tr>
<td>Ownership</td>
<td>-.148</td>
</tr>
<tr>
<td>ISO certification</td>
<td>.003</td>
</tr>
<tr>
<td>Size of the company</td>
<td>.124</td>
</tr>
<tr>
<td><strong>Model variables:</strong></td>
<td></td>
</tr>
<tr>
<td>Regulations</td>
<td></td>
</tr>
<tr>
<td>Market Demand</td>
<td></td>
</tr>
<tr>
<td>Firm Internal Initiative</td>
<td></td>
</tr>
<tr>
<td>$R^2$</td>
<td>.017</td>
</tr>
<tr>
<td>Adjusted $R^2$</td>
<td>-.012</td>
</tr>
<tr>
<td>F</td>
<td>.580</td>
</tr>
</tbody>
</table>

Note: *$p<0.05$; **$p<0.01$; ***$p<0.001$; Model 1 = Control variables were regressed on DV; Model 2 = Control variables and IV were regressed on DV

The similar analysis was repeated for the impacts of determinants on green process innovation. Table 6 illustrates the result of the two-step regression analysis of control variables and determinants on green process innovation. The first step shows that three control variables (firm ownership, ISO certification and firm size) do not have significant impact on green process innovation and the explanation is only 4.8% of variance in green process innovation.
This is coherent with the finding from the first step of the impact of control variables on green product innovation. By including the determinants in step two, the R squares increased by 22.5% which means that the determinants explain 22.5% of the variance in green process innovation. All the three determinants have significant impact on green process innovation. However, the most significant one is market demand ($\beta=.31$, $p<0.001$), followed by firm internal initiative ($\beta=.24$, $p<0.01$) and lastly regulations ($\beta=.21$, $p<0.05$). The results subsequently support the hypotheses H1.1b (regulations positively impact green process innovation), H1.2b (market demand positively impact green process innovation) and H1.3b (firm internal initiative positively impact green process innovation).

**TABLE 6**
MULTIPLE REGRESSION RESULT FOR EFFECTS OF CONTROL VARIABLES AND DETERMINANTS ON GREEN PROCESS INNOVATION

<table>
<thead>
<tr>
<th>Variables</th>
<th>DV: Green Process Innovation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Step 1 (Model 1)</td>
</tr>
<tr>
<td></td>
<td>Std. Beta</td>
</tr>
<tr>
<td>Control variables:</td>
<td></td>
</tr>
<tr>
<td>Ownership</td>
<td>-.054</td>
</tr>
<tr>
<td>ISO certification</td>
<td>-.189</td>
</tr>
<tr>
<td>Size of the company</td>
<td>.146</td>
</tr>
<tr>
<td>Model variables:</td>
<td></td>
</tr>
<tr>
<td>Regulations</td>
<td>.208*</td>
</tr>
<tr>
<td>Market Demand</td>
<td></td>
</tr>
<tr>
<td>Firm Internal Initiative</td>
<td></td>
</tr>
<tr>
<td>R²</td>
<td>.048</td>
</tr>
<tr>
<td>Adjusted R²</td>
<td>.020</td>
</tr>
<tr>
<td>F</td>
<td>1.692</td>
</tr>
</tbody>
</table>

Note: *$p<0.05$; **$p<0.01$; ***$p<0.001$; Model 1 = Control variables were regressed on DV; Model 2 = Control variables and IV were regressed on DV

**Effect of Green Innovation Initiatives on Outcomes or Performances**

The second hypothesis is green innovation initiatives (green product innovation and green process innovation) have positive influence on three types of performances (environmental, economy, and social performances). A two-step hierarchical regression analysis was carried out to test this hypothesis. In step one, the analysis tests the effect of control variables (firm ownership, number of employees and status of ISO certification) on dependent variables. In step two, the analysis includes and tests the marginal effect of the independent or predictor variables on the dependent variable. Table 7 presents the result of the two step regression analysis for testing the effect of control variables and green innovation initiatives on environmental performances. In step one, it shows none of the control variables have any significant effect on the environmental performances and the explainable of variables is only 2.5% of variance in the dependent variable. It implies that there is no relation of the factors related to ownership, size and ISO certification on environmental performances. By introducing the two types of green innovation initiatives into the model, R square increased by 36% and the model becomes significant ($F=12.44$, $p<0.001$). Both green product ($r=0.19$, $p<0.05$) and process innovations ($r=0.57$, $p<0.001$) show significant effect on environmental performances. Therefore, hypotheses H2.1a (green product innovation positively effects environmental performances) and hypothesis H2.1b (green process innovation positively effects environmental performances) were supported.
TABLE 7  
GREEN INNOVATION INITIATIVES ON ENVIRONMENTAL PERFORMANCES

<table>
<thead>
<tr>
<th>Variables</th>
<th>DV: Environmental Performances</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Step 1 (Model 1)</td>
</tr>
<tr>
<td></td>
<td>Std. Beta</td>
</tr>
<tr>
<td><strong>Control variables:</strong></td>
<td></td>
</tr>
<tr>
<td>Ownership</td>
<td>-.116</td>
</tr>
<tr>
<td>ISO certification</td>
<td>-.057</td>
</tr>
<tr>
<td>Size of the company</td>
<td>-.026</td>
</tr>
<tr>
<td><strong>Model variables:</strong></td>
<td></td>
</tr>
<tr>
<td>Green Product Innovation</td>
<td>.190*</td>
</tr>
<tr>
<td>Green Process Innovation</td>
<td>.571***</td>
</tr>
<tr>
<td>R²</td>
<td>.025</td>
</tr>
<tr>
<td>Adjusted R²</td>
<td>-.004</td>
</tr>
<tr>
<td>F</td>
<td>.864</td>
</tr>
</tbody>
</table>

Note: *p<0.05; **p<0.01; ***p<0.001; Model 1 = Control variables were regressed on DV; Model 2 = Control variables and IV were regressed on DV

Similar analysis was done for social performances and the result of regression analysis of control variables and green innovation initiatives on social performances is shown in Table 8. The control variables explain only 2.8% of variance in the dependent variable and the model as a whole is not significant. The addition of green innovation initiatives in step two contribute additional 23.2% in the value of R square and the model as a whole becomes significant (F=6.88, p<0.001). Also, both green product innovation (r=0.41, p<0.001) and process innovation (r=0.23, p<0.05) show significant effect on social performances. Therefore, hypotheses H2.2a (green product innovation positively effects social performances) and hypothesis H2.2b (green process innovation positively effects social performances) were supported.

TABLE 8  
GREEN INNOVATION INITIATIVES ON SOCIAL PERFORMANCES

<table>
<thead>
<tr>
<th>Variables</th>
<th>DV: Social Performances</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Step 1 (Model 1)</td>
</tr>
<tr>
<td></td>
<td>Std. Beta</td>
</tr>
<tr>
<td><strong>Control variables:</strong></td>
<td></td>
</tr>
<tr>
<td>Ownership</td>
<td>-.078</td>
</tr>
<tr>
<td>ISO certification</td>
<td>-.064</td>
</tr>
<tr>
<td>Size of the company</td>
<td>-.080</td>
</tr>
<tr>
<td><strong>Model variables:</strong></td>
<td></td>
</tr>
<tr>
<td>Green Product Innovation</td>
<td>.414***</td>
</tr>
<tr>
<td>Green Process Innovation</td>
<td>.225*</td>
</tr>
<tr>
<td>R²</td>
<td>.028</td>
</tr>
<tr>
<td>Adjusted R²</td>
<td>.000</td>
</tr>
<tr>
<td>F</td>
<td>.975</td>
</tr>
</tbody>
</table>

Note: *p<0.05; **p<0.01; ***p<0.001; Model 1 = Control variables were regressed on DV; Model 2 = Control variables and IV were regressed on DV

The result of regression analysis for testing the effect of green innovation initiatives on economy performances is presented in Table 9. The control variables explain only 3.5% of variance in the dependent variable and the model of a whole is not significant (F=1.20). In step two, the addition of green innovation initiatives explain additional 27.6% of the variance in the economy performances and the model as a whole becomes significant (F=8.90, p<0.001). Both green product innovation (r=0.45, p<0.001) and process innovation (r=0.25, p<0.01) show significant effect on economy performances. Therefore, hypotheses H2.3a (green product innovation positively effects economy performances) and hypothesis H2.3b (green process innovation positively effects economy performances) were supported.
### TABLE 9
GREEN INNOVATION INITIATIVES ON ECONOMY PERFORMANCES

<table>
<thead>
<tr>
<th>Variables</th>
<th>Step 1 (Model 1)</th>
<th>Step 2 (Model 2)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Std. Beta</td>
<td>Std. Beta</td>
</tr>
<tr>
<td><strong>Control variables:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ownership</td>
<td>.027</td>
<td>.107</td>
</tr>
<tr>
<td>ISO certification</td>
<td>-.191</td>
<td>-.145</td>
</tr>
<tr>
<td>Size of the company</td>
<td>-.011</td>
<td>-.103</td>
</tr>
<tr>
<td><strong>Model variables:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Green Product Innovation</td>
<td>.451***</td>
<td></td>
</tr>
<tr>
<td>Green Process Innovation</td>
<td></td>
<td>.250**</td>
</tr>
<tr>
<td>R²</td>
<td>.035</td>
<td>.311</td>
</tr>
<tr>
<td>Adjusted R²</td>
<td>.006</td>
<td>.276</td>
</tr>
<tr>
<td>F</td>
<td>1.195</td>
<td>8.851***</td>
</tr>
</tbody>
</table>

Note: *p<0.05; **p<0.01; ***p<0.001; Model 1 = Control variables were regressed on DV; Model 2 = Control variables and IV were regressed on DV

### DISCUSSION

The results of the study showed that the firms in Malaysia automotive logistics industry are highly adopt green process innovation (mean=3.76) and green product innovation (mean=3.75) as well. Based on these results, it can be concluded that the adoption green innovation initiatives are high among the automotive logistics industry in Malaysia with the increasing consciousness of the environmental issues and the continue growing of automotive industry in Malaysia. Thus, efforts have been taken to tackle the environmental as automotive industry is claimed to be the main contributor to the air pollution due to the emission of carbon dioxide. The results are in line with the survey done by KPMG International Cooperative (2009) which found that process and product innovations are the main focus in innovation for local automotive industry.

Based on the results obtained from the regression analysis in this study, regulations determinant showed to have a positive impact on the green product innovation (H1.1a) and green process innovation (H1.1b) among the automotive logistics industry in Malaysia context. This result to be well supported by the survey being done among the automotive industry in the Southern Germany, the research clearly indicated that one of the main factor for environmental product and process innovations among firms of are the environmental regulation and company environmental policy such as the Kyoto Protocol, the European Directive on alternative car fuels and the Euro 4 and 5 emission limit values (Triebswetter & Wackerbauer, 2004). However, the introduction of regulations elements in Malaysia context especially in automotive industry, this can be shown by the comment from IGPN that there are no well-established environmental green regulations being practice by Malaysia. The results obtained here imply that in order for Malaysia automotive industry to move forward for adopting in green innovation practices, establish and stringent the environmental policies in Malaysia are required to motivate this particular industry for moving and implemented green in their company environment.

Apart from that, the regression analysis on market demand also appears to have a significant positive impact on affecting green product innovation (H1.2a) and green process innovation (H1.2b). Or in other words, market demand is positively impact the green innovation (H1.2). From the survey done by Triebswetter and Wackberbauer (2004) among the firms of the automotive sector in Southern Germany, the researchers claimed that market demand will be another factor that motivates automotive industry to practicing green specifically from the innovation perspective. Based on the citation examples that show above, Malaysia internally or even global consumers are moving towards demanding on green product, some of them even willing pay on the higher price for obtained the green product. Based on the supply and demand theory, automotive industry especially in the Malaysia context should look one step ahead to identify the requirements on today market need, for sure, what public want today will have a significant different if compare to the old time consumers. No doubt, green innovation is an appropriate strategy for automotive firm to obtain the market share on these “green consumers”.

Therefore the positive study result from this study can also be conclude that automotive industry in Malaysia are aware on this market demand shift, however the early adoption in green initiative is required in Malaysia context, which aimed to become the largest global automotive component’s supplier. Similar to the impact of regulations and market demand, firm internal initiative also depicted positive significant impact on green product innovation (H1.3a) and green process innovation (H1.3b). Apparently, firm internal initiative has positive impact on green innovation initiatives.
The result is consistent with the survey done by Lin and Ho (2008) that found that organization determinants such as organizational encouragement and quality of the human resources have positively influence the intention to adopt green innovation among the logistic companies in Taiwan. Lin et al. (2009) added that the successfulness of green innovation is also depend on the management skills, the training and education provided to the employees to become more environmental conscious.

This is further evidenced through the result from the descriptive analysis which also showed that firm internal initiative has the highest level of existence among Malaysia firms in the automotive logistic industry (mean = 4.00). By investigating the profile of the firms in Table 4.2, 75% of the sampled firms are large in size with more than 200 employees and more than half that is 54.8% are considered as well-established with more than 15 years old. Furthermore, 65.3% of the sampled firms are having annual sales turnover more than RM200 millions. Large and well-established firms have the accumulation of resources and capabilities available that enabled them to adopt green innovation. Moreover, high revenue firms have the strong financial resources and willing to spend on the research and development to help support the technologies capabilities needed to adopt green innovation in the firm.

**Conclusion**

From the literature review input, automobiles industry in Malaysia context can be considered still under developing stage, however, the environmental negative impacts from automotive industry are significant. Therefore the green initiatives adoption in automotive industry should more aggressively to suite the environment today and green innovation will be a good approach for automotive industry to adopt. The study reveals that green innovation initiatives for both process and product are showing an encouraging level of adoption in the automotive firm in Malaysia. The study on the key determinants shows that regulation, market demand and firm internal factor showing a significant positive impact on influencing automotive firms in Malaysia to implement green innovation initiatives in the firm process design and also end product design. The result provide an input to the automotive firm decision team to pay more attention on this aspect before the stringent policies or regulations introduce in Malaysia contain and fulfil the demand for consumer that required and look for the green product.

**REFERENCES**


THE LOGISTICS SYSTEM REVIEW: GMS INTEGRATION

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THE LOGISTICS SYSTEM REVIEW: GMS INTEGRATION

by

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ABSTRACT

The review aims at benchmarking the logistics system of the Greater Mekong Subregion (GMS) countries, ie, China, Thailand, Myanmar, Lao PDR, Vietnam and Cambodia. As the regional supply chain is as strong as the weakest link, the weakness in each perspective must be identified and therefore the improvement strategies can be deployed accordingly. The review is based on secondary information, however internationally recognized, ie, the World Bank’s The Logistics Performance Index and Its Indicators, the World Bank’s Doing Business 2011, World Economic Forum’s The Global Competitiveness Report 2010-2011, and US Government Central Intelligence Agency’s World Factbook. The result shows strong indications suggest several improvement in these countries in various perspectives.

KEYWORDS
Logistics System, Logistics Performance Index, Business, Global Competitiveness, World Factbook

INTRODUCTION

The Greater Mekong Subregion (GMS) collaboration was established in 1992 with the assistance of the Asian Development Bank (ADB). The collaboration is made up from 6 Mekong-aligned countries, ie, China (Yunnan and Guangxi regions), Thailand, Myanmar, Lao PDR, Vietnam and Cambodia. The program aims at developing and integrating the infrastructure to promote trade and investment as well as developing human resource and skill competencies and protect the environment and promote sustainable use of the region’s resources. (Asian Development Bank, 2011)
Launched from started, there are activities implemented in focused sectors, i.e., agriculture, energy, environment, human resource development, investment, telecommunications, tourism, trade, transport, multi-sector and development of economic corridors. (Asian Development Bank, 2010)

Table 1 collects basic information of these GMS countries based on the database, World Factbook by US Government Central Intelligence Agency. The information of interest are area, land boundary, coast line, population, GDP, GDP growth rate, GDP per capita, exports and imports.

<table>
<thead>
<tr>
<th>TABLE 1 BASIC INFORMATION OF GMS COUNTRIES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Area sq.km</td>
</tr>
<tr>
<td>-------------</td>
</tr>
<tr>
<td>513,120</td>
</tr>
<tr>
<td>4,863</td>
</tr>
<tr>
<td>3,219</td>
</tr>
<tr>
<td>66.720</td>
</tr>
<tr>
<td>GDP (purchasing power parity) US$</td>
</tr>
<tr>
<td>GDP Growth Rate</td>
</tr>
<tr>
<td>GDP Per Capita US$</td>
</tr>
<tr>
<td>Exports US$</td>
</tr>
<tr>
<td>Imports US$</td>
</tr>
</tbody>
</table>

Source: US Government Central Intelligence Agency’s World Factbook (Central Intelligence Agency, 2011)
In general, it can be seen that China is the largest and biggest (in term of population) among GMS countries, in fact, in the world. Where GMS collaboration involves only Yunnan and Guanxi region, the specific information of the region are inaccessible. Therefore, the information of China as a country is used in this study. Thailand is also strong in economic, indicated by GDP, import and export figures. Lao PDR, Myanmar and Cambodia, on the other hand, are economically under-rated.

In more specific perspective, ie, logistics system focus, the supply chain and economic integration among GMS countries should be promoted. This includes the human and natural resources as well as manufacturing, trading and investment. However, it can be seen from the preliminary observation that these countries are very much difference. Yet in logistics perspectives, by which will be review in this study, it may see the possible gap that will result in difficulty and limitation of the integration. Therefore, the study will review and benchmarking the logistics system of these countries based on available secondary information, ie, the World Bank’s The Logistics Performance Index and Its Indicators, the World Bank’s Doing Business 2011 and World Economic Forum’s The Global Competitiveness Report 2010-2011. Then the improvement strategies can be deployed accordingly.

**LOGISTICS SYSTEM COMPONENTS & KPIS**

In general, logistics system comprises of 4 components, ie, infrastructure, institutional framework, shippers & consignees and logistics service providers. (Banomyong, et.al., 2010) Whereas several KPIs can be used to reflect these components, the study selects KPIs published by World Bank’s The Logistics Performance Index and Its Indicators, the World Bank’s Doing Business 2011 and World Economic Forum’s The Global Competitiveness Report 2010-2011.

1. The Logistics Performance Index and Its Indicators Report by World Bank conduct reviews on 1) efficiency of the customs clearance process, 2) quality of trade and transport-related infrastructure, 3) ease of arranging competitively priced shipments, 4) competence and quality of logistics services, 5) ability to track and trace consignments and 6) frequency with which shipments reach the consignee within the scheduled or expected time. (Arvis, J., et.al., 2010) There are 6 KPIs reflecting the logistics system in terms of infrastructure, institutional framework, shippers & consignees and logistics service providers, ie,
   1. Customs
   2. Infrastructure
   3. International Shipments
   4. Logistics Quality and Competence
   5. Tracking and Tracing
   6. Timeliness

2. Doing Business 2011 Report by World Bank conduct reviews on 1) starting a business, 2) dealing with construction permits, 3) registering property, 4) getting credit, 5) protecting investors, 6) paying taxes, 7) trading across borders, 8) enforcing contracts and 9) closing a business. (The World Bank, 2011) There are 6 KPIs reflecting the logistics system in terms of institutional framework, shippers & consignees and logistics service providers, ie,
   1. Documents to Export
   2. Time to Export
   3. Cost to Export
   4. Document to Import
   5. Time to Import
   6. Cost of Import

3. The Global Competitiveness Report 2010-2011 by World Economic Forum conduct reviews on 1) institutions, 2) infrastructure, 3) macroeconomic environment, 4) health and primary education, 5) higher education and training, 6) goods market efficiency, 7) labor market efficiency, 8) financial market development, 9) technological readiness, 10) market size, 11) business sophistication and 12) innovation. (The World Economic Forum, 2010). There are 5 KPIs reflecting the logistics system in terms of infrastructure, ie,
   1. Quality of Overall Infrastructure
   2. Quality of Roads
   3. Quality of Railroad Infrastructure
   4. Quality of Port Infrastructure
   5. Quality of Air Transport Infrastructure
Where here, all KPIs can be deployed into each logistics component as summarized in Table 2.

### TABLE 2
LOGISTICS COMPONENTS AND KPIs RELATIONSHIP MATRIX

<table>
<thead>
<tr>
<th>Logistics System Benchmarking</th>
<th>Infrastructure</th>
<th>Institutional Framework</th>
<th>Shippers &amp; Consignees</th>
<th>Logistics Service Providers</th>
</tr>
</thead>
<tbody>
<tr>
<td>The Logistics Performance Index and Its Indicators</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Customs</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Infrastructure</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>International Shipments</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Logistics Quality and Competence</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tracking and Tracing</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Timeliness</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Doing Business 2011</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Documents to Export</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time to Export</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cost to Export</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Document to Import</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time to Import</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cost of Import</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>The Global Competitiveness Report 2010-2011</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quality of Overall Infrastructure</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quality of Roads</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quality of Railroad Infrastructure</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Quality of Port Infrastructure</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quality of Air Transport Infrastructure</td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

Remarks: ■ Direct KPIs ○ Indirect KPIs

**LOGISTICS SYSTEM BENCHMARKING**

*The Logistics Performance Index and Its Indicators*

The first set of KPIs is taken from The Logistics Performance Index and Its Indicators (LPI) by the World Bank. Scoring is based on more than 5,000 individual country assessments made by nearly 1,000 international freight forwarders to compare the trade logistics profiles of 155 countries. The scoring system is then given based on 1-5 mark where 5 indicate the best practise. Ranking is also used to compare countries.

Figures 2 and 3 illustrate the benchmarking of GMS countries in 7 LPI’s KPIs.

**FIGURE 2**
OVERALL LPI RANK OF GMS COUNTRIES

![LPI Rank Chart](image-url)
Here, it can be seen that China is outstanding from other GMS countries in all KPIs. Ranked 27 out of 155 LPI’s databased countries, China scored ranged from 3.16-3.94, averaged at 3.493. Top three best performance KPIs are timeliness, tracking and tracing and infrastructure, scored 3.94, 3.55 and 3.49 respectively.

Thailand also performs very good, ranked at 35, averaged score at 3.292. Top three best performance KPIs are timeliness, tracking and tracing and international shipments, scored 3.73, 3.41 and 3.27 respectively.

Vietnam, ranked 53, averaged score at 2.952, also comparably good in terms of timeliness, tracking and tracing and international shipments, scored more than 3 points.

On the other hand, Lao PDR, Cambodia and Myanmar are much far behind at ranked 118, 129 and 133 and averaged scored at 2.440, 2.370 and 2.315 respectively. Among the worst, Myanmar’s infrastructure, customs and logistics quality and competence are scored at 1.92, 1.94 and 2.01 respectively. Lao PDR’s infrastructure is also scored at 1.95. Cambodia is best among the worst, scored ranged from 2.19 to 2.84.

**Doing Business 2011**

The study by World Bank, called Doing Business 2011 (DB), is one of the most recognized business and economics reference. The database is constructed of 183 countries, focusing on a variety of perspectives as described in section 2. However, of interest of the study are 6 logistics KPIs as Documents to Export, Time to Export, Cost to Export, Document to Import, Time to Import and Cost of Import. The data is taken from the survey through more than 8,200 local experts, including lawyers, business consultants, accountants, freight forwarders, government officials and other professionals routinely administering or advising on legal and regulatory requirements. It shall be noted that Myanmar is not included in the report. Therefore, Myanmar is not in consideration for this section.

Figures 4 and 5 illustrate the benchmarking of GMS countries in 7 DB’s KPIs.
From the overall score, Thailand performs best in terms of trading across border, ranked at 12 out of 183 countries. It requires less documents and less time if import or export. China also performs considerably good at rank 50. Vietnam, Cambodia and Lao PDR on the other hand are comparably worse, ranked at 78, 147 and 171 respectively.

Focusing in each KPI, it can be seen that Lao PDR is trading-across-border difficult where it requires high expenses if import or export and it requires a long period of time if import or export. It shall be highlighted that China and Vietnam require less expense to import and export. This somehow indicates the logistics performance of the logistics service providers in these countries.

**The Global Competitiveness Report 2010-2011**

World Economic Forum has published The Global Competitiveness Report 2010-2011 (GCI), focusing on so-called 12 pillars of economic competitiveness. Where the KPI related to the logistics system component is reflected in the infrastructure pillar, here, Quality of Overall Infrastructure, Quality of Roads, Quality of Railroad Infrastructure, Quality of Port Infrastructure and Quality of Air Transport Infrastructure are of interest.

It shall be noted again that Myanmar and Lao PDR are not included in the report. Therefore, they are not in consideration for this section.

Figures 6 and 7 illustrate the benchmarking of GMS countries in 7 GCI’s KPIs.
FIGURE 6
OVERALL GCI’S INFRASTRUCTURE SCORE OF GMS COUNTRIES

FIGURE 7
GCI RANK FOR GMS COUNTRIES

Here, it can be seen that Thailand outperform China, Vietnam and Cambodia. Where Thai stands in the better rank in Quality of Overall Infrastructure, Quality of Road, Quality of Port Infrastructure and Quality of Air Transport Infrastructure, but Quality of Railroad Infrastructure. China is the best in term of Quality of Railroad Infrastructure. Vietnam is quite weak in most area except Quality of Railroad Infrastructure. Cambodia, in general, is quite weak in term of logistics infrastructure.

CONCLUSION AND DISCUSSION

Investigating GMS countries’ logistics system components focusing on infrastructure, institutional framework, shippers & consignees and logistics service providers, not to compete to each other, but to indicate room for improvement. Therefore, the integration of the region can be possible. Following the study of World Bank’s The Logistics Performance Index and Its Indicators, the World Bank’s Doing Business 2011 and World Economic Forum’s The Global Competitiveness Report 2010-2011, several indications are revealed. The following summarizes key findings from the study;
TABLE 3
SUMMARY OF LOGISTICS SYSTEM COMPONENT OF GMS COUNTRIES

<table>
<thead>
<tr>
<th>Country</th>
<th>Infrastructure</th>
<th>Institutional Framework</th>
<th>Shippers &amp; Consignees</th>
<th>Logistics Service Providers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thailand</td>
<td>Strong, except railroad infrastructure</td>
<td>Customs is friendly. Easy to import and export, but expensive to import and export</td>
<td>Acceptable</td>
<td>Acceptable</td>
</tr>
<tr>
<td>China</td>
<td>Strong, especially railroad</td>
<td>Customs is friendly. Import and export is quite easy and cheap.</td>
<td>Good</td>
<td>Good</td>
</tr>
<tr>
<td>Myanmar</td>
<td>Strongly need appropriated development</td>
<td>Need appropriated development</td>
<td>Need appropriated development</td>
<td>Need appropriated development</td>
</tr>
<tr>
<td>Lao PDR</td>
<td>Strongly need appropriated development</td>
<td>Strongly need appropriated development</td>
<td>Need appropriated development</td>
<td>Need appropriated development</td>
</tr>
<tr>
<td>Vietnam</td>
<td>Adequate</td>
<td>Customs is acceptable. Import and export is adequately good.</td>
<td>Adequate</td>
<td>Adequate</td>
</tr>
<tr>
<td>Cambodia</td>
<td>Strongly need appropriated development</td>
<td>Need appropriated development</td>
<td>Need appropriated development</td>
<td>Need appropriated development</td>
</tr>
</tbody>
</table>

Here, it can be seen that each country are benchmarked to each other. Where Thailand, China and Vietnam are mostly fine by this review. It can be seen that development should be focused mostly in Myanmar, Lao PDR and Cambodia. Now it is not the individual interest if one is improved, but the development as a whole that will result in the collaboration. Otherwise, the bottle neck will exist and the integration would never be success.

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15-17 December 2011, Kurumba Maldives Resort, Male, Maldives
0150

DRIVERS FOR SUSTAINABLE PORTAL UTILIZATION IN SUPPLY CHAIN MANAGEMENT

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DRivers for Sustainable Portal Utilization in Supply Chain Management

by

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ABSTRACT

The aim of this conceptual paper is to highlight factors influencing the intended utilization of portal in supply chain management concept in Malaysia. History agreed that portal can help to overcome the problems that plague many supply chains. In today’s business, portal is very important for information sharing and service delivery and history agreed that portal has the potential to develop the performance of an organization in terms of productivity and business process efficiency. Portal is never ended project and need modification time to time as for the business requirements. However implementing portals can make negative significant changes to business environment. Therefore in this conceptual paper, the researcher has identified and analysed some critical success factors towards sustainability utilization of portals. A factor regarding quality perspective is a must to sustain utilization of portal in organisations and satisfaction views from users also very important in order to make the portal sustainability without re-engineering the root factors. The researcher also suggested a framework to this research to comply the objective of the research: to study the quality factors towards the portal utilization in Supply Chain Management, to study the effect of intranet portal utilization towards satisfaction and to examine the effect of satisfaction on staff benefits. By reading this paper, reader will be able to obtain clearer picture about conducting future research in order to understand value factors that make the portal more sustain.

KEYWORDS
Portal, Supply Chain Management, Quality, Satisfaction, Benefits

INTRODUCTION

Information technology can help to overcome the uncertainties of the modern business environment. Electronic exchange of information leads to a reduction of errors and increased efficiency of the work processes. When one company can use the information of other companies in the supply chain, the negative effects of uncertainty (i.e., higher inventory levels, inaccurate forecasts, and unfulfilled orders) can, in theory, be mitigated. In practice, however, the exchange of information between companies is not as easy as it seems. Many different systems and standards are used, the number of peer-to-peer relationships with other companies in the network is usually too large to manage, and most systems are not open for easy exchange of information with other systems. Furthermore, most companies are very reluctant to share information with other companies in the first place and the worst is the information provided is out of date, information overloaded and not user friendly

A portal represents a solution to overcome these problems. Standardized interactions with one portal are easier to manage than are many peer-to-peer relationships. The portal provides an organization with a single, unified database, linked across all functional systems, both within the organization and between the organization and its major supply chain partners. The role of portals as tools for managing organizational operation and knowledge has been constantly changing throughout their short lifetime. An important recent advancement in the functionality of portals is their ability to connect companies together, joining internal and external knowledge sources to assist in the operation by the creation of valuable knowledge. Nowhere is this increased functionality and utility more evident than in the use of portals to manage the supply chain. A common trend in supply chain management (SCM) is the formation of one central strategy for the entire production network, which involves going beyond an organization’s external boundary. This represents a shift from a commodity-based approach to SCM to a more collaborative and relationship-building strategy. As this “extended enterprise” comes into being, an extended IT infrastructure is needed. Portal is ultimately solutions, which assist in spanning organizational boundaries and ensuring a timely information exchange can help support this strategy. Portal technology allows the IT infrastructure of one firm to span multiple organizations and be utilized by many (Dyer,
2000). The globalization of supply chains also presents an opportunity for the utilization of portal technology (Tan, Shaw, & Fulkerson, 2000). Geographically dispersed organizations have an increasingly greater need to share information, even though they experience issues with systems spanning different processes, cultures, and vast distances. A portal’s ability to utilize the Internet can assist in the networking of such distributed firms.

The fundamental resource required for these extended organizations is knowledge, whether it is knowledge of markets, supply conditions, manufacturing, and logistical strategies, or of a supply partner’s needs and capabilities. As knowledge is a resource characterized by “perfectly increasing returns” (Dyer, 2000, p. 61), knowledge can flow within a supply network and dramatically add value for all members. A small innovation at one end can often have a ripple effect through the supply chain, and result in a significant development at the other end. All forms of supplier networks require supporting technology to facilitate the creation and utilization of supply knowledge, and portal technology is often fulfilling this need. But the problem is not much portal added by quality factors.

BACKGROUND

A portal is a Web presence that consolidates a variety of information and services for example, searching, transacting, news, e-mail, discussion groups, and e-commerce (Ma, Bacon, Petridis, & Windall, 2006). Commonly, the aim of Web portals is to select, organize, and distribute content (information, or other services and products) in order to satisfy its users/customers (Domingues, Soares, & Jorge, 2006). Although the term was initially used to refer to general purpose Web sites such as Yahoo, it is increasingly being used to refer to vertical Web sites that feature personalization/customization, cross-platform usability, distributed access, management, and security of information and services within a particular enterprise/industry, and thus the so-called enterprise, corporate, or vertical portals (Ma et al., 2006).

Over the past years, the number of Web portals has grown, in such a way that nowadays a wide variety of portals are offered. Consequently, portal users and organizations have to choose one portal among several hundred possibilities. Therefore, the success of a portal depends on customers using and returning to their sites, because if a new portal puts up a competitive site of higher quality, customers will almost immediately shift their visits to the new site once they discover it (Offutt, 2002). As more people use Web portals, the quality of Web portals has become an important issue for owners to satisfy their users. Bearing all that in mind, it can be concluded that portal existence once they discover it (Offutt, 2002). As more people use Web portals, the quality of Web portals has become an important issue for owners to satisfy their users. Bearing all that in mind, it can be concluded that portal existence.

Meanwhile Supply Chain Management [SCM] can be defined as “... a set of approaches utilized to efficiently integrate suppliers, manufacturers, warehouses, and stores, so that merchandise is produced and distributed at the right quantities, to the right locations, and at the right time, in order to minimize system wide costs while satisfying service level requirements” (Mak & Ramaprasad, 2003, p. 175). This, in essence, states that SCM must create an infrastructure of knowledge and information that facilitates the integrated operations of supply chains. Knowledge supply chains emerge that are “… integrated sets of manufacturing and distribution competence, engineering and technology deployment competence, and marketing and customer service competence that work together to market, design, and deliver end products and services to markets” (Mak & Ramaprasad, 2003, p. 175).

Others definition of SCM “The supply chain encompasses all activities associated with the flow and transformation of goods from raw materials stage (extraction), through to the end user, as well as the associated information flows. Material and information flow both up and down the supply chain. Supply chain management (SCM) is the integration of these activities through improved supply chain relationships to achieve a sustainable competitive advantage” Handfield RB (1999). In line with this definition, but extending to related terms, purchasing, sourcing, supply and supply chain were all used for identifying related publications. This is justified as the review in particular wanted to address inter-organisational issues. Hence, papers on purchasing were also included.

Meanwhile Sustainable development is defined as “a development that meets the needs of the present without compromising the ability of future generations to meet their own needs” WCED (1987). While diverse comprehensions of sustainability exist, one central concept helping to operational sustainability is the triple bottom line approach, where a minimum performance is to be achieved in the environmental, economic and social dimensions Elkington J (2002). This can be comprehended as being in line with the notion of order qualifiers a company has to fulfil before it is able to even
Handfield and Nichols (2002) stress the importance of relationships in a supply chain, which they define as “.. the integration and management of supply chain organizations and activities through cooperative organizational relationships, effective business processes and high levels of information sharing to create high-performing value systems...” (Handfield & Nichols, 2002, p. 8). In this view, the supply chain should encompass the management of information and knowledge systems in order to be successful. Simply, a supply chain consists of the following processes within the network: buying raw materials, making and designing products, inventory management, selling to customers, and delivery of products (Poirier & Bauer, 2001). Whether done by one stand-alone firm (known as a vertically integrated firm), or a network of firms (dispersed in their business functions), each of these processes contributes to the product design manufacturing, selling, and delivery to the customer. Portals, through their unique enterprise-wide architecture, contribute to the information and knowledge sharing needs of each process. The following sections will examine the potential contribution of portal technology.

SUPPLY CHAIN PORTAL TECHNOLOGY

Portal technology has emerged as an enabler of supply chain strategies, offering increased distributed access to partners through standard technology applications and processes. Initially, many larger organizations adopted electronic data interchange (EDI), an electronic messaging standard defining the data formats for the exchange of key business documents across private networks or the Internet. The Internet became important during the mid 1990s with the emergence of the World Wide Web and the adoption of HTML. Companies began to convert their EDI information exchange technologies to HTML, and later standardized XML formats in order to take advantage of greater selection of business applications, and the increased availability to all partners offered by the Internet. But for many organizations, the Web connection has become a strategic tool that strengthens the buyer-supplier relationship through establishing broad information connections that have a major impact on the overall supply strategy (Zank & Vokurka, 2003).

Initially, portals were used as an intrafirm system linking various functional areas of an organization together to share information. Usually linking various modules of an enterprise resource planning system (ERP), they allowed information to flow between the traditional silos of a business. Purchasing, engineering, manufacturing, logistics, and accounting could now receive and utilize data from all points along an internal supply chain (Handfield & Nichols, 2002). Supply chain portals evolved to become the first interfirm portals to be commercialized and are now central to addressing the challenges of interfirm portals. Facilitating the flow of information and knowledge through every supply chain business process, supply chain portals extend the capability of members to share information and plan operations based on each other’s activities. As production supply chains become more integrated as a result of increased information flows, the initial stage in the production chain, the product design and development stage, is increasing its level of interfirm information and recently knowledge sharing. Both formal and informal sources of knowledge contribute to the successful design and development of new products and processes, and much of this information must come from sources external to the organization such as customers and supply chain partners (Paquette & Moffat, 2005).

SUPPLY CHAIN COLLABORATION WITH PORTAL TECHNOLOGY

As previously discussed, a supply chain incorporates processes involving buying, making, inventory, selling, and delivery. Each of these processes can benefit from an extended enterprise structure supported by portal technology. The buying function of a supply chain procures the necessary materials required for the product of the goods and services. In order to lower costs by leveraging combined purchasing volumes, a portal can link the network’s buyers into one central purchasing function, allowing for controlled costs and the ability to negotiate lower costs based on volumes from the entire network. Standardized items can be designated, allowing for further standardization throughout the network. Tracking information for purchases can be made available to the entire network, allowing for production and sales planning at the other end of the supply chain. Notification of supply shortages or delays can be shared with network participants, allowing them to plan their schedules accordingly. Ultimately, a purchasing partnership may emerge, which is “... an agreement between a buyer and a supplier that involves a commitment over an extended time period, and includes the sharing of information along with a sharing of the risks and rewards of the relationship” (F.-R.Lin, Huang, & Lin, 2002, p. 148).
The making of goods and services, which would include the product design and development functions, can gain a great deal of value from portal technology. In supply chains following the collaborative model, network partners face the challenge of connecting with their partners to exchange product requirements information (Lin, Hung, & Wu, 2002). Portal applications supporting production chain collaboration should allow for the acquisition, sharing, optimization, and utilization of these requirements between customers and partners to detect any discrepancies or gaps within the requirements. Concurrent engineering (Mclvor, Humphreys, & McCurry, 2003) supports collaborative product design processes through connecting multifunctional teams comprising of design and manufacturing employees and customers and suppliers. Portal technology linking supply chain applications can play a major role in supporting such concurrent engineering. Collaborative work applications implemented by all partners across the supply chain can be instrumental in the development of specifications, creation of interchangeable parts, part standardization or simplification, and part exclusion, all of which contribute towards cost reduction. Huang and Mak (1999) describe such a system consisting of "virtual consultants" in "virtual teams" organized within a “virtual office” equipped with “virtual design board,” available to all participants no matter where they are located, whether internal or external.

NEEDED OF PORTAL

Climate change in IT and demographics turnover are changing the fundamentals of world economy – supply chain management concept need to look forward and use different information to inform decisions. Markets will be threatened by new factors and success measured against tomorrow’s needs. Sustainability report had to present the business case for disclosing their performance data. To drive change and added value, organization need to shift the question from “Why do you use intranet portal?” to “Why don’t you use intranet portal?” By looking at the proposed framework (figure 1), factors towards sustainable portal utilization derived from 7 factors: responsiveness, assurance, tangible, empathy, reliability, data quality and security.

FIGURE 1
PROPOSED FRAMEWORK

The quality perspective derived from Portal Quality Model (PQM) by Moraga, Calero, and Piattini (2004). This model has been made using as a basis the SERVQUAL model, presented by Parasuraman, Zeithami, and Berry (1998) and the GQM (Goal Question Metric) method (Basili, Caldiera, & Rombach, 1994). The different dimensions of the SERVQUAL model have been adapted to the portal context and some of them are split up into sub dimensions, in order to create a quality model for Web portals. As a final result, the dimensions identified for the PQM model are:
1/ Responsiveness: Willingness of the portal to help and provide its functionality
   • Scalability: Ability of the portal to adapt smoothly to increasing workloads
   • Speed: Ability of the portal to remain within the response time boundaries tolerated by portal users.

2/ Empathy: Ability of the portal to provide caring and individual attention
   • Navigation: Simplicity and intuitiveness of the navigation paths provided by the portal.
   • Presentation: Clarity and uniformity of the interface.
   • Integration: Degree of global portal coherence achieved after the inclusion of the components
   • Personalization: The portal’s capability to adapt to the user’s priorities.

3/ Tangible: Characteristic of the portal according to its functionality.
   • Adaptability: Ability of the portal to be adapted to different devices
   • Transparent access: Ability of the portal to provide access to the resources

4/ Reliability: Ability of the portal to perform its functionality accurately.
   • Fault tolerance: Capability of the portal to maintain a specified level of performance
   • Resource utilization: Capability of the portal to offer its resources to the user according to his profile
   • Availability: Capability of the portal to be always operative, access and use it anywhere, anytime.
   • Search Quality: Appropriateness of the results that the portal provides when undertaking a search/request made by the user.

5/ Data quality (DQ): This characteristic is defined as the quality of the data contained in the portal.
   • Intrinsic DQ: Degree of care taken in the creation and preparation of information.
   • Representation DQ: Degree of care taken in the presentation and organization of information for users.
   • Accessibility DQ: Degree of freedom that users have to use data, define or refine the manner in which information is input, processed or presented to them.
   • Contextual DQ: Degree to which the information provided meets the needs of the users.

6/ Security: Capability of the portal to prevent, reduce, and respond to malicious attacks adequately. Its sub characteristics are:
   • Access control: Capability of the portal to allow access to its resources only to authorized people. Thus, the portal must be able to identify, authenticate, and authorize its users.
   • Security control: Capability of the portal to carry out auditing of security and to detect attacks. The auditing of security shows the degree to which security personnel are enabled to audit the status and use of security mechanisms by analysing security-related events. In addition, attack detection seeks to detect, record, and notify attempted attacks as well as successful attacks.
   • Confidentiality: Ability to guard the privacy of the users.
   • Integrity: Capability of the portal to protect components (of data, hardware, and software) from intentional or unauthorized modifications.

7/ Assurance: is “The ability of the portal to convey trust and confidence”.
   • Confidentiality: Ability to keep the privacy of the users.

Previously, supply chain management has moved from a low-profile, ancillary concern to a recognized strategic component with tangible, positive impact on the firm’s bottom line. Adapt to business activities background, supply chain management is currently taking centre stage in business planning (Lancioni R, 2000). Capturing the attention of senior managers, shareholders, and academics, supply chain management is, today, a respected management science with a strong and growing body of theory, testable models, and empirical research. At the heart of this shift in status are technology riven changes in marketplace conditions, the evolution of business practices, new expectations among supply chain participants, and, ultimately, the demand for increased value by end users.

User satisfaction has received favourite attention of researchers since the 1980s as an important surrogate measure of information systems success (Aladwani and Palvia, 2002; Aladwani, 2002; Bailey and Pearson, 1983; Goodhue and Thompson, 1995). While most user satisfaction instruments were developed for transaction processing and traditional systems that were not Web-based at the time of development, some instruments have been successfully validated in an Internet-based environment. This validation is important if we assume that the Internet provides a unique environment that makes a user’s experience considerably different from that of a traditional information system. In the
In the paragraphs that follow we provide a review of literature on user satisfaction primarily from a measurement perspective. This research evaluates multiple dimensions that can affect user satisfaction (Sampson and Manouselis, 2004). As a first step, the authors defined several dimensions related to the main satisfaction factors:

<table>
<thead>
<tr>
<th>Dimensions</th>
<th>Web portal content</th>
<th>Design of a Web portal</th>
<th>Personalization</th>
<th>Community support</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Web portal content</strong></td>
<td><strong>Satisfaction from content organization</strong>: refers to the categorization of information so as to enable efficient search and retrieval.</td>
<td><strong>Satisfaction from content organization</strong>: closely related to the organization of content. In this context, however, it is approached rather from the system design perspective, and it can therefore be considered independent.</td>
<td><strong>Satisfaction from the personalization of navigation</strong>: All issues related to the adjustment of the navigation mechanism and functions to the needs of individual users.</td>
<td><strong>Satisfaction from the communication support</strong>: It refers to tools and services related to the communication between the members of a virtual community.</td>
</tr>
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<td></td>
<td><strong>Satisfaction from content creditability</strong>: refers to the trust and reliability of the information and the content provider and has multiple facets, such as the accuracy and clarity of the content and the trustworthiness, recognition and reputation of the content author or provider.</td>
<td><strong>Satisfaction from information architecture</strong>: Address all issues related to the interaction and navigation of the user in the portal.</td>
<td><strong>Satisfaction from the personalization of information/content</strong>: All issues related to notifying users about new relevant content and providing them with information tailored to their needs and preferences.</td>
<td><strong>Satisfaction from the collaboration support</strong>: Related to the tools and services allowing effective and efficient collaboration between users.</td>
</tr>
<tr>
<td></td>
<td><strong>Satisfaction from content usefulness</strong>: refers the focus of the content, the use of appropriate language, and the usefulness of information according to the needs of the audience to whom it is directed.</td>
<td><strong>Satisfaction from usability</strong>: Address all issues related to the interaction and navigation of the user in the portal.</td>
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<td></td>
<td><strong>Satisfaction from content integration</strong>: concerns all content services related with the integration of external sources of information and the provision of links to external resources.</td>
<td><strong>Satisfaction from graphical design</strong>: The Web portal design should be subject to periodical revisions and redesigns from time to time, with the minimum possible effect to the portal operation.</td>
<td><strong>Satisfaction from the personalization of interface</strong>: related issues to the adaptation of the interface to the needs and preferences of the users and the properties of their equipment.</td>
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</tr>
<tr>
<td></td>
<td><strong>Design of a Web portal</strong></td>
<td><strong>Satisfaction from technical integrity/ performance</strong>: The dimension concerned with proper operation of the Web portal services and the satisfactory performance of the overall services.</td>
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<td></td>
</tr>
<tr>
<td></td>
<td><strong>Personalization</strong></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td><strong>Community support</strong></td>
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</tbody>
</table>
RESEARCH METHODOLOGY

Portal is rather modernized topic in an academic research, especially in Malaysia. Government in Malaysia currently looking forward to implement portal in order to assists, to gather information and to minimize workload. Portal roles and importance are recognised to monitor, simplify, control and promote their businesses.

This study will use questionnaire to collect data which was designed to equivalent with the objective of the study and conceptual framework. Likert Scale was applied as it considered as the one of the most appropriate and reliable measurement scale for such type of questions and is the most widely used scale in survey research. Questionnaires with 5 point rating scale were used to measure respondent’s evaluation by asking them the degree of importance with statements in the questionnaire that ranked from (1) least important or least problem to (5) most important or most problem. The higher the score the most important the variables are as evaluate criteria.

RESEARCH IMPLICATIONS

The lesson distilled from this study can be summarized on issues concerning the design and the requirement of portal. Users perspective can be value added in order to make the portal more sustain. Customers or users should be highlight about the benefits of using the portal so that it will make it more usable. This paper also provided the satisfaction issues that should be highly considered by the organizations so that they will know about the needs, expectation and also perception on their portal amongst the customers.

Current knowledge, in the forms of models and framework, is sufficiently mature to facilitate development of portal, which received little or not attention by most selected organizations. Concerning the quality factors, data quality and security is an added value and contribution of this paper, suitable to the that current situation of business processes and comply to the real world. Customers and also organization should look into portal issues since by optimizing the utilization of the portal, productivity of the organization can be increased.

CONCLUSION

As supply chains continue to move away from a commodity-based and more towards a collaborative model, their need for timely and accurate information throughout the supply network will increase. This demand allows for portal technology to be deployed in order to meet the inter firm information and knowledge-sharing needs. From the design and development of new products to their marketing and delivery, portals can supply the supply chain with the information required to meet the cost and time requirements of customers. Portal technology can create a competitive advantage for a supply chain by enabling its information and knowledge sharing capabilities to provide organizations with up-to the-minute information regarding new products, customer demand, inventory status, and production schedules. As Internet technologies, and in particular portal applications, become more common amongst supply-chain members, their ability to create, identify, and utilize critical supply information will lead them to new levels of service, innovation, and success.

This conceptual paper provides managers, portal development team and also customers with ideas on how the portal can be employed to improve the management of their supply chain systems. The researcher look at all of the major components of supply chain management and demonstrate that the future holds tremendous opportunity for those firms that take advantage of all of its possibilities. To ensure the quality factors together blended with the development of portal, sustainability of its usage will provide benefits to the organizations.

REFERENCES


THE DEVELOPMENT OF THE INTEGRATED SUPPLY CHAIN CENTER USING SUFFICIENT ECONOMY APPROACH: A CASE STUDY OF BETTA FISH VILLAGE IN NHONGPAKROENG, MUENG, NAKHON PATHOM

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THE DEVELOPMENT OF THE INTEGRATED SUPPLY CHAIN CENTER USING SUFFICIENT ECONOMY APPROACH: A CASE STUDY OF BETTA FISH VILLAGE IN NHONGPAKROENG, MUENG, NAKHON PATHOM

by

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ABSTRACT

Due to the study “Building the Betta Fish Supply Chain Database System for Export,” the researchers conducted field studies and several interviews on people who participated in the Betta fish supply chain system in Nakhon Pathom. The results show that the quality of Thai ornamental fish are widely accepted around international market especially the Betta Splendens (Siamese Fighting Fish) which is a local breed and very popular in the market. The researchers believe that Betta fish businesses in Thailand are in the forms of household business and community enterprise which have a very distinctive characteristic of its own. The nature of the business, according to the researchers, is merit a thorough research study and knowledge exchange about life cycle of the Betta fish, breeding technique, breeder way of life, and traditional knowledge in fish farming. This would leads to the development of integrated eco-tourism center which would create more income and improve standard of living of breeders and the locals. Furthermore, it will also preserve traditional folkways with the inclusion of creative economy approach for the local community. The objectives of this research study is to develop the potential for the supply chain center, “the Betta Fish Village,” and the integrated Betta fish supply chain study center through sufficiency economy approach. The case study for this research is focuses on Betta fish farming community in Nhongpakroeng, Mueng, Nakhon Pathom. The scope of the study will be focuses on local community context, community capital such as economic and social capital, and human capital in order to develop further into the development of potential eco-tourism center, “Betta Fish Village.” This would be the creation eco-tourism sightseeing place that integrated study center and the creation of creative economy for sustainable development for local community.

KEYWORDS
Potential, Supply Chain, Betta Fish, Sufficiency Economy

BACKGROUND AND OBJECTIVES

The creation of local community strength by increasing its potential by focusing on the use and maximizing its resources for self-reliance sufficiently and sustainably is the strategy of the 11th National Development Plan. Nakhon Pathom is a province that is known for its biological diversity and fertile natural resources. The province also has a rich traditional local knowledge that supports sustainable development. Moreover, the area made its name as the largest Betta (Siamese fighting fish) breeding place in Thailand. The Betta, which is the most popular local breed for decades, was raised as export product due to its beautiful coloration on its tail. The researchers conducted field studies and several interviews on people who participated in the Betta fish supply chain system in Nakhon Pathom. The results show that Thai ornamental or aquarium fish are wildly accepted by importers around the world due to its quality, especially for the Betta. The researchers believe that Betta fish businesses in Thailand are in the forms of household business and community enterprise which have a very distinctive characteristic of its own. The nature of the business, according to the researchers, is merit a thorough research study and knowledge exchange about life cycle of the Betta fish, breeding technique, breeder way of life, and traditional knowledge in fish farming. This would leads to the development of integrated eco-tourism center which would create more income and improve standard of living of breeders and the locals. Furthermore, it will also preserve traditional folkways with the inclusion of creative economy approach for the local community. The researchers selected Nhongpakroeng, Mueng, Nakhon Pathom community as the study area due to the density of Betta breeders in the area and the reputation of the Betta as one of the best in Thailand. The area also known for its sufficiency agricultural way of life and the use of traditional knowledge that can be develop into a well known eco-tourism center for the province in the future. The administration in the province can also build tourist route that appropriate to its tradition and folkways. This would increase potential for Nakhon Pathom in term of competitiveness in order to be a province that has a higher standard of living and develop at the national level. Hence, the objectives of this
study is to develop potential for eco-tourism center, “the Betta fish village,” and integrated Betta fish supply chain study center using sufficiency economy approach for breeders group in Nhongpakroeng, Mueng, Nakhon Pathom.

**THEORY AND SCOPE OF THE STUDY**

The research study the development of the integrated supply chain center using sufficiency economy approach: the case study of Betta fish village in Nhongpakroeng, Mueng, Nakhon Pathom aims to develop community potential by integrated with others development fields to achieve the highest level by using the following theories and concepts.

*Tourism behavioral analysis*

According to Nawarat Pleaynoi, Mekong Region Tourism Research Center, Khon Kean University (2548), the analysis of tourism behavior commonly focuses on the three important factors that individual use in selecting destinations. These factors include travel expenditure, time for travel, and commitment on traveling. These three important factors are the determinants that satisfy human thirst for traveling. It is also that scope that point out the differences of direction and behavior based on the limitation of factors such as income, time, and commitment on tourist places that have better quality and modernity.

The commitment in traveling is always changed as McIntosh and Goeldner (1980: 124-125) indicate that it’s usually based on 4 motivators, i.e.:

1. Physical Motivators: this is the factor that encourages tourism for leisure, relaxation or health, and sporting activities or vocation on the beach.
2. Culture: this factor encourages tourism for knowledge or learning experience that focuses several local cultures.
3. Interpersonal Motivators: this factor encourages tourism that lead to the meeting of relatives or many people.
4. Status or Prestige Motivators: this is the factor that aiming to improve the status of the individual in order to increase prestige and honor. For example, travel abroad, seminar or observe activities trip etc., are the kind of traveling that shows honor or success in career.

Moreover, there are more important motivators such as career motivators which originated from daily operation in workplace or welfare from private company such as travel for a seminar, observe activities, training, or award from career achievement etc. As a result, the above motivators are the origin of the objectives of each individual in finding travel destination.

*Tourism Destination Development*

Kotler (cited in Richardson and Fluker, 2004) states that travel destination is the existing place according to perception of traveler. Travel destination can be divided into many levels, for example, area level, local level, national level, and regional level. However, for convenience, World Tourism Organization divided travel destinations according to administrative level, which is village, sub-district, district, province, and continent.

Middleton (cited in Richardson and Fluker, 2004) indicates that travel destination is the product of tourism which consists of 5 elements.

1. Interesting point – for instance, area where there are beautiful scenery, museum, shopping mall, or amusement park etc.
2. Accommodation – for instance, hotel, restaurant, public transportation, tourist center etc.
3. Accessibility – easiness to access to travel destination which also referring to number of choices.
4. Image – for instance, thought and belief of travelers on the travel destination.
5. Price – this include all the travel expenditure i.e., travel expense, accommodation, entrance fees. The travel expense of the same travel destination can vary differently according to the level of traveling method and accommodation or even travel seasons.

*Concept related to the logistics of sustainable tourism*

Pureath Foundation (2007) says that sustainable tourism is the kind of tourism that satisfied the need of travelers and the host community. It focuses on natural resources, cultural, and local community way of life management for highest benefits at present and in the future.
Nowadays, sustainable development is the trend that all groups are interested in. In order to push forward sustainable development, it is necessary that all sides must commit to the course and maintain under the concept of sustainable development as follows:

1. Sustainable development must operate under the capability to support by local natural resources, culture, tradition, ways of life that related to tourism.
2. Realizes about community participation
3. Allows host community to receive economic benefits that resulted from tourism management justly.
4. Must be guided by the desire of host community.
5. Allows visitors to understand and learn about local area, natural resources, and traditional ways of life.

The researchers will incorporate these sustainable tourism concepts to study the development of traditional and eco-tourism for the local community in order to develop into tourism and learning center in the future.

CONCEPTUAL FRAMEWORK

Conceptual framework of the study to develop integrated eco-tourism center, “Betta fish village,” by using sufficiency economy approach at Nhongpakroeng, Mueng, Nakhon Pathom will be focuses on local community context, community capital such as economic and social capital, and human capital in order to develop further into the development of potential for eco-tourism center, “Betta Fish Village.” This would be the creation eco-tourism sightseeing place that integrated study center and the creation of creative economy for sustainable development for local community. This can be explains by the following conceptual model:

FIGURE 1
CONCEPTUAL MODEL

<table>
<thead>
<tr>
<th>Community context</th>
</tr>
</thead>
<tbody>
<tr>
<td>Community economic and social capital</td>
</tr>
<tr>
<td>Human capital</td>
</tr>
<tr>
<td>Creative economy</td>
</tr>
</tbody>
</table>

BENEFITS OF THE STUDY

1. The study aims to know about the community context, community economic and social capital of the Betta breeders in Nhongpakroeng, Mueng, Nakhon Pathom.
3. To build integrated eco-tourism center which will be the pilot learning center that incorporated many fields of study with creative economy and sufficiency economy approach.
RESEARCH METHODOLOGY

<table>
<thead>
<tr>
<th>Description</th>
<th>Month</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Researchers have participated with betta fish community and supply chain</td>
<td></td>
</tr>
<tr>
<td>2. Set up discussion among communities</td>
<td></td>
</tr>
<tr>
<td>3. Study prototype of betta fish learning center</td>
<td></td>
</tr>
<tr>
<td>4. Collect information and study feasibility</td>
<td></td>
</tr>
<tr>
<td>5. Study and analysis Betta fish learning center</td>
<td></td>
</tr>
<tr>
<td>6. Discussion with betta fish stakeholders and study betta fish learning center</td>
<td></td>
</tr>
<tr>
<td>7. Set up team and committees of betta fish village to operate supply chain betta fish learning center</td>
<td></td>
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<tr>
<td>8. Set up supply chain betta fish learning center in Nakornpatom</td>
<td></td>
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<tr>
<td>9. Open supply chain betta fish learning center</td>
<td></td>
</tr>
<tr>
<td>10. Brainstorm learning center performance and report to Thai Research Center</td>
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<tr>
<td>10. Conclude data and information</td>
<td></td>
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<tr>
<td>11. Analysis</td>
<td></td>
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<tr>
<td>12. Present research to Thai Research Center</td>
<td></td>
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</tbody>
</table>

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Operation Research
A MULTI-OBJECTIVE ROBUST SUPPLY CHAIN DESIGN MODEL

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A MULTI-OBJECTIVE ROBUST SUPPLY CHAIN DESIGN MODEL

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ABSTRACT

We develop a multi-objective stochastic programming model for supply chain design under uncertainty using an interactive approach. This is a comprehensive model, which includes both the strategic and tactical levels. The uncertainty regarding demands, supplies, processing and transportation costs is captured by generating discrete scenarios with given probabilities of occurrences. The objective functions involved are the expected total cost (min), the variance of the total costs (min) to get a robust design, and the probability of not meeting a certain budget (min). Then, an interactive multi-objective technique with explicit trade-off information given named surrogate worth trade-off (SWT) method is used to solve the multi-objective model.

KEYWORDS
Supply Chain Management, Multiple Objective Programming, Stochastic Programming, Risk Management

INTRODUCTION

Many attempts have been made to model and optimize supply chain design, most of which are based on deterministic approaches, see for example Bok et al. [3], Timpe and Kallrath [10], Gjerdrum et al. [5] and many others. However, most real supply chain design problems are characterized by numerous sources of technical and commercial uncertainty, and so the assumption that all model parameters, such as cost coefficients, supplies, demand, etc., are known with certainty is not realistic.

In order to take into account the effects of the uncertainty in the production scenario, a two-stage stochastic model is proposed in this paper. Decision variables which characterize the network configuration, namely those binary variables which represent the existence and the location of plants and warehouses of the supply chain are considered as first-stage. On the other hand, decision variables related to the amount of products to be produced and stored in the nodes of the supply chain and the flows of materials transported among the entities of the network are considered as second-stage variables.

There are a few research works addressing comprehensive (strategic and tactical issues simultaneously) design of supply chain networks using two-stage stochastic models. MirHassani et al. [8] considered a two-stage model for multi-period capacity planning of supply chain networks. The authors used Benders decomposition to solve the resulting stochastic integer program. Tsiakis et al. [11] also considered a two-stage stochastic programming model for supply chain network design under demand uncertainty. The authors developed a large-scale mixed-integer linear programming model for this problem. Alonso-Ayuso et al. [1] proposed a branch-and-fix heuristic for solving two-stage stochastic supply chain design problems. Santoso et al. [9] integrated a sampling strategy with an accelerated Benders decomposition to solve supply chain design problems with continuous distributions for the uncertain parameters. However, the robustness of decision to uncertain parameters is not considered in above studies.
Azaron et al. [2] developed a multi-objective stochastic programming approach for designing robust supply chains. The objective functions of the model were (i) the minimization of the sum of current investment costs and the expected future processing, transportation, shortage and capacity expansion costs, (ii) the minimization of the variance of the total cost, and (iii) the minimization of the financial risk or the probability of not meeting a certain budget. Then, they used goal attainment technique, see Hwang and Masud [7] for details, to solve the resulting multi-objective problem. In this paper, we use an interactive multi-objective technique with explicit trade-off information given (SWT method), see [7] for details, to solve the problem as described in [2]. The other advantage of this paper over [2] is that we are going to minimize downside risk or risk of loss instead of financial risk.

**PROBLEM DESCRIPTION**

We first describe a deterministic mathematical formulation for the supply chain design problem. Consider a supply chain network $G=(N,A)$, where $N$ is the set of nodes and $A$ is the set of arcs. The set $N$ consists of the set of suppliers $S$, the set of possible processing facilities $P$ and the set of customer centers $C$, i.e., $N = S \cup P \cup C$. The processing facilities include manufacturing centers $M$ and warehouses $W$, i.e., $P = M \cup W$. Let $K$ be the set of products flowing through the supply chain.

The supply chain configuration decisions consist of deciding which of the processing centers to build. We associate a binary variable $y_i$ to these decisions: $y_i=1$ if processing facility $i$ is built, and 0 otherwise. The tactical decisions consist of routing the flow of each product $k \in K$ from the suppliers to the customers. We let $x_{ij}^k$ denote the flow of product $k$ from a node $i$ to a node $j$ of the network where $(ij) \in A$, and $z_j^k$ denote shortfall of product $k$ at customer centre $j$, when it is impossible to meet demand. A deterministic mathematical model for this supply chain design problem (1) is formulated as follows (see [9] for more details):

$$\text{Min} \quad \sum_{i \in P} c_i y_i + \sum_{k \in K} \sum_{(ij) \in A} q_{ij}^k x_{ij}^k + \sum_{k \in K} \sum_{j \in C} h_j^k z_j^k$$

s.t. 
$$y \in Y \subseteq \{0,1\}^{|P|}$$
$$\sum_{i \in N} x_{ij}^k - \sum_{i \in N} x_{ji}^k = 0 \quad \forall j \in P, \forall k \in K$$
$$\sum_{i \in N} x_{ij}^k + z_j^k \geq d_j^k \quad \forall j \in C, \forall k \in K$$
$$\sum_{j \in N} x_{ij}^k \leq s_i^k \quad \forall i \in S, \forall k \in K$$
$$\sum_{k \in K} \left( \sum_{i \in N} x_{ij}^k \right) \leq m_j y_j \quad \forall j \in P$$
$$x_{ij}^k \geq 0 \quad \forall (ij) \in A, \forall k \in K$$
$$z_j^k \geq 0 \quad \forall j \in C, \forall k \in K$$

(1)

We now propose a stochastic programming approach based on a recourse model with two stages to incorporate the uncertainty associated with demands, supplies, processing/transportation, shortage and capacity expansion costs. It is also assumed that we have the option of expanding the capacities of sites after the realization of uncertain parameters. Considering $\xi=(d,s,q,h,f)$ as the corresponding random vector, the two-stage stochastic model (2) is formulated as follows (see [2] for details):

$$\text{Min} \quad c^T y + E[G(y, \xi)]$$

s.t. 
$$y \in Y \subseteq \{0,1\}^{|P|}$$

[Expected Total Cost]

[Binary Variables]
where $G(y, \xi)$ is the optimal value of the following problem:

$$\text{Min} \quad q^T x + h^T z + f^T e$$

s.t.

- $Bx = 0$ [Flow Conservation]
- $Dx + z \geq d$ [Meeting Demand]
- $Sx \leq s$ [Supply Limit]
- $Rx \leq My + e$ [Capacity Constraint]
- $e \leq Oy$ [Capacity Expansion Limit]
- $x \in R_{+}^{[|K|]}$, $z \in R_{+}^{[|K|]}$, $e \in R_{+}^{[p]}$ [Continuous Variables]

$$\text{(2)}$$

In this paper, the uncertainty is represented by a set of discrete scenarios with given probabilities of occurrence.

**INTERACTIVE MULTI-OBJECTIVE TECHNIQUE**

As explained, to develop a robust model, two additional objective functions are added into the traditional supply chain design problem. The first is the minimization of the variance of the total cost, and the second is the minimization of the downside risk or the risk of loss. The definition of downside risk or the expected total loss is:

$$\text{DRisk} = \sum_{l=1}^{L} p_l \ast \text{Max}(\text{Cost}_l - \Omega, 0)$$

where $p_l$, $\Omega$ and $\text{Cost}_l$ represent the occurrence probability of $l$th scenario, available budget and total cost when $l$th scenario is realized, respectively. The proper multi-objective stochastic model (4) for our supply chain design problem will be:

$$\begin{align*}
\text{Min} & \quad f_1(x) = c^T y + \sum_{l=1}^{L} p_l (q^T_l x_l + h^T_l z_l + f^T_l e_l) \\
\text{Min} & \quad f_2(x) = \sum_{l=1}^{L} p_l \left( q^T_l x_l + h^T_l z_l + f^T_l e_l - \sum_{l=1}^{L} p_l (q^T_l x_l + h^T_l z_l + f^T_l e_l) \right)^2 \\
\text{Min} & \quad f_3(x) = \sum_{l=1}^{L} p_l \ast DR_l
\end{align*}$$

s.t.

- $Bx_l = 0$, $l = 1, \ldots, L$
- $Dx_l + z_l \geq d_l$, $l = 1, \ldots, L$
- $Sx_l \leq s_l$, $l = 1, \ldots, L$
- $Rx_l \leq My + e_l$, $l = 1, \ldots, L$
- $e_l \leq Oy$, $l = 1, \ldots, L$
- $c^T y + q^T_l x_l + h^T_l z_l + f^T_l e_l - \Omega \leq DR_l$, $l = 1, \ldots, L$
- $y \in Y \subseteq \{0,1\}^p$
- $x \in R_{+}^{[|K|]}$, $z \in R_{+}^{[|K|]}$, $e \in R_{+}^{[p]}$, $DR \in R_{+}^{L}$

$$\text{(4)}$$

*Surrogate worth trade-off (SWT) method*

In this subsection, we explain the details of the SWT method, which is an interactive approach with explicit trade-off information given. It is a virtue that all the alternatives during the solution process are non-dominated. Thus the decision maker is not bothered with any other kind of solutions. The major steps in the SWT method to solve the multi-objective problem (4) are:
Step 1. Determine the ideal solution for each of the objectives in problem (4). Then, set up the multi-objective problem in the form of (5).

\[
\text{Min } f_j(x) \\
\text{s.t.: } f_2(x) \leq \varepsilon_2 \\
\quad f_3(x) \leq \varepsilon_3 \\
\quad x \in S \quad \text{(Feasible region of problem (4))} \\
\] (5)

Step 2. Identify and generate a set of non-dominated solutions by varying \( \varepsilon \)'s parametrically in problem (5). Assuming \( \mu_j, j=2,3 \), as the Lagrange multipliers corresponding with the first set of constraints of problem (5), the non-dominated solutions are the ones, which have non-zero values for \( \mu_j \).

Step 3. Interact with the DM to assess the surrogate worth function \( w_j \), or the DM’s assessment of how much (from –10 to 10) he prefers trading \( \mu_j \) marginal units of the first objective for one marginal unit of the \( j \)th objective \( f_j(x) \), given the other objectives remaining at their current values.

Step 4. Isolate the indifference solutions. The solutions, which have \( w_j = 0 \) for all \( j \), are said to be indifference solutions. If there exists no indifference solution, develop approximate relations for all worth functions \( w_j = \hat{w}_j \left( f_j, j = 2,3 \right) \), by multiple regressions. Solve the simultaneous equations \( \hat{w}_j \left( f_j \right) = 0 \) for all \( j \) to obtain \( f' \) (\( f' \) does not include \( f_{1*} \)). Then, solve problem (6). Present this solution to the DM, and ask if this is an indifference solution. If yes, it is a preferred solution; proceed to Step 5. Otherwise, repeat the process of generating more non-dominated solutions around \( \hat{w}_j \left( f_j \right) = 0 \) and refining the estimated \( f' \) until it results in an indifference solution.

\[
\text{Min } f_j(x) \\
\text{s.t.: } f_2(x) \leq f_{2*}(x) \\
\quad f_3(x) \leq f_{3*}(x) \\
\quad x \in S \\
\] (6)

Step 5. The optimal solution \( f_{1*} \) along with \( f' \) and \( x^* \) would be the optimal solution to the multi-objective problem (4).

NUMERICAL EXAMPLE

Consider the supply chain network design problem depicted in Fig. 1. A wine company is willing to design its supply chain. This company owns three customer centers located in three different cities L, M, and N, respectively. Uniform-quality wine in bulk (raw material) is supplied from four wineries located in A, B, C and D. There are four possible locations E, F, G and H for building the bottling plants.

FIGURE 1
THE SUPPLY CHAIN DESIGN PROBLEM OF THE WINE COMPANY

Wineries       Bottling Plants       Customer Centers

\begin{verbatim}
A       E       L     
B       F       M     
C       G       N     
D       H       
\end{verbatim}
For simplicity, without considering other market behaviors (e.g. novel promotion, marketing strategies of competitors and market-share effect in different markets), each market demand merely depends on the local economic conditions. Assume that the future economy is either boom, good, fair, or poor, i.e. four situations with associated probabilities of 0.13, 0.25, 0.45, or 0.17, respectively. The unit production costs and market demands under each scenario are shown in Table 1.

The supplies, transportation costs and shortage costs are considered as deterministic parameters. (475000, 425000, 500000, 450000) are investment costs for building each bottling plant E, F, G and H, respectively. (65.6, 155.5, 64.3, 175.3, 62, 150.5, 59.1, 174.5, 87.5, 208.9, 110.5, 100.5, 109, 97.8) are the unit costs of transporting bulk wine from each winery A, B, C and D to each bottling plant E, F, G and H, respectively. (200.5, 300.5, 699.5, 693, 533, 362, 163.8, 307, 594.8, 625, 613.6, 335.5) are the unit costs of transporting bottled wine from each bottling plant E, F, G and H to each distribution center L, M, and N, respectively. (10000, 13000, 12000) are the unit shortage costs at each distribution center L, M, and N, respectively. (375, 187, 250, 150) are the maximum amount of bulk wine that can be shipped from each winery A, B, C and D, respectively, (315, 260, 340, 280) are the capacities of each bottling plant E, F, G and H, respectively, if it is built.

We also have the option of expanding the capacity of bottling plant F, if it is built. (100, 80, 60, 50) are the unit capacity expansion costs, when the future economy is boom, good, fair or poor, respectively. In addition, we cannot expand the capacity of this plant more than 40 units in any situation.

### TABLE 1

<table>
<thead>
<tr>
<th>Future Economy</th>
<th>Demands</th>
<th>Unit Production Costs</th>
<th>Probabilities</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>L</td>
<td>M</td>
<td>N</td>
</tr>
<tr>
<td>Boom</td>
<td>400</td>
<td>188</td>
<td>200</td>
</tr>
<tr>
<td>Good</td>
<td>350</td>
<td>161</td>
<td>185</td>
</tr>
<tr>
<td>Fair</td>
<td>280</td>
<td>150</td>
<td>160</td>
</tr>
<tr>
<td>Poor</td>
<td>240</td>
<td>143</td>
<td>130</td>
</tr>
</tbody>
</table>

The problem attempts to minimize the expected total cost, the variance of the total cost and the downside risk in a multi-objective scheme while making the following determinations:

(a) Which of the bottling plants to build (first-stage variables)?
(b) Flows of materials transported among the entities of the network (second-stage variables)?

Now, we use SWT method to solve this multi-objective supply chain design problem. Using this method, the single objective optimization problem for generating a set of non-dominated solutions is formulated according to (5). Then, $\epsilon_j, j=2,3,$ are varied to obtain several non-dominated solutions.

For example, by considering $\epsilon_2 = 100000$ and $\epsilon_2 = 1000$, we obtain a non-dominated solution for the location variables as $[1,1,1,0]$, which can also be considered as an indifference solution by the DM. This indifference solution has the same structure as the STEM compromise solutions, but certainly with different second-stage variables. The corresponding objective vector is $f^* = (f_1^*, f_2^*, f_3^*) = (2143678,748031500,4467.3)$. The computational time to get this solution is equal to 06:39 (mm:ss).

### CONCLUSION

The proposed model in this paper accounts for the minimization of the expected total cost, the variance of the total cost and the downside risk in a multi-objective scheme to design a robust supply chain network. By using this methodology, the trade-off between the expected total cost and risk terms can be obtained. The interaction between the design objectives has also been shown.

We used SWT method to solve the problem. The main advantage of this interactive technique is that the preferred solution does not depend on the goal and weight vectors, unlike traditional goal programming technique.
Since the final mathematical model is a large-scale mixed-integer nonlinear program, developing a meta-heuristic approach such as genetic algorithm or simulated annealing will be helpful in terms of computational time.

REFERENCES


AN INCREMENTAL ONLINE HEURISTIC FOR EVALUATING THE FEASIBILITY OF THE m-VRPTWAR

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ABSTRACT

In this paper, a heuristic approach for evaluating the feasibility of an instance of the multi-depot heterogeneous fleet vehicle routing problem with time windows and assignment restrictions (m-VRPTWAR) is presented. The heuristic approach tries to find a feasible solution by solving two sub-problems of the m-VRPTWAR: a 3-dimensional variable-sized bin-packing problem (3DVSBPP) and a traveling salesman problem with time windows (TSPTW). In order to address the first problem, an on-line algorithm is presented. This algorithm expects shipments to be inserted in an online fashion and assigns them to freight routes by first-fit. Repacking already assigned shipments is permitted. The TSPTW part of the problem is addressed by a 2-phase heuristic that is based on algorithms presented by Savelsbergh (1985) and Ascheuer (1996). If there is no feasible solution for a new shipment, this shipment will be rejected. The heuristic approach is evaluated by solving several large-scale scenarios and monitoring the rejection rate of the algorithm.

KEYWORDS
Vehicle Routing, Time Window, Assignment Restriction, Heuristic, Online Algorithm
INTRODUCTION

In this paper a heuristic approach for evaluating the feasibility of an instance of the Multi-Depot Heterogeneous Fleet Vehicle Routing Problem with Time Windows and Assignment Restrictions (m-VRPTWAR) is presented. In this problem an assignment of a set of shipments to a set of freight routes that minimizes the unused cargo volume of the vehicles has to be determined. The assignment of each shipment is restricted to a subset of the freight routes. Furthermore, the shipment has to be delivered in a specified time window. Thus it is necessary to determine an order of the shipments of each freight route that guarantees the observance of all time windows. An introduction to this problem, including an ILP (Integer Linear Program) formulation and first calculation results for solving the problem to optimality, can be found in [37]. In further research, it is required that for a given set of shipments and freight routes there always has to be a feasible solution. In a real-life example that assumption might be critical. It cannot be excluded that there is a shipment that will not fit in any vehicle or that the time window of a shipment conflicts with another time window. For that purpose a heuristic algorithm is developed that will be able to evaluate the feasibility of an instance of the m-VRPTWAR. The algorithm expects the shipments to be added to the problem instance in an online fashion and separately evaluates the feasibility after each addition of a shipment. If no feasible solution can be found the recently added shipment will be rejected.

Further down a heuristic algorithm is introduced that tries to find a feasible solution for an instance of the m-VRPTWAR by solving two sub-problems: a 3-Dimensional Variable-sized Bin Packing Problem (3DVSBPP) and a Traveling Salesman Problem with Time Windows (TSPTW). The connection of these problems and the overall complexity of finding a feasible solution for the m-VRPTWAR will be discussed in the next section.

COMPLEXITY

In the introductory work [37] it could be shown that the m-VRPTWAR includes two known sub-problems, the Bin-Packing Problem (BPP) and the Traveling Salesman Problem with Time Windows (TSPTW). This fact has been used to prove that the optimization problem is NP-hard. First of all it shall be shown that the decision, whether a feasible solution for an instance of the m-VRPTWAR exists or not, is a NP-complete problem, in a similar way.

The problem of deciding whether an instance of the m-VRPTWAR can be solved is NP-complete. We are given a problem-instance Π with one single freight route \( l_1 \) and the shipments \( S = \{s_1, \ldots, s_N\} \). Suppose it is possible to assign all shipments to this freight route \( l_1 \) without exceeding its capacity or breaking the assignment restrictions. For this instance of the m-VRPTWAR it has to be verified if an order of shipments exists, for which all delivery time windows can be met. This is equal to the feasibility problem of the “Traveling Salesman Problem with Time Windows” (TSPTW) according to [7], which, as shown in [34], is a NP-complete problem. Since the feasibility problem of the m-VRPTWAR itself obviously belongs to the complexity class NP and furthermore includes the feasibility problem of the TSPTW as a special case, the assumption is proven.

In addition to the above remarks, the NP-completeness of the solvability problem can be derived from the proof of the optimization problem’s NP-hardness in [37]. Thus the m-VRPTWAR includes the Bin-Packing Problem as a special case, the NP-completeness of the corresponding decision problem is indicated. This makes clear, that the solvability problem itself can only be solved with high computing complexity, even if only very few shipments are assigned to the freight routes, so that the order of the shipments can be determined relatively fast. Due to the solvability problem’s complexity, the chosen heuristic approach seems to be suitable for determining a m-VRPTWAR-instance’s solvability.
**RELATED WORK**

The Multi-Depot Heterogeneous Fleet Vehicle Routing Problem with Time Windows and Assignment Restrictions is a relatively new problem class. There does not exist any preliminary work in scientific literature at this point, which is relevant for this publication. Regarding an exact solution method and the formulation as ILP, we refer to [37]. As mentioned before, it is possible to divide an instance of the m-VRPTWAR into a Bin-Packing Problem and a Traveling-Salesman Problem with Time Windows. Therefore it does certainly make sense to analyze existing literature regarding the solution of these sub-problems. The classical Bin-Packing Problem consists in distributing \(N\) objects of the defined weight \(w_i\) into \(M\) bins of equal capacity \(c\), in such a way that as few bins as possible are needed to store all objects. “Variable-Sized Bin-Packing” (VSBPP) according to [16] is a version of the BPP where the capacities of the bins differ.

Thus in this case not the number of bins, but the required total capacity should be minimized. Furthermore both problem-models have been extended to higher dimensional problems, where not only a weight but a weight-vector \(\vec{w_i} = (w_1^i, w_2^i, \ldots, w_d^i)\) of the objects is given. The bins’ capacities are consequently also defined as vectors. In this case one speaks of “d-Dimensional Bin Packing” (d-DBPP) or “Vector Bin Packing” (VPP). “3-Dimensional Variable-Sized Bin-Packing” (3DVSBPP) corresponds to the problem addressed in this work, except for taking delivery time windows and assignment restrictions into account. The three dimensions are cargo volume, payload limit, and maximum number of shipments assigned to a freight route. There will be taken a closer look at this relation in the description of the heuristic. The classical BPP has been discussed extensively in scientific literature and was one of the first problems, for which the approximate solving methods have been tested for their asymptotical worst-case performance.

**Definition 1: Asymptotical worst-case performance of Bin-Packing Problems**

Let \(L\) be the list of objects in a Bin-Packing Problem, and let \(A\) be an approximate algorithm for this problem. Let \(A(L)\) be the number of bins required for the solution by algorithm \(A\), and let \(OPT(L)\) be the number of bins of an optimal solution. According to [36], the definition of the asymptotical worst-case performance of algorithm \(A\) is represented as

\[
R^m_A = \limsup_{k \to \infty} \sup_{L \in \mathcal{A}} \left\{ \frac{A(L)}{OPT(L)} \middle| OPT(L) = k \right\}
\]

The most common solution methods for the BPP are “First-Fit” (FF) and “Best-Fit” (BF) with a worst-case performance of \(17/10\), as well as “First-Fit Decreasing” (FFD) and “Best-Fit Decreasing” (BFD) with a performance of \(11/9\). An elaborate overview of these and further algorithms for the classical BPP and their asymptotical behaviour is given in [8]. The work in [22] relies on the idea of the FFD and BDF algorithms and adapts these to the VSPBPP. The resulting algorithms “Iterative First-Fit Decreasing” (IFFD) and “Iterative Best-Fit Decreasing” (IBFD) achieve a worst-case performance of \(3/2\). These algorithms use the FFD and BFD algorithms respectively, to find a feasible solution for the VSBPP and then go through a phase, in which further feasible solutions are generated through iteratively redistributing the objects. At the end, the best of these solutions is selected. If the objects’ weights and the bins’ capacities are in a defined relation, IFFD and IBFD always find the optimal solution. Further algorithms for the VSBPP have been proposed amongst others in [13] and [32].

In addition to the introduced algorithms there are online algorithms for both bin-packing variants, where the assumption is made that not all objects can be assigned to the bins at the same time, but have to be added to the system sequentially. For the BPP especially the “Next-Fit” Algorithm according to [21], which has a performance of 2, and the HARMONIC Algorithm in [25] are to be mentioned (cf. [36]). The latter has been adapted to the VSBPP in [9] as VARIABLE HARMONIC Algorithm. The author of [35] was able to show that under certain circumstances this algorithm is an optimal approximative algorithm for the VSBPP. Another solution method for the BPP, which is settled between the typical offline- and online algorithms, is described in [20]. This method demands, like an online algorithm, that objects are added to
the system and distributed sequentially, but allows to withdraw objects from a bin and relocate them. This leads to a significantly better worst-case performance compared to online algorithms, namely \( \frac{5}{4} \). For the solution of the d-dimensional problem variants, usually the previously mentioned l-dimensional methods are carried out first. Therefore weight- and capacity vectors are transformed to scalar values. Different possibilities for such a transformation, like computing the sum or product of the vector components, are discussed in [18], [23], [28], and [10]. These adapted solution methods mostly achieve a notably worse worst-case performance compared to their classical pendants, but within the online algorithms ‘d-dimensional First-Fit’ (d-FF) for \( d \geq 2 \) is considered to be the best known approximative solution algorithm for the d-DBPP, achieving a worst-case performance of \( d + \frac{7}{10} \) (cf. [17]). Algorithms which have been explicitly developed for multidimensional Bin-Packing Problems, are amongst others described in [26] and [12].

The “Traveling Salesman Problem with Time Windows” (TSPTW) like the classical TSP consists in finding an optimal circular tour through \( N \) different nodes, but additionally the time window of each single node has to be met. In scientific literature different approaches to solving the TSPTW optimally have been proposed. The first works on this topic, which are [7] and [4], are based on special Branch-and-Bound algorithms and were successfully implemented for problems with up to 50 nodes, yet have efficiency issues if the time windows of a problem instance are overlapping too much. In [24] a modified formulation of the problem model is used, which is designed especially for the handling of time windows. Further exact solution methods, which rely on dynamic- or constraint-programming, were examined in [11] and [33]. In [15] classical optimization techniques are combined with constraint programming methods to a hybrid algorithm. These methods could successfully solve problems with up to 200 nodes. A variant of the TSPTW, where the distance between two nodes is not symmetric - the so-called asymmetric TSPTW -, is described thoroughly in [2; 3]. Especially in newer scientific literature several heuristic approaches can be found beside these exact solution methods. These heuristic approaches are mostly based on meta-heuristics like Local Search [34], Tabu Search [6], Simulated Annealing [31], Genetic Algorithms [29; 30], Ant Colony Optimization Algorithms [27] or Variable Neighborhood Search [14]. In [19] a so-called Insertion Heuristic is described, where all nodes of the TSPTW are added to a path sequentially in such a way that this path meets all time windows. As soon as the path goes through all nodes of the TSPTW, which means that a feasible solution has been found, it is optimized by iteratively deleting and re-inserting nodes. This heuristic has proved to be very robust towards overlapping time windows and in most cases finds optimal or nearly-optimal solutions. The last heuristic algorithm, which should be mentioned here, goes back to [5]. It solves a special auxiliary problem exactly and afterwards transforms its solution to a solution for the TSPTW via a heuristic method. The solutions found this way were often better than those, which have been determined using the previously mentioned heuristic according to [19].

**Heuristic Approach**

The task of the heuristic developed here is to check if for a given set \( S \) of shipments and a given set \( L \) of freight routes a feasible solution of the m-VRPTWAR exists, when a further shipment \( s_i \) is added to the system. This problem is NP-complete, which means that it probably cannot be solved efficiently (if the presumption \( P \neq NP \) holds). Therefore a suitable strategy might be dividing this problem into less complex sub-problems. Like mentioned before, solving the 3DVSBBP and TSPTW as sub-problems seems to be the task. In the following, heuristics for these two sub-problems shall be presented, which can then be combined to a heuristic for the m-VRPTWAR.

**Heuristic for the Bin-Packing Sub-Problem**

In this chapter at first delivery time windows are not taken into account. This means the only task is to find a feasible assignment of the shipments to the freight routes. Yet, the shipments are not known from the beginning, but step by step added to the system. Thus it is a typical application for online algorithms. Now, one could think about redistributing all previously added shipments, when a new shipment is added, to use
the advantages of offline algorithms. But presumably in a realistic scenario the number of shipments is so big, that regarding the heuristic’s performance, such an offline strategy would be too time-consuming. Since repacking shipments from one freight route to another is not strictly excluded in the problem, it nevertheless makes sense to adopt it in the algorithm at least to some limited extent (semi-online algorithm). As shown in [20], the algorithm can be considerably improved this way.

If time windows are not taken into account in the problem described above, it is the severally mentioned Bin-Packing Problem. More precisely it is the “3-Dimensional Variable-Sized Bin Packing Problem” (3DVSBPP), since for every freight route there are the three dimensions cargo volume, payload limit, and maximum number of shipments assignable to a freight route (“3-Dimensional”), and the maximum value of these three dimensions can vary for each freight route (“Variable-Sized”). The assignment restrictions are problematic since they are normally not considered in the Bin-Packing Problem. However, if a single shipment $s_i$ is considered, which has to be assigned to one of the freight lines of set $B$, the problem can again be considered a Bin-Packing Problem. Therefore, in the problem dealt with here, for each shipment a local instance of the 3DVSBPP has to be solved. It is obvious, that through an optimal assignment in these local instances, also globally an optimal assignment is achieved. Hence, despite assignment restrictions, it makes sense to search for a heuristic for the 3DVSBPP in the following. Several methods of different authors for solving the Bin-Packing Problem have already been presented. For the 3DVSBPP, however, no heuristic solution method has been proposed, yet. Thus in the following it cannot be relied on a proven heuristic. Like it is shown in [17], the First Fit Algorithm with an asymptotical worst-case performance of $d + \frac{7}{2}$ for $d \geq 2$ is the best known online approximation-algorithm for the d-DBPP, known. Therefore, this algorithm shall form the basis of the algorithm to be developed, which will be called “Repacking First Fit” (RFF) Algorithm. First the algorithm tries to find a freight route to which the shipment can be assigned, using the First Fit Algorithm. If no such freight route exists, the repacking-phase is initiated. Thereby it is tried to take back an already assigned shipment in such a way, that the freight route is preferably filled completely, after assigning the new shipment to it. This approach is supposed to make room for the new shipment on the one hand, and on the other hand to ensure that as the cargo volume of the freight routes is utilized as much as possible. The RFF Algorithm can be described as follows:

**Repacking First Fit (RFF) Algorithm**

1. Initialise the algorithm with set $L$ of freight routes. At the beginning each of these freight routes is empty.
2. Wait until a new shipment $s_{new}$ is added to the system.
3. Use the First Fit Algorithm to search for a freight route, to which the shipment $s_{new}$ can be assigned. This assignment has to be feasible. If such a freight route is found, assign the shipment to this freight route and go back to step 2.
4. If no such freight route is found, search for the freight route which has the least remaining capacity, after a shipment which has already been assigned to this freight route is replaced by $s_{new}$. The replacement must not lead to an infeasible solution.
5. If no freight route is found, the shipment $s_{new}$ has to be rejected. Go back to step 2.
6. If the maximum repacking-depth is reached, all withdrawals have to be revoked and the originally new shipment has to be rejected. Go back to step 2.
7. Otherwise, withdraw from the previously chosen freight route the shipment that leads to the lowest remaining capacity after replacing it with $s_{new}$, and assign $s_{new}$ to this route. The removed shipment is now considered as a new shipment and the algorithm continues with step 3.

On the one hand this algorithm demands that shipments are added to the system sequentially, but on the other hand allows repacking of a certain number of shipments from one freight route to another, for
adding a new shipment. This number is called repacking depth. In the carried out calculation results a repacking depth of 6 shipments has proven suitable. It is important to pay attention that a shipment is only allowed to be removed, if it has not already been removed and repacked in the previous step. To complete the heuristic for the m-VRPTWAR, this algorithm has to be extended in such a way, that it can steadily be guaranteed that a feasible order of a freight route’s shipments exists. Therefore in the following paragraph another algorithm is presented, which has to be integrated into the RFF Algorithm. The integration has to be made at the place at which the above heuristic checks the feasibility of the current assignment, thus in step 3 and step 4. This way, at this point it is not only checked if the capacity restrictions and assignment restrictions are met, but also if an order of shipments exists, which meets the time windows of each shipment. The heuristic for the m-VRPTWAR is now complete.

**Heuristic for the Traveling-Salesman Sub-Problem**

If only shipments are considered, which have been assigned to one single freight route, and an order of these shipments, in which all time windows are met, is being determined, this order is a feasible solution of the “Traveling Salesman Problem with Time Windows”. In technical literature different algorithms for finding an optimal order of the TSPTW were proposed. For the problem described here, however, it is sufficient if the following algorithm is able to find any feasible order. Savelsbergh introduced a heuristic for an optimal solution of the TSPTW (cf. [34]), which requires knowing a feasible start-solution. Therefore in these work at the same time an algorithm was presented, which enables determining such a feasible start-solution. This algorithm seems to be suitable for determing a feasible order of the shipments, and thus is adopted in the following, with slide modifications. Since this algorithm is an offline algorithm, it computes a new order for all shipments of the freight route, every time a shipment is added, instead of adding the new shipment into the existing order. However, since the number of shipments, which can be assigned to a freight route is strongly restricted, this should not affect the heuristic’s execution time too bad. Moreover, the chance of finding a feasible order is increased by using such an offline strategy. The following list is a summary of the algorithm’s description according to Savelsbergh ([34]).

**Start-Solution Heuristic According to Savelsbergh**

1. Divide set $S$ of shipments $s_i$ with time windows $T_i = (t^i_1, t^i_2)$ in the set $S^-$ of those shipments with narrow delivery time windows and the set $S$ of those with wide delivery time windows.
2. Initialize the algorithm with start-order $(s_0, s_m)$. The shipments $s_0$ and $s_m$ are therefore created with the time windows $T_0 = (0, 0)$ and $T_m = (0, \infty)$, respectively, and mark beginning and end of the order to be determined.
3. For a given order $(s_0, s_1, s_2, \ldots, s_n, s_m)$ determine for each shipment $s_u \in S^-$ the pair of indices $i_u, i_{u+1}$ in between of which this shipment should be put. Therefore compute the value $C_1(i_u, u, i_{u+1})$ for each pair of shipments $s_i, s_{i+1}$ in the given order, in between of which the shipment $s_u$ can feasibly be put, and choose those indices $i^+_u, i^-_{u+1}$, for which $C_1$ is maximal. If the shipment cannot be put into any position, no feasible order exists, and the algorithm can be terminated.
4. From the set of shipments $S^-$ choose the shipment which should be added to the present order. Therefore, compute $C_2(i^+_n, u, i^-_{n+1})$ for each $s_u \in S^-$, with the indices $i^+_u, i^-_{u+1}$ for $s_u$ computed in the previous step. Select the shipment $s_u^*$ for which $C_2$ reaches a minimum.
5. Add the shipment $s_u^*$ at the position $i_u^*, i^-_{u+1}$ and remove $s_u^*$ from set $S^-$. 
6. If $S^-$ is not empty, continue with step 3.
7. For a given order $(s_0, s_1, s_2, \ldots, s_n, s_m)$, determine for each shipment $s_i \in S^+$ the pair of indices $i_u, i_{u+1}$ in between of which the shipment should be put. Therefore compute the value $C_2(i_u, u, i_{u+1})$ for each pair of shipments $s_i, s_{i+1}$ in the given order, in between
of which the shipment \( s_u \) can feasibly be put, and select those indices \( i_{n}^*,i_{n+1}^* \), for which \( C_2 \) is minimal. If the shipment cannot be put at any position, no feasible order exists and the algorithm can be terminated.

8. Select from the set of shipments \( S^+ \) the shipment which should be added to the present order. Therefore compute the value \( C_1(i_{n}^*,u,i_{n+1}^*) \) for each \( s_u \in S^+ \), with the indices \( i_{n}^*,i_{n+1}^* \) for \( s_u \), determined in step 7. Select the shipment \( s_u^* \) for which \( C_1 \) is maximal.

9. Add the shipment \( s_u^* \) to the order at position \( i_{n}^*,i_{n+1}^* \) and remove \( s_u^* \) from \( S^+ \).

10. If the set \( S^+ \) is not empty, continue with step 7.

11. Else all shipments have been assigned and the algorithm can be terminated successfully.

When a delivery time window is considered to be narrow or wide is not explicitly defined in the algorithm according to [34], but has to be chosen specifically for each application. In the measurements presented below, an interval of two hours has proven a suitable size for the time windows. The functions \( C_1 \) and \( C_2 \), which are used as selection criteria in the above algorithm, form indicators for the flexibility of an order (\( C_1 \)) as well as for the increase in the total temporal length of an order (\( C_2 \)). It should be mentioned, that when processing \( S^- \) and \( S^+ \) the functions \( C_1 \) and \( C_2 \) are each used in opposite ways. For an exact definition of these functions and further details of the above algorithm cf. [34]. To increase the presented heuristic’s efficiency, it shall be integrated into an algorithm, which has been described in [1]. This algorithm first checks if several easy computable orders are feasible, and only thereafter, uses a more complex heuristic. If combined with the previously described algorithm, the following procedure arises as a result. This algorithm can now be used, in this variant, for the m-VRPTWAR heuristic. In order to do this, only the mentioned integration into the RFF algorithm is needed.

**ALGORITHM FOR DETERMINING A FEASIBLE ORDER**

1. For a set \( S \) of shipments, check if the trivial order \((s_1,s_2,\ldots,s_N)\) is feasible.

2. Sort the set \( S \) by the start point of the shipments’ delivery time windows in an ascending order, and check if this order is feasible.

3. Sort the set \( S \) by the end point of the shipments’ delivery time windows in an ascending order, and check if this order is feasible.

4. Sort the set \( S \) by the central point of the shipments’ delivery time windows in an ascending order, and check if this order is feasible. The central point of a shipment’s time window \( T_i = (t_i^s,t_i^e) \) is defined as \( t_i^m = t_i^s + \frac{t_i^e - t_i^s}{2} \).

5. Try to find a feasible order using the start-solution heuristic according to Savelsbergh.

**CALCULATION RESULTS**

To evaluate the behaviour of the just presented RFF Algorithm, different large-scale test-scenarios have been created, using a generator-tool (cf. Table 1). In the created scenarios each relation between start- and target area is served by five different trucks. An important measurement variable, which should be recorded during the tests of the algorithm, is the number of shipments which are erroneously rejected by the test. To measure this value, during generating the test-scenarios it has to be ensured that all shipments of a test-scenario can theoretically be scheduled. Otherwise, when a shipment is rejected, it is not clear if it was rejected because it could actually not be scheduled, or because the heuristic rejected it erroneously. Moreover, it should be checked how the heuristic behaves when many shipments have already been accepted and it is becoming harder and harder to schedule another shipment. Therefore, the test-scenarios have been generated in such a fashion that an exact algorithm could calculate an assignment of the shipments to the freight routes, where no shipment is rejected and all freight routes are filled completely. The calculation results are shown in Figure 1 and 2.
**Table 1**

Detailed list of parameters of different test-scenarios for the RFF algorithm.

<table>
<thead>
<tr>
<th>Scenario name</th>
<th>Relations</th>
<th>Freight routes</th>
<th>Shipments</th>
</tr>
</thead>
<tbody>
<tr>
<td>RFF-1500</td>
<td>300</td>
<td>1500</td>
<td>6040</td>
</tr>
<tr>
<td>RFF-2000</td>
<td>400</td>
<td>2000</td>
<td>8085</td>
</tr>
<tr>
<td>RFF-2500</td>
<td>500</td>
<td>2500</td>
<td>10315</td>
</tr>
<tr>
<td>RFF-3000</td>
<td>600</td>
<td>3000</td>
<td>11955</td>
</tr>
<tr>
<td>RFF-3500</td>
<td>700</td>
<td>3500</td>
<td>14495</td>
</tr>
</tbody>
</table>

**Figure 1**

Rejection rate of the RFF algorithm for scenarios defined in Table 1.

**Figure 2**

Execution time of the RFF algorithm for scenarios defined in Table 1.
The measurements were carried out on an Intel Core 2 Quad Q9650 CPU with 4 Cores (3.0 GHz each) and 8 GB RAM. Windows 7 Professional 64-bit has been used as operating system. Furthermore the Java Virtual Machine (JVM) of SUN Java Development Kit (JDK) 1.6.0-20 has been employed, since the reference implementation of the heuristic method has been programmed in Java.

The measurements in Figure 1 show the heuristic’s behaviour for the test-scenarios, defined in Table 1. The values are plotted over the number of already added shipments. During each series of measurements the shipments were added to the scenario step by step and tested for their ability to be scheduled by the heuristic. After each test, the current rejection rate and totally required execution time was recorded and illustrated in the charts in Figure 2. Here, execution time stands for the time which is needed for checking all shipments. It is clearly observable that the heuristic rejects very few shipments (less than 1 %), as long as only a little part of the shipments was added to the scenario. Only after approximately $\frac{3}{4}$ of the shipments have been added, the rejection rate increases faster and ends at approximately 7.6 % in every scenario. Regarding the heuristic’s execution time a similar tendency can be observed. The greatest part of the total execution time is needed for the inspection of the last 25 % of shipments. Keeping in mind that the inspection of a shipment takes the longer the more shipments have to be repacked, this result is not surprising.

CONCLUSION & OUTLOOK

Based on current research activities, in this work, a heuristic method for checking the feasibility of an instance of the m-VRPTWAR has been presented. The heuristic is able to carry out this test in relatively short time and thereby, in the tests of the previous chapter, only rejects 7.6 % of the shipments erroneously. Regarding the algorithm’s heuristic character and the fact that we are dealing with an online process, this seems to be an acceptable result. The same is true for the algorithm’s execution time, which even in the worst case is not exceeding 44ms per shipment. Using a more complex algorithm which is able to further reduce the rejection rate, but has a higher execution time, can be thought of here. An imaginable strategy for doing so would be modifying the algorithm in such a fashion that not only one, but multiple assigned shipments from a freight route, are considered in the repacking phase, to make room for a newly arriving shipment. Likewise, the algorithm could be extended in such a way, that not only one shipment, but multiple shipments at the same time, can be withdrawn from different freight routes during repacking. Both repacking strategies would lead to checking considerably more possible shipment-freight-route combinations for feasibility, and it must be assumed that this decreases the algorithms rejection rate. This has to be investigated in further research works.

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THE MULTI-DEPOT HETEROGENEOUS FLEET VEHICLE ROUTING PROBLEM WITH TIME WINDOWS AND ASSIGNMENT RESTRICTIONS (m-VRPTWAR)

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ABSTRACT

In this paper, the multi-depot heterogeneous fleet vehicle routing problem with time windows and assignment restrictions (m-VRPTWAR) is introduced. The problem addresses the assignment of a set of shipments to a set of freight routes that the unused cargo volume of the vehicles will be minimized. The assignment of each shipment is restricted to a subset of the freight routes. Furthermore, the shipment has to be delivered in a specific time window. Thus, it is necessary to determine an order of the shipments of each freight route that guarantees the observance of all time windows. Firstly, a formulation of an integer linear program (ILP) for solving the m-VRPTWAR is developed and the problem is proven to be NP-hard. Afterwards, the ILP is evaluated by solving several large-scale scenarios using the solvers CPLEX and Gurobi.

KEYWORDS
Vehicle Routing, Multi-Depot, Time Window, Assignment Restriction, Integer Linear Program
INTRODUCTION

The subject of current research is the development of a novel logistic management system in the area of partial loads transportation. This system is based on so-called freight routes. Freight routes are fixed relations between a start and a target area that are periodically served by direct transport (see Figure 1). Partial loads are picked-up in the start area, loaded into a single truck and transported to the target area directly without the use of handling centers. Afterwards the loads are delivered to their respective recipients. Because the areas of the freight routes can overlap, the assignment of a partial load to a freight route is ambiguous. At this point, there is great potential for optimizations that can be used to reduce the unused cargo volume of the available trucks. Thus the transport network can be used more efficiently.

In the following a problem model, in form of an Integer Linear Program (ILP), is presented. This problem model determines a distribution of shipments over available freight routes, while minimizing the unused cargo volume. In this optimization process various restrictions have to be considered. The cargo volume of a freight route is always limited by its capacity. This limit refers both to spatial extent and to the total weight of cargo. In addition, it has to be possible to limit the number of shipments that will be assigned to the same freight route. Besides these restrictions there are also temporal constraints. The recipients of the shipments often specify time windows that must be considered during the delivery of the shipments. Thus, in context of the optimization process it is necessary to determine not only a distribution of the shipments over the freight routes, but also an order for the delivery of the shipments. This order must ensure that the time windows for all shipments of a freight route can be observed. Furthermore, the transport of a shipment usually is restricted to just a few days. Accordingly, the optimization technique must ensure that all shipments are delivered within the respective time windows. The last restriction to be considered here is referred to the assignment restriction in the following. As Figure 1 shows, a shipment can only be assigned to a freight route, that covers the shipment by its start and target area. In addition, freight routes are operated only on a single day. So only freight routes are considered, that are served on a day the shipment may be transported. In general, for each shipment a set of freight routes is defined, which can be used to transport the shipment. This fact is discussed below in more detail. It is assumed that shipments and freight routes are always chosen in a way, that it is possible to determine a distribution and an order of the shipments for each freight route. Accordingly, each assignment restriction includes at least one freight route.

RELATED WORK

Vehicle routing problems have always been the subject of research since the first work on this issue by [5]. The “Multi-Depot Heterogeneous Fleet Vehicle Routing Problem with Time Windows and Assignment Restrictions” (m-VRPTWAR), that is introduced in this paper, is a further contribution in this direction. There has been no known research done on this problem class, but there are some few related problems. In [6] a multilevel solution method has been shown for the “Multi-Depot Heterogeneous Fleet Vehicle Routing Problem with Time Windows”. First the algorithm determines reasonable clusters of the nodes with the
help of a heuristic and afterwards distributes these nodes over the trucks in a valid order by solving a Mixed Integer Linear Program (MILP). This method was able to solve problem instances with up to 100 nodes, but the deviations from the optimal solutions were at up to 30%. Furthermore, the solution method neither takes the assignment restrictions into account nor does it aim at the minimization of the unused cargo volume. The same problem class was covered by [7]. This work didn’t focus on the development of a solution method, but the development of an efficient mathematical formulation of the problem model was concerned. The authors first described a compact MILP and extended it by specific rules that can reduce the size of the MILP (measured by the number of variables). It was shown, that this could significantly decrease computation time. From this work a few ideas could be adopted for the formulation of the problem described here. Considering the more general problem class of the “Vehicle Routing Problem with Time Windows”, the papers of [3; 4], [1] and [2] may be referred.

**TERMS AND DEFINITIONS**

To build the following remarks on a solid mathematical framework, at first it is necessary to define some fundamental terms. Afterward these can be used to give a precise formulation of the mathematical model.

**Definition 1: Timestamp, Time Window, Time Span**

A timestamp \( t \in \mathbb{N} \) is a non-negative integer, that clearly references a specific point of time. All timestamps share a common basis (e.g. 01.01.1900, 0:00:00) and specify the time in seconds that has passed since this point of time. An ordered pair \( T = (t_1, t_2) \) of timestamps with \( t_1 \leq t_2 \) is called time window. The difference between the timestamps \( \bar{t} = t_2 - t_1 \geq 0 \) is named time span.

**Definition 2: Geographic Location, Set of all Geographic Locations**

An ordered pair \( A = (\lambda, \phi) \), which components are geographic coordinates on the globe, is called geographic location. For the longitude \( \lambda \in \mathbb{R} \) and the latitude \( \phi \in \mathbb{R} \) the conditions \(-180^\circ \leq \lambda \leq 180^\circ \) and \(-90^\circ \leq \phi \leq 90^\circ \) hold. Let \( \mathbb{W} \) denote the set of all geographic locations.

**Definition 3: Distance Function**

A function \( d: \mathbb{W} \times \mathbb{W} \rightarrow \mathbb{R} \) is called distance function, if for any geographic locations \( A \neq B \neq C \in \mathbb{W} \) the following conditions hold:

\[
\begin{align*}
&d(A, B) \geq 0 \quad \text{(The distance always is positive)} \\
&d(A, B) = 0 \iff A = B \quad \text{(A location only has a distance of zero to itself)} \\
&d(A, B) \leq d(A, C) + d(C, B) \quad \text{(A detour via location C can not decrease the distance)}
\end{align*}
\]

**Definition 4: Area Center, Area Dimension, Area, Set of all Areas**

Let \( A \in \mathbb{W} \) be a geographic location, \( r \in \mathbb{R} \) a real number and \( d: \mathbb{W} \times \mathbb{W} \rightarrow \mathbb{R} \) a distance function. Then the set \( G_{A, r, d} = \{ X \in \mathbb{W} \mid d(A, X) \leq r \} \subset \mathbb{W} \) is called area. In this case \( A \) is called area center and \( r \) is the area dimension. Let \( \mathbb{G} \) denote the set of all areas.

The shape of an area is significantly determined by the choice of its distance function. In the following two functions are considered exemplary. The function \( d_e \) calculates the Euclidean distance between two geographic locations. By contrast, the function \( d_t \) determines the time that is needed to reach from one geographic location to another when using the road network. In areas with a well developed road network the difference between these variants is marginal, but certainly there are examples with strong differences, as shown in Figure 2. Furthermore, the interpretation of the parameter \( \bar{r} \) is only possible in the context of the associated distance function. So \( \bar{r} \) can be interpreted as both: a metric or a time indication.
Definition 5: Shipment, Set of all Shipments
Let \( V \in \mathbb{W} \) be the place of dispatch, \( E \in \mathbb{W} \) the place of delivery, \( w \in \mathbb{R} \) the required loading metres, \( m \in \mathbb{R} \) the total weight, \( T = (t^s, t^f) \) the delivery time window, \( \bar{T} = (\bar{t}^s, \bar{t}^f) \) the time window of the transportation deadline and \( \bar{t} \) the time span needed for unloading. The tuple \( s = (V, E, w, m, T, \bar{T}, \bar{t}) \) is called shipment. The set of all shipments will be denoted by \( S \).

Definition 6: Freight Route, Set of all Freight Routes
Let \( G' \in \mathbb{G} \) be the start area, \( G'' \in \mathbb{G} \) the target area, \( c \in \mathbb{R} \) the available loading metres, \( a \in \mathbb{N}^+ \) the total amount of shipments and \( \tau = (\tau^s, \tau^f) \) a time window, that determines a specific day. The tuple \( l = (G', G'', c, n, a, \tau) \) is called freight route. The route is served on day \( \tau \) by exactly one truck. If the relation between start and target area has to be served by \( k \) trucks, each of this trucks defines a new freight route \( l_1, \ldots, l_k \) with its individual vehicle characteristics. Let \( L \) denote the set of all freight routes.

Definition 7: Cargo Volume of a Freight Route, Cargo Volume Utilization of a Shipment
Let \( S_i = (V_i, E_i, w_i, m_i, T_i, \bar{T}, \bar{t}) \in \mathbb{S}, i \in \mathbb{N} \) be a shipment and \( l_j = (G'_j, G''_j, c_j, n_j, a_j, \tau_j) \in \mathbb{L}, j \in \mathbb{N} \) be a freight route. The cargo volume of a freight route is determined by the function \( f : L \to \mathbb{R} \). This function can have various specifications, like \( f(l_j) = c_j \), \( f(l_j) = n_j \) or \( f(l_j) = c_j \cdot n_j \). The corresponding cargo volume utilization of a shipment is defined as the function \( g : \mathbb{S} \to \mathbb{R} \) with specifications like \( g(s_i) = w_i \), \( g(s_i) = m_i \) or \( g(s_i) = w_i \cdot m_i \). The respective specification of each function is related to the specific goal of optimization.

The Mathematical Model

Let \( S \subseteq \mathbb{S} \) be the set of shipments \( s_i = (V_i, E_i, w_i, m_i, T_i, \bar{T}, \bar{t}) \) with \( T_i = (t^s_i, t^f_i), \bar{T}_i = (\bar{t}^s_i, \bar{t}^f_i), i \in \mathbb{N} \) and \( L \subseteq \mathbb{L} \) the set of freight routes \( l_j = (G'_j, G''_j, c_j, n_j, a_j, \tau_j) \) with \( \tau_j = (\tau^s_j, \tau^f_j), j \in \mathbb{N} \), that are considered for the optimization. The objective of the optimization technique is to determine an feasible assignment of the shipments \( S \) to the freight routes \( L \) that minimizes the unused cargo volume of the trucks.

Definition 8: Assignment, Feasibility of an Assignment
An assignment is a function \( z : S \to L \) with
\[
z(s_i) = l_j, \text{ if } s_i \in S \text{ is transported by freight route } l_j \in L
\]
An assignment is feasible, if it complies with all restrictions mentioned in this section.
Defining the unused cargo volume is not possible by just using the recently presented definition of an assignment. For this purpose, the functions \( x : S \times L \rightarrow \{0, 1\} \) and \( y : L \rightarrow \{0, 1\} \) with

\[
x(s_i, l_j)_{\text{short}} = x_{ij} = \begin{cases} 1, & \text{if } z(s_i) = l_j \\ 0, & \text{otherwise} \end{cases}
\]

(2)

\[
y(l_j)_{\text{short}} = y_j = \begin{cases} 1, & \text{if } \exists s_i \in S : z(s_i) = l_j \\ 0, & \text{otherwise} \end{cases}
\]

(3)

have to be derived from the assignment \( z \). Using the definitions of the cargo volume and the cargo volume utilization, the unused cargo volume now can be determined to

\[
\sum_j [f(l_j) \cdot y_j - \sum_i g(s_i) \cdot x_{ij}]
\]

\[
\Leftrightarrow \sum_j f(l_j) \cdot y_j - \sum_i g(s_i) \cdot \sum_j x_{ij}
\]

(4)

Because the term \( \sum_i g(s_i) \) is constant for a fixed amount of shipments \( |S| \), the objective function of the ILP results in

\[
\min \sum_j f(l_j) \cdot y_j
\]

(5)

So, minimizing the unused cargo volume can be done by minimizing the overall available cargo volume. Of course, the consistency between the functions \( x \) and \( y \) has to be ensured. For this purpose, the ILP is extended with the constraints

\[
x_{ij} \leq y_j \ \forall i, j
\]

(6)

If \( x_{ij} \) is 1, implying that shipment \( s_i \) is assigned to freight route \( l_j \), the corresponding function value \( y_j \) must obtain the value 1 as well. Thus the functions will remain consistent. In addition, it must be ensured that each shipment is assigned to exactly one freight route. The necessary equation for the ILP is

\[
\sum_j x_{ij} = 1 \ \forall i
\]

(7)

Further constraints result from the limitation of the cargo capacity, the permissible total weight and the maximum amount of shipments of a freight route. These restrictions have to be observed for each freight route \( l_j \). The inequalities that must be added to the ILP for that purpose are

\[
\sum_i w_i \cdot x_{ij} \leq c_j \ \forall j
\]

(8)

\[
\sum_i m_i \cdot x_{ij} \leq n_j \ \forall j
\]

(9)

\[
\sum_i x_{ij} \leq a_j \ \forall j
\]

(10)

Finally the assignment restrictions of the shipments have to be taken into account. Let \( B_j \) be the set of all freight routes \( l_j \) the shipments \( s_i \) may be assigned to. From now on only the assignment restrictions regarding the start and target areas of the freight routes and the transportation deadlines of the shipments will be considered. Thus the set \( B_j \) is defined as

\[
B_j = \{l_j \mid V_l \in G^s_j, \ E_l \in G^e_j, \ \tau^s_l \leq \tau^s_j, \ \tau^e_l \leq \tau^e_j \}
\]

(11)

The start area \( G^s_j \) of route \( l_j \) must contain the place of dispatch \( V_l \) of shipment \( s_i \) and accordingly the target area \( G^e_j \) the place of delivery \( E_l \). Additionally, the day \( \tau_j = (\tau^s_j, \tau^e_j) \) the freight route is served has to match
the transportation deadline \( T_i = \langle t_i^l, t_i^u \rangle \) of the shipment. Further restrictions, like special freight routes for hazardous materials, can be included by a modified definition of \( B_i \). Restricting the assignment in the ILP can be achieved by using the constraints

\[
x_{ij} = 0 \quad \forall j \not\in B_i \quad \forall i
\]

These equations prevent the assignment of a shipment \( s_i \) to a freight route that is not part of the set \( B_i \). Alternatively, it would be possible to remove the corresponding variables \( x_{ij} \) from the model. However, here the assignment restriction is explicitly modelled, as shown in Equation 12.

For extending this model to consider delivery time windows, it is necessary to discuss the concept of assigning a shipment to a freight route. An assignment as defined above (Equation 1) does neither consider the determination of an order nor temporal restrictions between shipments. Thus, for a given assignment \( z \) and a given set of shipments \( S \) the ordering relation

\[
R(z) = \{(s_i, s_k) \mid z(s_i) = z(s_k)\} \subseteq S \times S
\]

has to be defined that determines an order for the delivery of the shipment. This order can be specified by a function \( r : S \times S \rightarrow \{0, 1\} \) with

\[
r(s_i, s_k) \overset{\text{short}}{=} r_{ik} = \begin{cases} 1, & \text{if } s_i \text{ is delivered before } s_k \\ 0, & \text{if } s_i \text{ is delivered after } s_k \end{cases}
\]

\[
r(s_i, s_k) = 1 - r(s_k, s_i)
\]

The function \( r \) is called ordering function. This function defines a total order of the shipments in \( S \). Of course, in context of the problem described above it is not necessary to determine an order for all shipments but only for these shipments \( s_i \) and \( s_k \) that are assigned to the same freight route. Thus, the function values \( r_{ik} \) are only defined for shipments \( s_i, s_k \) with \( z(s_i) = z(s_k) \) and \( i \neq k \).

**Definition 9: Ordered Assignment, Feasibility of an Ordered Assignment**

Let \( z : S \rightarrow L \) be an assignment and \( r : S \times S \rightarrow \{0, 1\} \) an ordering function. The pair of functions \( \langle z, r \rangle \) is called ordered assignment. If \( z \) is feasible and the ordering relation fulfills all delivery time windows, the ordered assignment \( \langle z, r \rangle \) is feasible as well.

Hence, the aim of the optimization technique is not determining a feasible assignment anymore, but determining a feasible ordered assignment while minimizing the unused cargo volume. For ensuring the observance of the delivery time windows by constraints in the ILP, a further auxiliary function \( t : S \rightarrow \mathbb{N} \) is needed. The function value \( t(s_i) \) specifies the point in time when the delivery of the shipment \( s_i \) will take place. So for two shipments \( s_i \) and \( s_k \) with \( r_{ik} = 1 \) and \( z(s_i) = z(s_k) \) the conditions

\[
t_k \geq t_i + \bar{t}_i + d_i(E_i, E_k) + \varepsilon
\]

always hold. The function \( d_i \) is equal to the distance function described above and determines the travel time of a truck between the place of delivery of shipment \( s_i \) to the place of delivery of shipment \( s_k \). Because the function values \( d_i(E_i, E_k) \) are constant in each of these constraints, they can be evaluated in a preprocessing stage. The constant \( \varepsilon \) functions as a temporal buffer.

The function values \( t_i \) are bounded by the delivery time windows of the shipments. This restriction is considered by adding the constraints

\[
t_i^l \leq t_i \leq t_i^u \quad \forall i
\]

to the ILP. Finally, it is necessary to take the temporal mutual dependencies from Inequation 15 into account.
when determining an order of the shipments. This can be achieved by the constraints (cf. [7] or [6])

\[
\begin{align*}
t_k & \geq t_i + d_i(E_i, E_k) + \varepsilon - M(1 - r_{ik}) - M(2 - x_{ij} - x_{kj}) & \forall i < k \forall k, j \quad (17) \\
t_i & \geq t_k + d_k(E_k, E_i) + \varepsilon - M \cdot r_{ik} - M(2 - x_{ij} - x_{kj}) & \forall i < k \forall k, j \quad (18)
\end{align*}
\]

Herein \( M \in \mathbb{N} \) is a sufficiently large integer. The terms \( M(1 - r_{ik}) \) and \( M \cdot r_{ik} \) ensure that for given \( i, k, j \) with \( i \neq k \) only one of Inequation 17 or Inequation 18 has to be satisfied. Similarly, the term \( M(2 - x_{ij} - x_{kj}) \) achieves that the inequations are only mandatory for shipments \( s_i \) and \( s_k \) that have been assigned to the same freight route \( l_j \). Extending the problem model with Inequation 16 to 18 is sufficient to determine a feasible ordered assignment of shipments to freight routes.

**Complexity**

After the problem of this work has been described in detail its complexity will be studied below. For that purpose the tools of the complexity theory can be utilized (see [9]).

**Theorem 1: Optimization Problem is NP-hard**

The “Multi-Depot Heterogeneous Fleet Vehicle Routing Problem with Time Windows and Assignment Restrictions” described above is NP-hard.

**Proof.** Given a problem instance \( \Pi \) of the ILP. For \( \Pi \) there are no assignment restrictions \( B_i = L \ \forall i \), the amount of shipments assigned to a freight route is unlimited \( a_j \rightarrow \infty \ \forall j \), there are no restrictions regarding the total weight \( m_i = 0, \ n_j > 0 \ \forall i, j \) and the delivery time windows are arbitrarily wide \( t_f = 0, \ t_r \rightarrow \infty \ \forall i \). The cargo volume \( f : L \rightarrow \mathbb{R} \) is specified as \( f(l_j) = 1 \ \forall l_j \in L \). For this problem instance it is not necessary to explicitly determine an order of the shipments. Because of the given delivery time windows the shipments can be arranged in any order. Instead it is possible to implicitly define an order of the shipments by the natural order of index \( i \). According to that, the problem instance \( \Pi \) is equal to the “Bin-Packing Problem” (BPP) as it is described, inter alia, by [10]. Thus, the m-VRPTWAR contains the BPP as a special case. As a consequence, the NP-hardness of the BPP as proven by [9] implies the NP-hardness of the m-VRPTWAR. \( \square \)

Considering the given problem complexity it is impossible to solve large worst-case scenarios of the m-VRPTWAR to optimality within a reasonable period of time (if the presumption \( P \neq NP \) holds). Hence, it is questionable, whether searching for an optimal solution is reasonable or if it is better to focus on approximation algorithms and heuristics. However, the assignment restrictions conspicuously reduce the amount of feasible assignments of shipments to freight routes so that considerably larger problem instances can be solved in the same time compared to an instance without assignment restrictions. In the latter case a naive solution algorithm would have to determine \( 2^{|S| \cdot |L|} \) different combinations of the function values \( x_{ij} \) and verify their feasibility. Using assignment restrictions with an average cardinality of \( |B_i| = b \) there are only \( 2^{|S| \cdot b} \) possible combinations. Based on the description of the problem for the average case the assumption \( b \ll |L| \) can be justified which implies \( 2^{|S| \cdot b} \ll 2^{|S| \cdot |L|} \). As a result, it might be possible to solve even large realistic problem instances within a reasonable period of time. In the best-case, finding an optimal assignment is even trivial. For \( |B_i| = 1 \ \forall i \) the assignment of each shipment is clearly set to a single freight route. So the optimal assignment easily can be determined to

\[
z(s_i) = l_j \text{ if } l_j \in B_i \ \forall i
\]

Afterwards an order of the shipments for each freight route has to be identified. This problem is equal to the “Traveling Salesman Problem with Time Windows”. Even though this problem belongs to the NP-hard problems [8] finding a feasible order should require relatively little time due to the fact that the amount of shipments assigned to a freight route is very limited (approximately \( \sum x_{ij} < 10 \ \forall j \)). This limitation can be deduced from the size of the shipments which are all partial loads as described above.
CALCULATION RESULTS

To evaluate the applicability of the presented ILP for solving the described problem, several realistic test scenarios have been created by using a generator tool (see Table 1). The columns “Variables” and “Constraints” show the amount of variables and constraints of the corresponding ILP. Each relation between a start and a target area is served by five different trucks. Afterwards an optimal ordered assignment has been determined for this scenarios. For the calculation of these assignments each of the solvers CPLEX and Gurobi were used. The measurements presented in the following have been performed on an Intel Core 2 Quad Q9650 processor with 4 cores (each 3.0 GHz) and 8 GB main memory. The operating system was Windows 7 Professional 64-bit. Due to the optimization technique was implemented in the programming language Java it was necessary to run the measurements with a Java Virtual Machine (JVM). For that purpose the JVM contained in the SUN Java Development Kit (JDK) 1.6.0-20 was used. The solvers CPLEX and Gurobi were present during the tests in versions 12.2 and 4.0.2. To enable the solution of even large scenarios, both solvers were configured to swap the used main memory to a hard drive if they have exhausted the available memory of 8 GB. In addition, all calculations were limited to a duration of 1.5 hours. If a calculation took more time, it has been aborted and the relative difference of the currently available solution to the optimal solution has been indicated.

So far, the objective function of the ILP has been considered only parametrized. The cargo volume $f : \mathbb{L} \rightarrow \mathbb{R}$ has not been defined clearly. Thus, to perform the test measurements the cargo volume $f$ of a freight route $l_j = (G_j^s, G_j^e, c_j, n_j, a_j, \tau_j)$ with area centers $A_j^s$ and $A_j^e$ has been specified to

$$f(l_j) = \frac{1}{2} \cdot \left( \frac{c_j}{c_{\max}} + \frac{n_j}{n_{\max}} \right) \cdot d_e(A_j^s, A_j^e) \quad \text{with} \quad c_{\max} = \max_j \{c_j\}, \quad n_{\max} = \max_j \{n_j\}$$

The first part of this equation determines the capacity of the truck serving the freight route in relation to a fictitious largest possible truck with available loading metres $c_{\max}$ and a payload limit of $n_{\max}$. This ratio is weighted with the length of the freight route that is given by the Euclidean distances $d_e$ between the area

<table>
<thead>
<tr>
<th>Name of Scenario</th>
<th>Relations</th>
<th>Freight Routes</th>
<th>Shipments</th>
<th>Variables</th>
<th>Constraints</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1500-S(mall)</td>
<td>300</td>
<td>1500</td>
<td>739</td>
<td>6645</td>
<td>17461</td>
</tr>
<tr>
<td>S1500-M(edium)</td>
<td>1546</td>
<td>14749</td>
<td>44212</td>
<td></td>
<td></td>
</tr>
<tr>
<td>S1500-L(large)</td>
<td>2094</td>
<td>20376</td>
<td>63087</td>
<td></td>
<td></td>
</tr>
<tr>
<td>S2500-S</td>
<td>500</td>
<td>2500</td>
<td>1805</td>
<td>16528</td>
<td>44515</td>
</tr>
<tr>
<td>S2500-M</td>
<td>2546</td>
<td>23778</td>
<td>67924</td>
<td></td>
<td></td>
</tr>
<tr>
<td>S2500-L</td>
<td>3644</td>
<td>35519</td>
<td>109607</td>
<td></td>
<td></td>
</tr>
<tr>
<td>S3500-S</td>
<td>700</td>
<td>3500</td>
<td>1984</td>
<td>19369</td>
<td>59565</td>
</tr>
<tr>
<td>S3500-M</td>
<td>3537</td>
<td>34996</td>
<td>111423</td>
<td></td>
<td></td>
</tr>
<tr>
<td>S3500-L</td>
<td>5332</td>
<td>54823</td>
<td>183891</td>
<td></td>
<td></td>
</tr>
<tr>
<td>S4500-S</td>
<td>900</td>
<td>4500</td>
<td>2217</td>
<td>20575</td>
<td>53007</td>
</tr>
<tr>
<td>S4500-M</td>
<td>4519</td>
<td>44484</td>
<td>135369</td>
<td></td>
<td></td>
</tr>
<tr>
<td>S4500-L</td>
<td>7074</td>
<td>72313</td>
<td>234711</td>
<td></td>
<td></td>
</tr>
<tr>
<td>S10000-S</td>
<td>2000</td>
<td>10000</td>
<td>5050</td>
<td>64893</td>
<td>298978</td>
</tr>
<tr>
<td>S10000-M</td>
<td>10122</td>
<td>126974</td>
<td>549774</td>
<td></td>
<td></td>
</tr>
<tr>
<td>S10000-L</td>
<td>15053</td>
<td>186857</td>
<td>787079</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

TABLE 1
DETAILED LISTING OF THE PARAMETERS OF THE DIFFERENT TEST SCENARIOS.
centers. As a result, small trucks driving on short freight routes are preferred for delivering the shipments. It is assumed that this leads to an economically optimized total traffic. Table 2 shows the measurements for the different test scenarios. Presented is the execution time for finding an optimal solution as well as solutions with 1 % and 5 % deviation to the optimal solution. If a timeout occurred (after 1.5 hours), the deviation between the best known solution and the optimal solution has been determined. The deviation is calculated from the best lower bound of the Branch&Bound algorithm used by CPLEX and Gurobi. Thus, the deviation indicates the maximum possible gap between the optimal and the best known solution.

### Table 2

**Comparison of the Solvers CPLEX and Gurobi for Different Scenarios in regard to Execution Time and Memory Usage**

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Opt.</th>
<th>1% Dev.</th>
<th>5% Dev.</th>
<th>Dev. on Timeout</th>
<th>peak Mem.</th>
<th>Opt.</th>
<th>1% Dev.</th>
<th>5% Dev.</th>
<th>Dev. on Timeout</th>
<th>peak Mem.</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1500-S</td>
<td>15s</td>
<td>15s</td>
<td>3s</td>
<td>-</td>
<td>0.35 GB</td>
<td>3s</td>
<td>3s</td>
<td>1s</td>
<td>-</td>
<td>0.76 GB</td>
</tr>
<tr>
<td>S1500-M</td>
<td>57s</td>
<td>57s</td>
<td>29s</td>
<td>-</td>
<td>0.89 GB</td>
<td>14s</td>
<td>12s</td>
<td>1s</td>
<td>-</td>
<td>1.05 GB</td>
</tr>
<tr>
<td>S1500-L</td>
<td>-</td>
<td>350s</td>
<td>25s</td>
<td>0.0724%</td>
<td>3.08 GB</td>
<td>24s</td>
<td>23s</td>
<td>3s</td>
<td>-</td>
<td>1.18 GB</td>
</tr>
<tr>
<td>S2500-S</td>
<td>-</td>
<td>142s</td>
<td>62s</td>
<td>0.0218%</td>
<td>1.55 GB</td>
<td>24s</td>
<td>14s</td>
<td>13s</td>
<td>-</td>
<td>1.12 GB</td>
</tr>
<tr>
<td>S2500-M</td>
<td>-</td>
<td>483s</td>
<td>116s</td>
<td>0.1037%</td>
<td>2.98 GB</td>
<td>37s</td>
<td>36s</td>
<td>34s</td>
<td>-</td>
<td>1.52 GB</td>
</tr>
<tr>
<td>S2500-L</td>
<td>235s</td>
<td>234s</td>
<td>49s</td>
<td>-</td>
<td>1.40 GB</td>
<td>82s</td>
<td>76s</td>
<td>5s</td>
<td>-</td>
<td>2.24 GB</td>
</tr>
<tr>
<td>S3500-S</td>
<td>851s</td>
<td>377s</td>
<td>377s</td>
<td>-</td>
<td>1.63 GB</td>
<td>1080s</td>
<td>31s</td>
<td>31s</td>
<td>-</td>
<td>6.71 GB</td>
</tr>
<tr>
<td>S3500-M</td>
<td>-</td>
<td>922s</td>
<td>787s</td>
<td>0.0654%</td>
<td>3.12 GB</td>
<td>482s</td>
<td>145s</td>
<td>68s</td>
<td>-</td>
<td>2.92 GB</td>
</tr>
<tr>
<td>S3500-L</td>
<td>-</td>
<td>5365s</td>
<td>103s</td>
<td>0.1913%</td>
<td>4.48 GB</td>
<td>-</td>
<td>179s</td>
<td>70s</td>
<td>0.0817%</td>
<td>63.08 GB</td>
</tr>
<tr>
<td>S4500-S</td>
<td>1271s</td>
<td>448s</td>
<td>91s</td>
<td>-</td>
<td>1.54 GB</td>
<td>45s</td>
<td>24s</td>
<td>24s</td>
<td>-</td>
<td>1.34 GB</td>
</tr>
<tr>
<td>S4500-M</td>
<td>-</td>
<td>3153s</td>
<td>90s</td>
<td>0.491%</td>
<td>3.29 GB</td>
<td>778s</td>
<td>122s</td>
<td>67s</td>
<td>-</td>
<td>3.46 GB</td>
</tr>
<tr>
<td>S4500-L</td>
<td>-</td>
<td>-</td>
<td>119s</td>
<td>3.1608%</td>
<td>5.46 GB</td>
<td>1231s</td>
<td>303s</td>
<td>104s</td>
<td>-</td>
<td>4.99 GB</td>
</tr>
<tr>
<td>S10000-S</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>7.2970%</td>
<td>5.92 GB</td>
<td>-</td>
<td>466s</td>
<td>466s</td>
<td>0.1882%</td>
<td>16.57 GB</td>
</tr>
<tr>
<td>S10000-M</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>6.0746%</td>
<td>11.22 GB</td>
<td>-</td>
<td>1503s</td>
<td>1.2572%</td>
<td>20.02 GB</td>
<td></td>
</tr>
<tr>
<td>S10000-L</td>
<td>-</td>
<td>-</td>
<td>602s</td>
<td>3.9919%</td>
<td>14.32 GB</td>
<td>-</td>
<td>1745s</td>
<td>2.4098%</td>
<td>22.14 GB</td>
<td></td>
</tr>
</tbody>
</table>

The results in Table 2 show that both solvers regularly fail in determining an optimal assignment in the specified time. As expected, this is associated with the increasing size of the scenarios. Here a high number of shipments seems to be more problematic for the solvers than a high number of freight routes. This result is not surprising, since an increasing number of freight routes leads to an increasing number of possible optimal assignments, whereas an increase of the shipments reduces this number. In addition, there are also other factors that determine the complexity of a scenario. So none of the solvers was able to solve the S3500-L scenario to optimality, but for several larger scenarios an optimal solution has been found.

In a direct comparison Gurobi turns out to be clearly inferior compared to CPLEX in determining an optimal solution, since the former may not even solve half as many scenarios as CPLEX to optimality. Moreover, CPLEX is generally preferable in regard to the computation times. Furthermore, the assignments found by CPLEX in the event of a timeout are almost always closer to the optimal solution. Only in terms of memory usage Gurobi has advantages over CPLEX. However, it is assumed that the beneficial computing times of CPLEX are also due to the high memory usage. Since the main memory is not a scarce resource in the problem discussed here, the high memory usage has to be considered rather as a further advantage of CPLEX.
CONCLUSION & OUTLOOK

In this work, an optimization technique for the disposition of shipments via freight routes has been presented. Based on a detailed description and analysis of the problem, at first a mathematical model in the form of an Integer Linear Program (ILP) has been developed. The tests in the previous section have shown that this model of the “Multi-Depot Heterogeneous Fleet Vehicle Routing Problem with Time Windows and Assignment Restrictions” abstracts the problem discussed here in an appropriate manner. This allows to include that problem class, which has not covered by the scientific literature so far, in the list of Vehicle Routing Problems. Moreover, it is possible to refine or extend the problem model in various places in future work. Thus, the cargo volume of a freight route has been defined to perform the tests, but it could not be shown that this definition also leads to the desired economic optimum. In this context, generally an extensive discussion of the objective function of the ILP is necessary. Since the distance traveled in the start and target areas is not considered yet, an extension of the objective function might be profitable. Solving the ILP using a standard solver has shown, that the solvers rapidly found good solutions for the given problem instances. In some test cases the selected solvers CPLEX and Gurobi reaching its limits and were unable to determine an optimal assignment in the available time period of 1.5 hours. However, an assignment that comes very close to the optimal solution can usually be found within a few minutes. At this point, a problem-specific solution algorithm that would certainly be able to solve larger problem instances to optimality can be developed in future work. In addition, it would be possible to preprocess a problem instance by a so-called clustering algorithm. This algorithm could try to split the set of freight routes into different clusters in a way that an assignment can be calculated separately for each of these clusters. As a result, large problem instances would be divided into smaller and thus easier solvable instances. Such a reduction of problem size, might cause a significant reduction in execution time. However, it must be examined, whether such clustering is applicable at all.

REFERENCES

AN M/M/M ANALYSIS OF PASSPORT CHECKING POINTS IN SUVARNABHUMI AIRPORT

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ABSTRACT

Suvarnabhumi airport has begun operating in Thailand now that requires correcting its deficiency in providing the service. One area needed in improving is its passenger building. The process in the building includes checking tickets, luggage weighting, ticket issuing, and passport checking for international passenger departure. The problem encountered in this process is a long congesting waiting line of the passengers. There are some researches dealing with assessing and improving efficiency in providing the services but cannot apply directly with Suvarnabhumi Airport. Hence, this paper aims to improve the efficiency in providing the service in passport checking for international passengers of Suvarnabhumi airport passenger buildings. The data is collected by observing that service point and this queuing system is analyzed by applying M/M/m models. Results of this study can be used to improve the operation of the airport.

KEYWORDS
Airport Passenger Building, M/M/m, Queuing Theory, Suvarnabhumi Airport

INTRODUCTION

Suvarnabhumi, meaning the Golden Land, Airport is a relatively new International Airport opened in 2006. It is located 25 kilometers from Bangkok. Suvarnabhumi accommodates 45 million passengers per year and 76 flights per hour which make it the third busiest airport in Asia, and the busiest in the country. Its passenger building is also the third largest single-building airport terminal in the world. The activities in this passenger building include checking passenger tickets, weighting the luggage, issuing the numbered tickets, checking flight transferred passengers. These activities automatically need waiting lines in providing the services. However, the waiting lines are very congested during peak hours. There are some studies in evaluating the service performances of the airports such as Don Mueang International Airport, Bangkok, Thailand (Tanastivanichchai, 1998) and Bandaranaike International Airport, Sri Lanka (Barros, 2007) which was done by using questionnaires. Some works also analyzed the waiting line systems in retail banks (Jiangalcharn, 2005). These works aimed at finding optimum services under the limited constraints. Since there is no study in analyzing the newly opened Suvarnabhumi Airport, this paper aims to apply the M/M/m waiting line theory to analyze this airport only the passport checking service.

DATA COLLECTION

This work collected data by using uninterrupted observation of the service of the passport checking points. The data collected the date, time, number of arrival passengers in each hour, number of service units, and average service time or the
service rate. This work picks the passport checking points in the passenger building because these points are the most congested activities in single-building airport terminal. The data is collected twenty-hours in each selected day. The data is collected four days. Two days are from a low season period in November 2010 and the other two days are from a high season period in December 2010. The numbers of hours collected totally is 96 hours.

**WAITING LINE THEORY**

The M/M/m waiting line model [Render] is used here. This model follows Kendall notation in representing a waiting line system.

- The first M means that the time between arrivals follows the Markowitz (exponential) distribution. Under this distribution, the arrival rate is a Poisson arrival. The number of arrivals is actually the number of passengers waiting for the service. The number of arrivals is assumed to be infinite or infinite calling population.

- The second M means that the service rate also follows the Markowitz (exponential) distribution. The service rate in the system is the average speed of time that the passport checking officers spent in providing service to the flight transferred passengers. The waiting line length is assumed to be unlimited.

- The last m is the number of service units which is the number of service counters of the passport checking points. The model proposed here also assumed that there is only one activity, which is the passport checking activity, in the system.

M/M/m waiting line model is used here due to its important property in memorylessness. This memoryless property means that the expected waiting time for receiving the service is the same as the average time no matter how long the arrival already spent waiting in the system. That means the waiting line system already has no memory at all. The memoryless property reflected very well of the true nature of the people in the arrivals or providing the service in which the data shows only the average arrival rate or the average service rate but the exact time that the next arrival will come or the exact time in finishing the service can not be mentioned.

With arrival rate \( \lambda \) and service rate \( \mu \), the formula used are as follows:

**Probability of idle:** \( P_0 = \frac{1}{\sum_{n=0}^{m-1} \frac{1}{n!} \left( \frac{\lambda}{\mu} \right)^n + \frac{1}{m!} \left( \frac{\lambda}{\mu} \right)^m \frac{m\mu}{m\mu - \lambda}} \)

**System length:** \( L = \frac{\lambda \mu (\lambda / \mu)^m}{(m-1)(m\mu - \lambda)} P_0 + \frac{\lambda}{\mu} \)

**System time:** \( W = \frac{L}{\lambda} \)

**Queue length:** \( L_q = L - \frac{\lambda}{\mu} \)

**Waiting line Time:** \( W_q = \frac{1}{\mu} - \frac{L_q}{\lambda} \)

**Utilization:** \( \sigma = \frac{\lambda}{m\mu} \)
THE RESULTS

M/M/m Goodness of Fit Test

To test the goodness of fit that the M/M/m waiting line model can be applied to the data, the distribution of the arrival passengers should be a Poisson and the distribution of the service time should be an exponential. The one sample K-S (Kolmogorov-Smirnov) test [5] is used to test the collected 4 days 96 hours data.

- For the arrivals, the averages of the arrival passengers per hour at the checking points during the high season is 459 passengers per hour and during the low season is 128 passengers per hour. The results form the K-S test in testing whether the arrival passenger distributions are Poisson show that the significance value from the high season data is 0.998 and the significance value from the low season is 0.270. Both values are greater than 0.05 which means the arrival passenger distributions do not deviate significantly from the Poisson distribution.

- For the service time, the averages of the service times per arrival at the checking points during the high season is 57.75 seconds per passenger and during the low season is 72.75 seconds per passenger. The results form the K-S test in testing whether the service time distributions are exponential show that the significance value from the high season data is 0.119 and the significance value from the low season is 0.105. Both values are greater than 0.05 which means the service time distributions do not deviate significantly from the exponential distribution.

- In conclusion, the K-S goodness of fit test shows that the arrivals are Poisson and the service time are exponential that means the M/M/m waiting line model can be applied to this collected data.

Waiting Line System Results

Since there are two checking points with four days data at each checking point, a high season one day (24 hours) data is shown in table 1 below to exemplify to result. The actual service units (m) is shown in column 3 of the table. The result shown that most of time spent in the system is the waiting time to be served. This can be seen from the high proportion of waiting time (Wq) compared with total time (W). This also can be seen that most of the arrivals are in the waiting line (Lq) compared with total arrivals in the system (L).
### TABLE 1
ANALYZED DATA OF DAY 1 OF HIGH SEASON AT THE PASSPORT CHECKING POINT 2

<table>
<thead>
<tr>
<th>From</th>
<th>To</th>
<th>m (units)</th>
<th>Arrivals (persons)</th>
<th>Service Time i (seconds)</th>
<th>L (persons)</th>
<th>Lq (persons)</th>
<th>W (minutes)</th>
<th>Wq (minutes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.00</td>
<td>0.59</td>
<td>8</td>
<td>464</td>
<td>61.10</td>
<td>63.699</td>
<td>55.832</td>
<td>8.246</td>
<td>7.227</td>
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<td>1.00</td>
<td>1.59</td>
<td>5</td>
<td>212</td>
<td>78.00</td>
<td>13.361</td>
<td>8.778</td>
<td>3.790</td>
<td>2.490</td>
</tr>
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<td>2.00</td>
<td>2.59</td>
<td>1</td>
<td>11</td>
<td>29.00</td>
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<td>0.142</td>
<td>2.424</td>
<td>0.758</td>
</tr>
<tr>
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<td>3.59</td>
<td>1</td>
<td>26</td>
<td>23.00</td>
<td>0.527</td>
<td>0.182</td>
<td>1.221</td>
<td>0.421</td>
</tr>
<tr>
<td>4.00</td>
<td>4.59</td>
<td>9</td>
<td>680</td>
<td>47.25</td>
<td>114.863</td>
<td>105.945</td>
<td>10.142</td>
<td>9.355</td>
</tr>
<tr>
<td>5.00</td>
<td>5.59</td>
<td>10</td>
<td>819</td>
<td>43.67</td>
<td>157.219</td>
<td>147.285</td>
<td>11.518</td>
<td>10.790</td>
</tr>
<tr>
<td>6.00</td>
<td>6.59</td>
<td>9</td>
<td>680</td>
<td>47.40</td>
<td>173.540</td>
<td>164.594</td>
<td>15.324</td>
<td>14.534</td>
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<tr>
<td>7.00</td>
<td>7.59</td>
<td>15</td>
<td>1,652</td>
<td>32.61</td>
<td>371.120</td>
<td>356.162</td>
<td>13.483</td>
<td>12.940</td>
</tr>
<tr>
<td>8.00</td>
<td>8.59</td>
<td>13</td>
<td>1,247</td>
<td>37.46</td>
<td>472.213</td>
<td>459.241</td>
<td>22.730</td>
<td>22.105</td>
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<td>1,274</td>
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<td>923</td>
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<td>310.334</td>
<td>299.370</td>
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<tr>
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<td>12</td>
<td>995</td>
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<td>319.656</td>
<td>307.694</td>
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<td>18.564</td>
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<tr>
<td>12.00</td>
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<td>1,089</td>
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<td>249.612</td>
<td>238.657</td>
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<td>860</td>
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<td>163.964</td>
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<tr>
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<td>14.59</td>
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<td>1,377</td>
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<td>263.922</td>
<td>251.969</td>
<td>11.500</td>
<td>10.979</td>
</tr>
<tr>
<td>15.00</td>
<td>15.59</td>
<td>9</td>
<td>1,517</td>
<td>21.30</td>
<td>333.301</td>
<td>324.328</td>
<td>13.187</td>
<td>12.832</td>
</tr>
<tr>
<td>16.00</td>
<td>16.59</td>
<td>8</td>
<td>774</td>
<td>37.06</td>
<td>245.763</td>
<td>237.796</td>
<td>19.051</td>
<td>18.434</td>
</tr>
<tr>
<td>17.00</td>
<td>17.59</td>
<td>11</td>
<td>891</td>
<td>44.22</td>
<td>206.131</td>
<td>195.186</td>
<td>13.881</td>
<td>13.144</td>
</tr>
<tr>
<td>18.00</td>
<td>18.59</td>
<td>9</td>
<td>905</td>
<td>35.69</td>
<td>273.064</td>
<td>264.097</td>
<td>18.114</td>
<td>17.519</td>
</tr>
<tr>
<td>19.00</td>
<td>19.59</td>
<td>10</td>
<td>1,134</td>
<td>31.65</td>
<td>335.909</td>
<td>325.940</td>
<td>17.773</td>
<td>17.245</td>
</tr>
<tr>
<td>20.00</td>
<td>20.59</td>
<td>7</td>
<td>549</td>
<td>45.67</td>
<td>198.321</td>
<td>191.357</td>
<td>21.674</td>
<td>20.913</td>
</tr>
<tr>
<td>21.00</td>
<td>21.59</td>
<td>12</td>
<td>1,274</td>
<td>33.86</td>
<td>527.887</td>
<td>515.910</td>
<td>24.871</td>
<td>24.307</td>
</tr>
<tr>
<td>22.00</td>
<td>22.59</td>
<td>14</td>
<td>1,841</td>
<td>27.32</td>
<td>425.528</td>
<td>411.561</td>
<td>13.872</td>
<td>13.417</td>
</tr>
<tr>
<td>23.00</td>
<td>23.59</td>
<td>16</td>
<td>2,655</td>
<td>21.66</td>
<td>556.169</td>
<td>540.198</td>
<td>12.569</td>
<td>12.208</td>
</tr>
</tbody>
</table>

**Estimated Costs**

The objective in designing an effective waiting line model is basically based on minimizing the trade off of the waiting line and the service cost. In order to estimated these two costs, this work uses the International dollar (Int $). This Int $ is a currency used by IMF (International Monetary Fund) when reporting GDP (gross domestic product) per capita or PPP (purchasing-power-parity) data. This Int $ used here is from the year 2009. The number of working hours per year is assumed to be 2,080 hours per year which is 8 hours per days x 5 days per week x 52 weeks per year.

- The waiting line cost is calculated by averaging the Int $ from the top ten nationalities of the international passengers that use Suvarnabhumi airport which is 33,587 Int $ per person per year. The estimated waiting line cost is 33,587 Int $ / 2080 hours or 16.147 Int $ per person per hour.
- The service cost is calculated by using Thailand Int $ of 8,634 Int $ per person per year. The estimated waiting line cost is 8,634 Int $ / 2080 hours or 4.155 Int $ per person per hour.
**A Recommend Improved System**

By adjusting the number of checking point counters opened, the system can be significantly improved considering based on the minimum total costs. An example of the proposed number of service counters is shown in table 2 below. For example from table 2 based on minimum total costs, 11 counters (service units) should be opened from 17:00 to 17:59, 10 counters from 18:00 to 18:59, and 19:00 to 19:59.

**TABLE 2**

**EXAMPLE OF A PROPOSED NUMBER OF SERVICE UNITS OPENED**

<table>
<thead>
<tr>
<th>Period (m)</th>
<th>Service Units (m)</th>
<th>Arrivals (A)</th>
<th>Service Rate (1/A)</th>
<th>Total Time (W)</th>
<th>Total Waiting Cost</th>
<th>Total Service Cost</th>
<th>Total Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>17.00 to 12</td>
<td>11</td>
<td>891</td>
<td>44.22</td>
<td>0.231</td>
<td>3.736</td>
<td>45.708</td>
<td>49.444</td>
</tr>
<tr>
<td>17.59</td>
<td>13</td>
<td>905</td>
<td>35.69</td>
<td>0.302</td>
<td>4.875</td>
<td>37.398</td>
<td>42.272</td>
</tr>
<tr>
<td>18.00 to 12</td>
<td>12</td>
<td>10</td>
<td>0.026</td>
<td>4.153</td>
<td>45.708</td>
<td>49.863</td>
<td>50.189</td>
</tr>
<tr>
<td>18.59</td>
<td>11</td>
<td>905</td>
<td>35.69</td>
<td>0.193</td>
<td>45.708</td>
<td>49.863</td>
<td>50.189</td>
</tr>
<tr>
<td>19.00 to 12</td>
<td>10</td>
<td>1134</td>
<td>31.65</td>
<td>0.173</td>
<td>45.708</td>
<td>49.863</td>
<td>50.189</td>
</tr>
</tbody>
</table>

**CONCLUSION**

This work proposes a more flexible ways in improving the passport checking points of Suvarnabhumi Airport based on minimizing the waiting line costs by adjusting the number of service counters opened by using the international dollar which is a GDP per capita to reflect a more accurate waiting line cost of the passengers using the airport.

Other waiting line models such as M/M/m with many activities or even the simulation approach can also be used to improve the performance of the airport. Also, other cost approaches can be used to reflect a more accurate waiting line costs.

**REFERENCES**


ALLOCATION DECISIONS FOR SUBSIDIZED PRODUCTS
CONSIDERING CONFLICTING OBJECTIVES OF STAKEHOLDERS

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by

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ABSTRACT

In the public sector environment, the design of distribution network is not always governed by the efficiency consideration. Very often, the equity and availability of products to the society is more important than achieving the most efficient distribution network design. In this study we present a model to design distribution network of a subsidized LPG products in Indonesia. In the last few years, Indonesian Government has been converting the consumption of kerosene to LPG, packaged in a special 3 kg container. This specific product is targeted for low-income households as well as micro-enterprises. The conversion has been done quite rapidly and thus, the supply chain of this product has not been very well prepared resulting in low efficiency, low responsiveness as well as high variance of utilization across different facilities in the distribution network. A goal programming model to evaluate (and design) the supply network of the above products has been developed. The objective is to obtain a distribution network design aiming at finding the best tradeoff between lower variance in utilization across different facilities in the network, better responsiveness to the customers reflected by reducing the long-distance shipments from one upstream to a downstream facility, and reducing the total transportation costs. The model was tested by using the data of a large province of Indonesia. Different weights to each of the above objectives have been assigned. The results show that weights have significant impacts on the performance of the resulted distribution network. The results also show that the recommended network has much better performance in terms of all objectives considered in this study.

KEYWORDS
Supply Network Design, Multi-Objective Decision Making, Public Sector, Supply Chain

INTRODUCTION

Designing distribution network is a strategic decision for almost every organization (Klose and Drexl, 2005; Altiparmak et al, 2006). It is a challenging task given the complex nature of the problem, especially when there are conflicting interests of different stakeholders. In general, within the business interest, a distribution network should be operating efficiently as well as responsive to customers. Business entities are obliged to maintain high service level to customers and at the same time are forced to operate under low cost and deliver high profit margin (Altiparmak et al, 2006). The ability to deliver products quickly to satisfy customer demand with high service level is a measure of responsiveness, while the total costs involved in investing, operating, and connecting facilities within the distribution network will determine the level of efficiency. The configuration of the supply chain network and the policies related to delivery frequency, truckload, and allocation will affect the total cost of a distribution network. Designing a distribution network will even be harder when there are other aspects beyond business interests that need to be considered. This is especially true for products that its availability would affect social stability of a country / region or for products that is subsidized by the government and directed toward a certain class of society. For such situations, it is also important to consider such factors as political correctness, equality, and other non-business related issues, yet the network should be operating efficiently.

There have been a large number of studies dealing with the distribution network design. Traditionally, the model has been focusing on a single objective of minimizing total cost of a supply network (e.g., Amiri, 2006; Tsiakis and Papageorgiou, 2008; Gumus et al, 2009) or maximizing profit (e.g., Shen, 2006). Recently, many researchers have considered multiple objectives when developing a model for network design (see for example, Altiparmak et al, 2006; Cintron et al, 2010; Cardona-Valdes et al, 2011). Most of the existing models have been applied to business entities where the objectives are mostly business related. There is no much work that address the balance between the interest of business entities, the society, and the government. Tzeng et al (2007) is an example of work that consider non-business
MODEL DEVELOPMENT

Problem Description

We are dealing with a network design problem to deliver packaged LPG product from filling plants to selling agents. Filling plants have a role of filling empty containers with LPG. The empty containers are obtained from suppliers or from agents in the form of the returned empty containers. Agents will serve the demand of retailers for a relatively small regions. Currently there are \(N\) number of filling plants and \(M\) number of selling agents, where each filling plant could serve any agent. It has been determined that each agent can only place orders to a single filling plant only to stabilize demand at each filling plant and to improve the control mechanism. Note that this LPG is subsidized by the government and thus, the price per kilogram is cheaper than the non-subsidized ones. Each filling plant has a certain production capacity. On the other hand, each agent has a certain demand forecast. The demand for LPG in each agent is quite stable given the relatively stable rate of consumption at the final customers. It is assumed that the location of each filling station is unchangeable, but it is possible to change the supply allocation from each filling plants to agents.

The current problem is that the filling plants are owned by independent parties, and thus some of the filling plants are located very close each other, while in some less-attractive areas, there is no filling plant and thus agents in these areas will have to be supplied from a filling plant located far away. For these less-attractive areas, supply of LPG will normally take longer time (and hence less responsive) as well as requiring long travel distance (and thus, making supply chain operations inefficient). The government has a role to ensure that all demand is satisfied. On the other hand, it is also important to ensure that all filling plants operate feasibly. Currently, with both supply points (filling plants) and demand (agents) are spreading unevenly across regions, there is a very big chance that one filling plant can easily sell products to nearby agents, and thus they make good profit while other filling plants could operate significantly below their capacity. In reality, capacity utilization should be high enough to ensure profitability, but not too high to ensure good responses to customers (and to absorb growth in future demand). Thus, as each facility in the supply chain is actually a profit making entity, it is important for the government to ensure that each facility (in this case the filling plant) is operating under a range of acceptable utilization rate. Given that the products are subsidized, the government has a more legitimate power to regulate the supply chain that consider the interests of society as the final customers, the business entities that involve in the distribution of the product, and the government itself. Hence, the model has to capture the following three objectives:

1. Each filling plant should be operating under a desired utilization rate. In our study it is assumed that the best utilization rate is somewhere between 0.7 and 0.9. If it is below 0.7, the filling plant could be economically infeasible. On the other hand, operating above 0.9 would potentially result in poor service to customers, unable to absorb growth in future demand, and causing some other filling plants to operate far below the acceptable rate if total supply exceeds total demand. It is then obvious that capacity utilization rate is related to government, business entities, and customers.

2. Each agent should obtain an acceptable response time from the assigned filling plant. This objective is important to protect the interest of the society as the customer of the LPG. In this study, response time is mostly determined by the distance between the agent and the filling plant. It is desired that the distance between the agent and the assigned filling plant is under a maximum of \(d\) kilometers.

3. The transportation cost for the whole system should be minimized. The transportation cost is a function of distance, volume transported, and unit transportation cost. By adding this objective, we aim to have an efficient design of distribution system. The transportation cost is directly paid by the agents, but it is also the interest of both customers and the government that the transportation costs should be minimum.
**Model Formulation**

A goal programming model is developed to capture the above problem. Let $i$ and $j$ represent indices for filling plant and agent respectively. The decision variables are:

- $x_{ij}$: the volume of product supplied from filling plant $i$ to agent $j$
- $z_{ij}$: a binary variable, 1 if filling plant $i$ supplies agent $j$ and 0 otherwise

The relevant parameters are:

- $d_{ij}$: distance from filling plant $i$ to agent $j$
- $k_i$: capacity of filling plant $i$
- $D_j$: demand of agent $j$
- $c_{ij}$: delivery cost per metric ton per kilometer for delivering LPG from $i$ to $j$
- $L$: minimum acceptable utilization rate
- $U$: maximum acceptable utilization rate
- $d_{max}$: maximum desired travelling distance

Initially, the objective functions can be formulated into the following 3 equations:

1. For each filling plant, utilization rate should be between acceptable minimum and maximum values

   \[ L \leq \frac{\sum_{j=1}^{M} x_{ij}}{k_i} \leq U \]  

2. For each delivery, the distance should be lower than the desired maximum value

   \[ d_{ij} z_{ij} \leq d_{max} \]  

3. The total distribution cost should be minimum

   \[ \text{Minimize } \sum_{i=1}^{N} \sum_{j=1}^{M} c_{ij} d_{ij} x_{ij} \]  

We then transform these three equations into a goal programming, where now the objective function is to minimize the total weighted deviation of the above three objectives. For the total distribution cost, the goal is set at the desirable total cost. Let $TC_{\text{min}}$ represents this desirable total cost, $W_k$ is the weight assigned to deviation to goal $k$, $d^+_k$ is positive deviation to goal $k$, and $d^-_k$ is negative deviation to goal $k$. Our goal programming model is then:

\[ \text{Minimize } Z = \sum_{i=1}^{N} \sum_{j=1}^{M} \left( W_{1i} d^+_{1i} + W_{2i} d^+_{2i} + W_{3i} d^+_{3i} + W_{4i} d^-_{i} + \sum_{j=1}^{M} z_{ij} \right) \]

Subject to:

\[ \sum_{j=1}^{M} \frac{x_{ij}}{k_i} + d_{1i} - d^+_{1i} = L \quad \forall i \]  

\[ \sum_{j=1}^{M} \frac{x_{ij}}{k_i} + d_{2i} - d^+_{2i} = U \quad \forall i \]  

\[ d_{ij} z_{ij} + d_{3ij} - d^+_{3ij} = d_{max} z_{ij} \quad \forall i,j \]  

\[ \sum_{i=1}^{N} \sum_{j=1}^{M} c_{ij} d_{ij} x_{ij} + d_{4i} - d^-_{4i} = TC_{\text{min}} \]  

\[ x_{ij} \leq k_i z_{ij} \quad \forall i,j \]
Note that the last term in the objective function (4) is to ensure that, if in equation (9) there is no delivery in the path \((i, j)\) then \(x_{ij}\) takes a value of zero. Constraint (5) is the goal constraint for the minimum utilization rate of filling plant \(i\) while constraint (6) is for the maximum utilization rate. Equation (7) is the goal constraint for the maximum delivery distance and equation (8) is for the goal constraint of minimizing total transportation cost. It is important to note in equation (7) that the goal to have a maximum delivery distance of \(d_{\text{max}}\) is only for the case where there is a delivery in the path \((i, j)\), otherwise the value of right hand side of equation (7) is zero. Equation (10) is to ensure that each agent is supplied by one filling plant only. For each filling plant, equation (11) ensures that the total delivery will not exceed its capacity. Finally, demand of each agent should be met as enforced by equation (12).

**CASE STUDY**

**Parameter Values and Existing Allocation**

For this study, we will use the above model to solve the LPG distribution problem of one province in Indonesia. In this province, there are currently 14 filling plants and 162 agents. The distance between each filling plant and each agent was obtained from secondary data, but due to incomplete record, some were collected through observation in the Google map. From our observation it is very clear that filling plants are concentrated within the capital of that province, while some others are spread over different areas. Agents are normally located closer to the market areas. Some agents are located in remote areas, while filling plants are normally within or in the vicinity of urban areas. It is understandable that many agents face difficulties in obtaining fast deliveries from the filling plants. It is assumed here that the annual capacity of each filling plant is 8100 MT (metric tons). In reality some filling plants could have a capacity higher than this, depending on the working day per year.

Demand for each agent was obtained from the realized demand data for 2010. According to the data from BP Migas (the oil and gas authority of Indonesia), the delivery cost per metric ton per kilometer is 835 rupiahs. The overall realized delivery for this province in 2010 is over 80 thousands metric tons. The parameter values are shown in Figure 1. Due to their large data points, we could not show parameter values for demand of each agent \(j\) and distance from filling plant \(i\) to agent \(j\).

**FIGURE 1**

**PARAMETERS’ VALUES**

<table>
<thead>
<tr>
<th>Parameter Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>(k_i) = 8100 MT / year for all (i)</td>
</tr>
<tr>
<td>(d_{\text{max}}) = 100 kilometers</td>
</tr>
<tr>
<td>(T_{C_{\text{min}}}) = 3 x 10^9 rupiahs</td>
</tr>
<tr>
<td>(L = 0.7)</td>
</tr>
<tr>
<td>(U = 0.9)</td>
</tr>
<tr>
<td>(c_{ij}) = 835 rupiahs/MT/km</td>
</tr>
<tr>
<td>(d_{ij}) : 2268 data points (not shown in this paper)</td>
</tr>
<tr>
<td>(D_j) : 162 data points (not shown in this paper)</td>
</tr>
</tbody>
</table>

Our benchmark is the proposed solution by a consulting company as an advise to the government, which is not necessarily the actual practice. This base solution was not using any optimization model. With this solution, as shown in Table 1, only 3 filling plants achieve a maximum delivery distance below the desired value, which is 100 kilometers. In
fact, there is one filling plant with maximum delivery distance of 359 kilometers. On the other hand, the variation in the utilization rate is so high. Our aim, at least in the short term, is to obtain minimum utilization rate of 70%, but currently there are 6 filling plants with utilization rate below this target. Furthermore, there are two filling plants with utilization rate below 40%. On the contrary, six others enjoyed over 90% utilization rate. Our calculation also shows that the total transportation costs for the base allocation is over 5 billion rupiahs. The targeted minimum total transportation cost of 3 billion rupiahs was based on the some preliminary results where that the minimum total costs obtained were close to that value.

**Alternative Scenarios**

The performance of current solution shown in Table 1 indicates a poor design of supply network. It shows high variation in utilization rate across filling plants, many long-distance deliveries, and high transportation costs. While this poor performance is partly due to location decisions of filling plants (which has been decided independently by each filling plant investors), it is also due to poor allocation decisions. The location of the filling plant can be considered as sunk cost, because it is very costly (and most likely impossible) to relocate these newly established facilities. The allocation, on the other hand, can be altered, and this should be the subject where the Government should have a right to intervene.

**TABLE 1**

**PERFORMANCE OF BASE SOLUTION**

<table>
<thead>
<tr>
<th>Filling Plan</th>
<th>Capacity Utilization</th>
<th>Max Distance (Km)</th>
<th>Average Distance (Km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>FP1</td>
<td>80%</td>
<td>294</td>
<td>62.3</td>
</tr>
<tr>
<td>FP2</td>
<td>49%</td>
<td>98</td>
<td>85.2</td>
</tr>
<tr>
<td>FP3</td>
<td>92%</td>
<td>95</td>
<td>22.6</td>
</tr>
<tr>
<td>FP4</td>
<td>98%</td>
<td>97</td>
<td>16.9</td>
</tr>
<tr>
<td>FP5</td>
<td>67%</td>
<td>243</td>
<td>97.7</td>
</tr>
<tr>
<td>FP6</td>
<td>91%</td>
<td>271</td>
<td>67.1</td>
</tr>
<tr>
<td>FP7</td>
<td>89%</td>
<td>134</td>
<td>47.4</td>
</tr>
<tr>
<td>FP8</td>
<td>94%</td>
<td>272</td>
<td>113.3</td>
</tr>
<tr>
<td>FP9</td>
<td>31%</td>
<td>309</td>
<td>246.1</td>
</tr>
<tr>
<td>FP10</td>
<td>91%</td>
<td>273</td>
<td>58.8</td>
</tr>
<tr>
<td>FP11</td>
<td>64%</td>
<td>359</td>
<td>202.8</td>
</tr>
<tr>
<td>FP12</td>
<td>94%</td>
<td>201</td>
<td>117.1</td>
</tr>
<tr>
<td>FP13</td>
<td>38%</td>
<td>160</td>
<td>160</td>
</tr>
<tr>
<td>FP14</td>
<td>59%</td>
<td>150</td>
<td>59.8</td>
</tr>
<tr>
<td><strong>Annual total transportation cost</strong></td>
<td><strong>5,015,161,035</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

We have used the above multi-objective models to seek alternative allocation scenarios that in the end give overall better performance. The model was solved using LINGO optimization package and the optimum solution to each scenario was obtained. As indicated earlier in this paper, the problem is essentially multi-objective: there are conflicts among different objectives and among stakeholders. Basically, the model can be used to evaluate different scenarios through giving different weight to each objective. Note that from the model, there are basically three objectives, but then we put them in four equations (e.g., 5, 6, 7, and 8) where the first two represent an objective to minimize variation in the utilization rate across different filling plants. We present the results of two scenarios based on different weights as follows:

- **Scenario 1** is giving more or less balanced weight to all four objectives ($w_1 = 1; w_2 = 1; w_3 = 1/d_{max}; w_4 = 1/TC_{min}$). This is based on a simple normalization process where we expect to limit the multiplication of weight and their associated value to about 1.

- **Scenario 2**: Both $w_1$ and $w_4$ are multiplied by 50, meaning that we aim to give more emphasis on minimizing number of filling plants with utilization below 70% and on minimizing total transportation cost.

Tables 2 and 3 show the results of the above two scenarios. We present the capacity utilization, the maximum delivery distance, and the average distance for each filling plant. The tables confirm that, the achievement toward a certain objective improves when higher weight is given to it. For example, when objective 1 is given a significantly higher value, all filling plants achieves utilization rate at least 70%, as shown in Table 3.
TABLE 2
RESULTS OF SCENARIO 1

<table>
<thead>
<tr>
<th>Filling Plan</th>
<th>Capacity Utilization</th>
<th>Max Distance (Km)</th>
<th>Average Distance (Km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>FP1</td>
<td>87%</td>
<td>83.7</td>
<td>28.2</td>
</tr>
<tr>
<td>FP2</td>
<td>90%</td>
<td>97.9</td>
<td>37.4</td>
</tr>
<tr>
<td>FP3</td>
<td>90%</td>
<td>120.0</td>
<td>38.5</td>
</tr>
<tr>
<td>FP4</td>
<td>89%</td>
<td>26.8</td>
<td>11.0</td>
</tr>
<tr>
<td>FP5</td>
<td>88%</td>
<td>96.4</td>
<td>61.8</td>
</tr>
<tr>
<td>FP6</td>
<td>89%</td>
<td>87.5</td>
<td>46.9</td>
</tr>
<tr>
<td>FP7</td>
<td>78%</td>
<td>50.6</td>
<td>32.3</td>
</tr>
<tr>
<td>FP8</td>
<td>67%</td>
<td>124.0</td>
<td>37.8</td>
</tr>
<tr>
<td>FP9</td>
<td>30%</td>
<td>58.5</td>
<td>49.6</td>
</tr>
<tr>
<td>FP10</td>
<td>88%</td>
<td>117.0</td>
<td>49.7</td>
</tr>
<tr>
<td>FP11</td>
<td>24%</td>
<td>99.1</td>
<td>39.9</td>
</tr>
<tr>
<td>FP12</td>
<td>81%</td>
<td>96.0</td>
<td>55.0</td>
</tr>
<tr>
<td>FP13</td>
<td>63%</td>
<td>120.0</td>
<td>56.4</td>
</tr>
<tr>
<td>FP14</td>
<td>72%</td>
<td>93.4</td>
<td>84.2</td>
</tr>
</tbody>
</table>

Annual total transportation cost: 3,458,880,000

The two scenarios show much better performance in all objectives than the base solution. The results of scenario 1 are essentially unacceptable since some filling plants still achieve capacity utilizations much lower than the targeted minimum value of 70%. Note that if we aim to minimize the total transportation cost and let some filling plants to close in a few months, as suggested in scenario 1, the total costs incurred to the system could be much higher than the transportation cost savings. However, it is uneasy to quantify the economic impact of closing one or two filling plants. Scenario 2 satisfies the minimum and maximum desired capacity utilization but costing the system higher transportation costs. Obviously, it is the decision maker’s (namely the Government) choice to select which one is considered best.

TABLE 3
SCENARIO 2 WHERE W1 AND W4 ARE MULTIPLIED BY 50

<table>
<thead>
<tr>
<th>Filling Plan</th>
<th>Capacity Utilization</th>
<th>Max Distance (Km)</th>
<th>Average Distance (Km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>FP1</td>
<td>73%</td>
<td>85.2</td>
<td>38.7</td>
</tr>
<tr>
<td>FP2</td>
<td>88%</td>
<td>97.9</td>
<td>41.4</td>
</tr>
<tr>
<td>FP3</td>
<td>71%</td>
<td>117.0</td>
<td>45.1</td>
</tr>
<tr>
<td>FP4</td>
<td>76%</td>
<td>82.3</td>
<td>18.8</td>
</tr>
<tr>
<td>FP5</td>
<td>72%</td>
<td>96.4</td>
<td>78.9</td>
</tr>
<tr>
<td>FP6</td>
<td>79%</td>
<td>87.5</td>
<td>30.9</td>
</tr>
<tr>
<td>FP7</td>
<td>76%</td>
<td>52.3</td>
<td>35.9</td>
</tr>
<tr>
<td>FP8</td>
<td>71%</td>
<td>124.0</td>
<td>72.3</td>
</tr>
<tr>
<td>FP9</td>
<td>70%</td>
<td>243.0</td>
<td>76.1</td>
</tr>
<tr>
<td>FP10</td>
<td>71%</td>
<td>120.0</td>
<td>38.2</td>
</tr>
<tr>
<td>FP11</td>
<td>70%</td>
<td>235.0</td>
<td>46.8</td>
</tr>
<tr>
<td>FP12</td>
<td>72%</td>
<td>100.0</td>
<td>83.6</td>
</tr>
<tr>
<td>FP13</td>
<td>70%</td>
<td>120.0</td>
<td>52.9</td>
</tr>
<tr>
<td>FP14</td>
<td>76%</td>
<td>93.4</td>
<td>73.6</td>
</tr>
</tbody>
</table>

Annual total transportation cost: 4,708,716,003
CONCLUSION

A multi-objective distribution network design model has been presented in this paper. The model considers improving uniformity of capacity utilization across different facilities (which are owned by different investors), minimizing the maximum delivery distance from each facility, and minimizing the total transportation costs. The model was applied to design the allocation of LPG from filling plants to selling agents. Our model suited the problem of public sector supply chain, where the government has to consider sustainability of business entities, ensure that the customers can obtain the products quickly, yet the efficiency of distribution process is also taken into account. Alternative scenarios were developed by assigning different weights to each objective. The computational results show that the model could generate much better performance than the existing solution. Our experiments also show that differing weights significantly alter the results.

Our study provide insights on how costly a poorly designed supply network is. In the case study, it is clear that the free market mechanism applied to the supply chain of LPG has resulted in poor performance. Given that each facility is owned by a different, independent investor, and each facility can supply to any selling agent, the resulted configuration of the supply network is neither operationally efficient nor responsive to the customers. The Government should take the responsibility of designing the network that attempt to balance achievements toward conflicting objectives.

REFERENCES


EMERGENCY LOGISTICS PLANNING FOR DISASTER RELIEF IN FLOOD-PRONE AREAS

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ABSTRACT

Logistics planning for flood-affected areas is one of the most crucial requirements for recovery of the population from disasters. Humanitarian requirements (food, water, medicine), and emergency industrial supplies/shipments are the main concern in disaster relief planning. Past incidences show that a flood does not instantly become intolerable to the affected population in flood prone areas. As such, it is possible to minimize the sufferings of population to a “tolerable level” using a severity-based logistics planning. Severity may be considered extreme (100%) when transport movement is possible only through waterways. Other severity levels may correspond to 25%, 50%, and 75% disruption of the land transportation system. Distribution of goods is a function of the availability of transportation, warehousing and transporting the products to suitable locations at the right time. In a disaster situation, the distribution quantity requirements, the locations of the affected areas and of supply centers including their distances, change from time to time based on the severity level. A model-based assessment and decision approach is proposed for emergency logistics planning and quick recovery that is applicable to flood disaster situations.

KEYWORDS
Disaster Recovery, Emergency Goods Distribution Planning, Humanitarian Requirements, Severity Levels, Tolerable Level of Suffering

INTRODUCTION

Natural disasters have been causing loss of human life, disruption of infrastructure and damage to several other resources from the time immemorial. There is an increasing recognition of humanitarian logistics planning for disaster management (van Wassenhove, 2003; Altay and Green III, 2006). Among the natural disasters, floods are the most damaging in many countries and regions, especially in the coastal regions, low lands and countries around oceans’ rims that are prone to heavy rainfalls (Chang et al., 2007). Floods impact the economy of the high-flood-frequency developing countries by disrupting communications, damaging the economic infrastructure, and creating long-term geostrategic implications (Rodriguez et al, 2012). Although flood disasters may be predicted well ahead of time, it is extremely difficult to handle the implications without preplanning. In some instances, flood consequences are so huge that even highly developed countries face great difficulties coping with the disaster. Flood consequences are the most damaging in developing countries due to their poor infrastructure and communication networks which become easily disrupted, making it difficult for governmental and non-governmental organizations (NGOs) to dispatch emergency humanitarian aid (food, drinking water and medicine) to the affected areas. Thus, the most crucial requirement of emergency humanitarian logistics planning for flood-affected areas is the transportation of emergency aid (EA) to distribution centers (DCs), and from there to the flood-affected demand centers.
To ensure the supply of EA to the demand centers in the flood-affected area the disaster management team (DMT) of a country needs to select only the minimum-distance reliable routes. Past experience shows that flood situations deteriorate from week to week and, sometimes from day to day. Although road links are disrupted, alternative emergency roads may exist (even though they may not be in very good condition), or are being constructed, in order to supply EA in this situation. In any case, the reliability requirements of the routes cannot be relaxed for ensuring supply to the demand centers. Based on the past history of flood occurrences, available road networks, and the population needs of the vulnerable flood prone areas, a DMT may draw an emergency logistics pre-plan that will identify potential EA collection centers, several alternative transportation routes, potential DCs and the demand zones. Such a preliminary exercise should be a model-based logistics planning that may be quickly adopted for emergency relief operations as soon as flood hits an area. A model-based decision system that collects information from monitoring agencies on available alternative routes, reliability status of existing and alternative routes, available modes of transportation, estimated amounts of EA requirements, and locations of demand centers, may be the most appropriate approach for ensuring humanitarian aid delivery in a flood situation.

This paper proposes a model that considers collection centers (CCs), distribution centers (DCs), demand zones (DZs), the EA requirements at DZs, available and alternative routes from CCs to DCs and from DCs to DZs, and changes in the reliability and distances of the routes, while the flooding persists, to develop a humanitarian logistics plan to fulfill the requirements at DZs.

Following a brief literature review, we present the model, and illustrate its applicability using a numerical example. We conclude with some observations.

LITERATURE REVIEW

Emergency logistics planning for disaster readiness and recovery operations in disaster affected areas has been gaining much importance as a research topic in recent years (see the review study by Caunhye et al., 2011). As continuing environmental changes and population increases in several countries have exposed large numbers of people to risks of disaster (Milly et al., 2002), research interest in disaster management as a part of emergency logistics planning will continue to grow in coming years.

There are few studies that have specifically addressed emergency planning for flood-based disasters. Chang et al. (2007) proposed a decision making tool that may be used by the government of a country to prepare for a potential flood. Todini (1999) proposed a decision support tool for planning and management of flood to address expected damages.

Most of the literature on emergency logistics planning developed decision support optimization tools to tackle emergency logistics problem (Caunhye et al., 2011). Emphasizing the complexity of an emergency situation, Matisziwa and Murraya (2009) suggested the use of decision support systems for the purposes of vulnerability assessment and emergency planning, and de la Toerre et al. (2011) suggested the use of operations research-based models for disaster relief routing. Rodriguez et al. (2012) recently proposed a two-level decision support tool to be used by the NGOs.

Based on the above literature review, it is apparent that model-based decision support tools are appropriate in emergency logistics planning. Inspired by the various approaches covered in the literature, this research proposes a model-based decision support tool for the preparation of logistics to supply emergency humanitarian aid in flood-stricken areas.

DISASTER MANAGEMENT MODEL

This section includes notations, problem statement, the mathematical model and the model descriptions.

Notation

Indices

\begin{align*}
C & \quad \text{set of centers /areas/zones/nodes, indexed by } c \in C, \ c' \in C \\
C^l & \quad \text{set of collection centers (CCs)/areas/zones/nodes, indexed by } c \in C^l, \ c' \in C^l \\
C^w & \quad \text{set of distribution centers (DCs)/areas/zones/nodes, indexed by } c \in C^w, \ c' \in C^w \\
C^d & \quad \text{set of demand zones where the items are to be distributed, indexed by } c \in C^d, \ c' \in C^d
\end{align*}
\( C^l, C^w, C^d \) are the partitions of \( C \).

- **E**: set of emergency items (e.g., food, water, and medicine), indexed by \( e \in E \)
- **S**: set of severity ratings, indexed by \( s \in S \)
- **T_m**: set of transportation modes, indexed by \( m \in T_m \)

### Parameters

- **CAP_{ec}**: capacity of node/center \( c \) to accommodate the flow quantity of item \( e \)
- **CD_{cc'}**: cost of distributing one standard unit of item from distribution center \( c \in C^w \) to demand zone \( c' \in C^d \)
- **CM_{mcc'}**: capacity of transportation mode \( m \) to carry item \( e \) on the route \( c \) to \( c' \)
- **CT_{cc'}**: cost of transporting one standard unit of an item on the route \( c \) to \( c' \)
- **dt_{cc'}**: time or distance covered by transportation mode \( m \) on the route \( c \) to \( c' \)
- **FCO_c**: fixed cost of opening a center \( c \in C \)
- **FM_m**: fixed cost of running the transportation mode \( m \)
- **rq_{ect}**: requirements of emergency item \( e \in E \) at affected zone \( c \in C^l \) in time period \( t \)
- **NT**: a large positive number
- **CT_{mcc'}**: cost of maintaining an existing route \( c \) to \( c' \) in reliable condition for transportation mode \( m \) in time period \( t \)
- **CAL_{mcc'}**: cost of providing and maintaining an alternative route \( c \) to \( c' \) for transportation mode \( m \) in time period \( t \)
- **dt_{cc'}**: time or distance covered by transportation mode \( m \) on the route \( c \) to \( c' \)
- **SU_{ect}**: quantity of item \( e \) to be supplied at collection center \( c \in C^l \) to fulfill the requirements at demand zones in time period \( t \)

### Variables

- **AL_{mcc'}**: =1 if the existing route is not reliable (i.e., \( ER_{mcc't} = 0 \)) and an alternative route from \( c \) to \( c' \) is to be selected in time period \( t \) for sending emergency aid using transportation mode \( m \); 0 otherwise
- **ER_{mcc't}**: =1 if the existing route from \( c \) to \( c' \) is reliable for sending emergency aid in time period \( t \) using transportation mode \( m \); 0 otherwise
- **F_{mcc'}**: quantity of item \( e \) delivered from \( c \) to \( c' \) using transportation mode \( m \) in time period \( t \)
- **FX_{mcc'}**: quantity of item \( e \) remaining at node \( c \) in time period \( t \) delivered by transportation mode \( m \)
- **X_{mcc'}**: quantity of item \( e \) delivered from \( c \in C^l \) to \( c' \in C^w \) in time period \( t \)
- **Z_{mcc'}**: quantity of item \( e \) distributed from distribution center \( c \in C^w \) to demand zone \( c' \in C^d \) in time period \( t \)
- **O_c**: =1 if center \( c \) is open; 0 otherwise
- **v_{ms}**: =1 if transportation mode \( m \) is selected at severity level \( s \); 0 otherwise
- **a_{cc'}**: =1 if \( c \in C^w \) is assigned to supply demand zone \( c' \in C^d \); 0 otherwise
- **r_{mcc'}**: reliability index of a route from \( c \) to \( c' \) for transportation mode \( m \) in time period \( t \); = 1 if reliable; 0 if not
- **NT_{mcc't}**: number of trips needed to fulfill the requirements for item \( e \) using transportation mode \( m \) from \( c \in C \) to \( c' \in C^d \) in time period \( t \)
- **Tdt_{mcc't}**: total time needed to cover a route from collection center \( c \in C^l \) to demand center \( c' \in C^d \) using transportation mode \( m \) in time period \( t \)
- **sv_{st}**: severity parameter corresponding to severity level \( s \) in time period \( t \); it assumes values of 0, 0.5, and 1 when severity level \( s \) (i.e., the level of truck route disruption) is 100%, 50% and 0%, respectively.
We consider a typical flood situation that causes transportation disruptions and could impact the regular supplies of food, medicine, etc. to the flood affected areas. It could also disrupt regular availability of potable water. The objective is to minimize the suffering of the population of the flood-affected areas by supplying them with a number of emergency humanitarian items \( e \in E \) (e.g., food, drinking water, medicine, etc.) at different amounts based on the severity level \( s \) of the situation, over a number of time periods \( t \in T \) while the flooding continues. The affected zones are to be supplied each item, using various suitable transportation modes \( m \in T_m \) (e.g., trucks, boats, helicopters, etc.) For collection, supply, and distribution of emergency humanitarian items a set of emergency or alternative temporary routes is to be planned. To handle the disaster effectively we need to optimize the logistics cost related to the transportation of items, and the construction and maintenance of reliable facilities, while striving to select a possible minimum distance, reliable route to supply the emergency items.

### The Mathematical Model

**Objective function:** minimize \( LC \),

\[
LC = \sum_{c \in C} \sum_{e \in C} CT_{ce} \sum_{i \in T} \sum_{e \in E} X_{ect}^i + \sum_{c \in C} \sum_{e \in C^d} \sum_{i \in T} \sum_{e \in E} CD_{ce}^i \sum_{s \in S} Z_{ect}^s + \sum_{c \in C} O_{c} FCO_c + \sum_{m \in M} \sum_{s \in S} \sum_{e \in E} \sum_{m \in M} \sum_{c \in C} \sum_{i \in T} (CL^m_{cet} ER^m_{cet}^m + CAL^m_{cet} AL^m_{cet})
\]

s.t.

\[
Z_{ect}^s = a_{ce}^s q_{ect}^s \quad \forall e \in E^w, c \in C^d, e, t
\]

\[
\sum_{c \in C} X_{ect}^i = \sum_{e \in C^d} Z_{ect}^s \quad \forall e \in E^w, c \in C^d, e, t
\]

\[
\sum_{c \in C} Z_{ect}^s \leq u_{c} CAP_{ec} \quad \forall e \in E^w, c \in C^d
\]

\[
a_{ce}^s \leq w_c \quad \forall e \in E^w, c \in C^d
\]

\[
F_{ect}^m \leq v_{sm} s_{vm} CM^m_{ect} \quad \forall m, s, e, c, c', t
\]

\[
F_{ect}^m \leq (ER_{cet}^m + AL_{cet}^m) CM^m_{ect} \quad \forall m, c, c', t
\]

\[
ER_{cet}^m + AL_{cet}^m \leq r_{cet}^m \quad \forall m, c, c', t
\]

\[
X_{ect}^i \leq BNI \sum_{m \in M} F_{ect}^m \quad \forall e, c, c', t
\]

\[
\sum_{e \in C} X_{ect}^i = S_{uct} 
\]

\[
FX_{ect}^m = \sum_{e \in C} F_{ect}^m - \sum_{e \in C} F_{ect}^m \quad \forall m, e, c, t
\]

\[
FX_{ect}^m \leq O_{c} CAP_{ec} \quad \forall m, e, c, t
\]

\[
X_{ect}^i = NT_{ect}^m CM_{ect}^m \quad \forall m, e, c, c', t
\]

\[
\sum_{c \in C} \sum_{c \in C^d} A_{ect}^m dt_{ect}^m = T_{dct}^m \quad \forall m, t, c \in C^l, c \in C^d
\]
The objective function (1) minimizes the logistics cost $LC$, which is defined in equation (2). $LC$ includes the cost of transporting and distributing emergency items; the cost of opening a center; the fixed cost of various transportation modes; the cost of keeping an existing route reliable, and the cost of constructing alternative reliable routes for a transportation mode. Constraint (3) ensures fulfillment of the requirements at demand zones by supplying items $e$ from the assigned distribution centers (DCs). Constraint (4) matches supplies into DCs with the distribution from DCs according to the capacity. Constraint (5) limits the supply from DCs according to the capacity.  Constraint (6) assigns a DC to a demand zone only when it is open. Constraint (7) regulates the item flow along a route based on the flood severity and the transportation mode to be used. Once the transportation mode is selected, constraint (8) ensures the item flow over a route according to the route’s capacity and reliability. Constraint (9) decides the item flow (over an existing route, or alternative route) based on the route reliability indices ($r_{mc}$) obtained by the DMT from the entities monitoring the roads and highways. Constraint (10) ensures the selection of a segment in a route (existing or alternative) only when it is reliable. Constraint (11) balances the total quantity flow along a route for all transportation modes. Equation (12) computes the inputs to be supplied at the collection centers based on the quantity flow requirements along the routes. Constraint (13) balances inflow and outflow at a node. According to constraint (14), the flow remaining in a node is limited by its capacity when it is open. Constraint (15) computes the number of trips needed to transport the required quantity of an item along a route based on the capacity of the transportation mode. The feasibility, in terms of time or distance, needed over an alternative route is verified by constraints (16) by comparing it with the time needed over an existing route in constraint (17), once the route segments are found reliable. Constraint (18) imposes integrality.

A NUMERICAL EXAMPLE

We solve a numerical example concerning the delivery of 6 emergency humanitarian items to 8 flood-affected demand zones through 5 distribution centers (DCs) over 3 periods (or three weeks) in a flood situation. The items are supplied from 3 collection centers (that are not affected by flood) using existing or alternative routes in periods 1-3. The demand zones can be reached from the collection centers by 3 modes of transport: trucks (TR), railways (RL), and a combination of trucks and water ways (CTW). The route networks along with the transport modes available in each period are shown in Figures 1 and 2. The total number of nodes is 21. The 6 types of emergency items (three types of food, water, and two types of medicine) are transported from the collection center to demand zones. Typical reliability indices and distances of various route segments are presented in Table 1. For example, in period 1, for the segment between nodes 1 & 4, transport mode 1 (TR) is suitable, transportation mode 2 (RL) is not available, and transport mode 3 (combination of truck and water ways) is not used since transport mode 1(truck) can cover the segment. In periods 2 and 3, the reliability index of the segment between nodes 1&4 with respect to transportation mode 1 is zero (unreliable), whereas the reliability index for transportation mode 3 is reliable. Table 1 also shows that the distance between the nodes 1 & 4 is 57 miles.

It is noted from Table 1 that the route segment between nodes 2 & 7 is disrupted by flood (shown as DIS) in periods 2 and 3, whereas it was reliable in period 1 for trucks and railways. Disrupted means the segment could not be linked even by transport mode 3. Table 2 presents the typical demands for the 6 emergency items at the demand zones in period 1. For example, the demand for item1 in period 1 at demand zone 1 is 2342 units. The demand items are transformed to standard units considering standard weights.
FIGURE 1
EXISTING RAILWAY AND TRUCK ROUTES AVAILABLE IN PERIOD 1

FIGURE 2
ALTERNATIVE OR CONSTRUCTED ROUTES FOR TRUCK-AND-WATER-WAYS TRANSPORTATION MODE IN PERIODS 2 AND 3

TABLE 1
RELIABILITY AND DISTANCE INFORMATION FOR TRANSPORT MODES IN PERIODS 1, 2 AND 3

<table>
<thead>
<tr>
<th>Route Segment</th>
<th>Period 1</th>
<th>Periods 2 and 3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Reliability of Route Segments with Respect to Transport Modes</td>
<td>Distance (in miles)</td>
</tr>
<tr>
<td></td>
<td>Mode 1 Truck</td>
<td>Mode 2 Railway</td>
</tr>
<tr>
<td>Node</td>
<td>Node</td>
<td>Mode 1</td>
</tr>
<tr>
<td>1</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>8</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>6</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>7</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>10</td>
<td>1</td>
</tr>
</tbody>
</table>

Legend: 1 Reliable; 0 Not reliable; NU Mode not used; X Mode not available; DIS segment disrupted by flood
TABLE 2
DEMANDS FOR EMERGENCY HUMANITARIAN ITEMS AT DEMAND ZONES IN PERIOD 1

<table>
<thead>
<tr>
<th>Emergency Humanitarian Items</th>
<th>Demand for items at demand zones</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>2342</td>
</tr>
<tr>
<td>2</td>
<td>1387</td>
</tr>
<tr>
<td>3</td>
<td>2470</td>
</tr>
<tr>
<td>4</td>
<td>2732</td>
</tr>
<tr>
<td>5</td>
<td>595</td>
</tr>
<tr>
<td>6</td>
<td>571</td>
</tr>
</tbody>
</table>

Figure 3 shows the routes selected by the model solution for delivering the 6 items to the 8 demand zones in period 1 using transportation mode 1 (TR). The model selects the route segments and the transportation mode 1, based on the reliability indices, the feasibility of the time needed for covering the distances and the transportation costs. Although transport mode 2 (RL) was available on some reliable route segments, the model did not select it in period 1, as may be observed in Figure 3. Finally, the model sends item flows to the distribution centers 17,18,19, 20 and from there to the demand zones. The model also decides the quantities shipped on each segment, ensuring that the cumulative item flows along the routes eventually fulfill the requirements of the demand zones in each period. The flow routes selected by the model (Figure 3) in period 1 are described in more details in Table 3.

FIGURE 3
MODEL DECISIONS ON ROUTE SELECTION AND TRANSPORTATION MODES IN PERIOD 1

TABLE 3
ANALYSIS OF THE SOLUTION DEPICTED IN FIGURE 3

<table>
<thead>
<tr>
<th>1→</th>
<th>4→</th>
<th>9→</th>
<th>10→</th>
<th>12</th>
<th>13→</th>
<th>17</th>
<th>Finally to demand zones</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>12</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Combining at 12</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>12→ 13</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>13→ 17</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>17→ 18</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>18→ 19</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>19→ 20</td>
</tr>
</tbody>
</table>
As discussed previously, as time passes the worsening flood situation causes some route segments to be disrupted. In such situations, most developing countries such as Bangladesh, India, Pakistan, etc., resort to a combination of trucks and water ways, or construct temporary routes suitable for mixed transportation modes to deliver emergency aid to the demand zones. Figure 2 depicts a typical situation where using alternative or constructed routes may be suitable for mixed transportation modes such as truck and water ways. Some of the nodes (for example 7 and 15) may not be possible to be connected to the road network even after such alternative arrangements are in place. Based on the available routes, their reliabilities, distances, and the transportation costs involved, the model solution for periods 2 and 3 involves route segments that use transportation mode 3 (CTW).

The solution is presented in Figure 4. Since the capacity of the mixed model transportation is, in this case, lower than that of the transportation mode 1 (TR), the model uses two collection centers and several more route segments to deliver the required items to the demand zones. It is evident that the logistics operations in periods 2 and 3 entail much higher transportation costs than in period 1. The flow routes selected by the model (Figure 4) for periods 2 and 3 are described in Table 4.

<table>
<thead>
<tr>
<th>Table 4 ANALYSIS OF THE SOLUTION DEPICTED IN FIGURE 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>2→ 5→ 10</td>
</tr>
<tr>
<td>+ Combining flows at 10</td>
</tr>
<tr>
<td>8</td>
</tr>
<tr>
<td>8→ 6→</td>
</tr>
<tr>
<td>Combining flows at</td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

Due to space limitations, the details of the input data and the model output have been omitted. The example problem involved a total of 23,482 variables, including 990 0/1 variables, and 24,486 constraints. The model was solved in 30 minutes using LINGO 09.
CONCLUSION

The paper introduced a disaster readiness model for preplanning the delivery of emergency humanitarian items to the flood-stricken areas considering potential collection centers, distribution centers, demand for emergency aid, and available routes for various transportation modes. The model may effectively be used after the occurrence of the flood to plan for supplying emergency aid to the affected zones over several periods. As the flood conditions change, the model is dynamically updated in terms of the inputs and parameters using actual, on-the-ground reliability information about the routes, distances, distribution centers, transportation modes and the requirements for relief items. The model considers the severity level of the flood dynamically over time in order to select the transportation modes, their capacities, and the routes. A numerical example is given to demonstrate how the model may be used effectively for preplanning in the event of a flood situation. The model is very much tractable and can be solved using commercial solvers such as LINGO 09 on a standard PC.

REFERENCES


MULTI-AGENT SYSTEM BASED MODEL DEVELOPMENT FOR CONTAINER TERMINAL SYSTEM OPERATIONS

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by

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ABSTRACT

The existing researches about multi-agent system (MAS) in container terminal have not yet fully depicted the entire operation processes. While in actually customs has pivotal roles in the system, it has been neglected. The past researches also used sequential method to model communication. This method has a weakness because decision optimality is only guaranteed for the agents that are directly involved in the discussion. While the other agents whose performance are affected by the decision, but not directly taking part in discussion, are not considered in the decision making process. This research tries to cope those weaknesses. The research object is enlarged by considering the customs entity. The utilizing of forward-backward linkage negotiation method is also expected to cope the lacking of the sequential communication method. Eight agents that depict entities in the terminal are considered, i.e. ship, port captain, terminal manager, stevedore, quay crane, straddle carrier, customs and truck. The agents interact in the processes of ship arrival sequencing, determination of ship’s service time and container picking. Based on the simulation result, agents’ behaviour can depict the real system. The agents tend to maximize profit in the early period and gradually decrease it to attain common agreement. The velocity of utility function attainment is about 2-5%, but because of the descend monotonic function, negotiation agreement is guaranteed to be attained. The customs clearance is more effective than the existing system because the truck can only come to the terminal when the corresponding containers have been completely inspected.

KEYWORDS
Container Terminal, Multi-Agent System, Negotiation, Customs Clearance

INTRODUCTION

The importance of container terminal operations has motivated the emergence of some researches in this field. Some of them are Golias et.al. (2010) and Tavakkoli-Moghaddam et.al. (2009) which developed models for berth allocation policy optimization and quay crane scheduling. In addition, Ng and Mak (2005), Park et.al. (2010) have developed models for yard stowage policy optimization and yard crane scheduling. However, those models only acted partially, not wholly depicting the entire processes in the terminal, begins from ship-berthing until the unloaded containers carried away by inland trucks to the hinterlands. The partial models also emphasized that optimal decision can only be attained with information-based from various actors in the terminal. As an example, to make berth allocation decision; ship’s, yard’s and gate’s information have to be integrated. In practice, this action is nearly impossible because every actor is independent, thus data-access is infeasible.

Those weaknesses had successfully been overcomed by Henesey et.al. (2006) who developed MAS model for transshipment terminal optimization. By this method, instead of centralized, decision making process is distributed in every agent involved. To assure the attainment of common goal, among agents still have to cooperate in searching the goal. But, model from Henesey et.al. (2006) still have incompleteness because in/out terminal gate was neglected. The barrier can be patched by model from Henesey et.al. (2003) and Yi et.al. (2002) who modeled MAS for export/import terminal optimization. Otherwise, the two researches also had neglected customs clearance entity. Whereas, customs is inseparable actor in container terminal. Often delays because of the long clearances process costs the shippers, the consigness as well costs the freight transporters because of additional costs that have to beared (Hsu et.al., 2009).
The entire aforementioned researches also used sequential communication method. The method only accomodates the importance of entities that directly discussed and overrides the others entities’ consideration that do not actively take part in the discussion, but their performance are still affected by the decision. With this method, the decision is prone of trapped in local optimal area only to the corresponding entities that directly takes part in the discussion. To overcome the gap of sequential communication method, Sholihah (2010) and Kusuma (2010) have put effort to scrutinize MAS model that employs forward-backward linkage negotiation method. The method guarantees that the decision is well suited to the entire agents, whether those which actively takes part in discussion or in other extreme only passively takes role but their performance is affected by the decision from the discussion.

PROBLEM DEFINITION

This research tries to consider customs clearance entity in the examined system. In addition, the employment of forward-backward linkage negotiation mechanism is expected to enhance the quality of decision compare to the sequential communication method. The research is emphasized in designing model of multi-agent system. The model pictures interaction among entities which are represented by the agents. The model is also representation of information exchange among entitites to make decisions.

There are two boundaries of this research. The first, the corresponding research object is container terminal begins from seaway in which ships queuing for their berthing turn until in/out terminal gate. The second, entities outside the research object such as hinterland, ocean and inland-road connecting the terminal with hinterlands are not considered.

The methodology for designing MAS refers to Sanz and Pavon (2004) and Govindu and Chinnam (2007). The MAS based container terminal optimization models used as references in this research are presented in Table 1. The classification from Henesey et.al. (2006) is added with one more subsystem, i.e. customs clearance. This research tries to cope the entire five subsystems which exist in a container terminal. The five subsystems have never been studied together in the past models. To complete customs model, reference from Hsu et.al. (2009) is employed. Eventhough the reference does not exactly deal with MAS modelling, the customs business processes concept can still be used. As long as the entire references which have been scrutinized, there is no research of MAS for customs processes in seaport. In addition to the reference models, the partial models deal with berth and yard optimization and are also needed to equip the lacking concepts in the main reference models.

**TABLE 1**

### THE REFERENCE MODELS

<table>
<thead>
<tr>
<th>Research/Subsystem</th>
<th>Ship to Shore</th>
<th>Transfer</th>
<th>Storage</th>
<th>Customs Clearance</th>
<th>Delivery Receipt</th>
</tr>
</thead>
<tbody>
<tr>
<td>Henesey et.al. (2006)</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td>Henesey et.al. (2003)</td>
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<td>Yi et.al. (2003)</td>
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<tr>
<td>Huynh and Vidal (2010)</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Cahyono et.al. (2011)</td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

**NEGOTIATION PROTOCOL**

Communication which happens among the modeled terminal’s entities uses negotiation concept of the monotonic concession protocol from Wooldridge (2002). To overcome gaps of negotiation models from Wooldridge (2002) and Jennings et.al. (2000), forward-backward linkage factor from Sholihah (2010) and Kusuma (2010) is considered. The complete negotiation protocol is as follow:

- Negotiation lasts for some discussion rounds.
- Agreement is tried to be reached by the discussed agents from the very first round based on the submitted proposals.
- Agreement is reached if by transaction $\delta_1$ and $\delta_2$ that is offered by every agent, utility $y_1(\delta_2) \geq y_1(\delta_1)$ and $y_2(\delta_1) \geq y_2(\delta_2)$.
• If agreement is attained, transaction value is stipulated by the value agreed by the two sides of agents which are discussing.
• If the transaction result between two agents have impact to performance of the other agents, the result has to be tested to the other corresponding agents to get mutual decision.
• If no agreement is reached, the discussion goes on to round \( u + 1 \), in which every agent cannot make bid that gives lower utility to the other agents compare to the utility in the round \( u \).
• If no agreement is reached between two agents in the round \( u > 0 \), negotiation is concluded with the last transaction as an agreement. Decision is taken from the agent’s bid that has higher authority per hierarchy.

Differ from base model from Wooldridge (2002), the consideration of forward-backward linkage factor makes utility function attainment is not only in one-side of an agent, but also has to guarantee the attainment of utility function to the two agents that are face-to-face. The utility function is often represented as maximum-minimum value range or based on the typical function, whether symmetric or one-side function.

AGENTS INTERACTION PROCESSES

There are eight agents considered in the system i.e. Ship Agent (SA), Port Captain Agent (PCA), Terminal Manager Agent (TMA), Stevedore Agent (SdA), Quay Crane Agent (QCA), Straddle Carrier Agent (SCA), Customs Agent (CA), and Truck Agent (TA). The interaction process is exemplified in Figure 1. Three main interaction processes exist i.e. ships arrival sequencing, ship’s service time determination, and containers picking.

**Ships arrival sequencing interaction**

Ships arrival sequencing period is conducted in every 24 hours. The ships which is about to arrive to the port give their notice of arrival (NOA) to PCA. Based on the NOA, the PCA predicts the ships’ arrival time which is later used to sequence their arrival with FIFO policy. The ships’ data will be retrieved by the PCA to be distributed onto TMA, SdA and CA. It has to be understood that SA(s) are plural agents in the process of ships notification arrival. There are many SA(s) that are going to arrive to the port. In other hand, the SA is treated as single agent in the arrival time evaluation process to check whether the SA is late more than two hours or not. The same treatment happens when the PCA retrieves the ships’ data.

The NOA is also sent to TA(s) which is representative of containers’ owners. In the existing process, the NOA used by the TA(s) as an estimation of containers picking time in the terminal. But, the estimation is prone of inaccuracy because the ships arrival does not exactly delineate the real container picking time. When the containers are unloaded from the ships, the containers still have to do some customs clearance processes and also waiting in the container yard (CY), those instance are not well depicted in the NOA.

**Ship’s service time determination interaction**

Interaction is commenced with a bid of Desired Service Time (DST) from SA to SdA which is calculated based on ship’s Estimation of Time Departure (ETD). The SA will put an endeavor to maximize gap between ETD and DST which commensurate with minimization of cost that has to be beared by the ship during delays in terminal. The SdA responds DST by computing Computed Service Time (CST). To be able in calculating CST, the SdA has to contact the corresponding agents i.e. TMA in quay allocation to ships berthing process, QCA in ships loading/unloading process, and SCA in CY marshalling process.

In determining the berthing point, the TMA conducts containers marshalling plan beforehand. The plan comprises of containers flow from every ship’s bay that enter/exit to/from every CY block. The point is selected based on distance minimization between CY block with highest flow of entering/exiting containers with entire ship’s possible berthing points. Ship’s berthing time is summation of ship’s transportation time from terminal’s gate to the berthing point and berthing operation time. Simultaneously, the SdA calculates QCA and SCA needed and proposes to the TMA. Based on allocation from the TMA, the QCA loads/unloads containers in the ship and record the elapsed time. The SCA that operates in the CY also records the time needed for CY operations.

The total time of those three operations time are equal with Estimation of Time Service (ETS). The SdA tries to maximize gap between ETS and DST which is directly correlated with minimization of the terminal’s operations cost. The
longer time needed in operating the terminal utilities, the higher the cost incurred. Depends on the corresponding utility functions, the SA and the SdA negotiates until both of the utility functions attained or the negotiation itself has reached maximum round. The SdA acts as dominant-authorization agent of SA if no possible decision can be obtained from bids proposed by both agents. If deadlock happens, the system will use the last bid from the SdA. The same procedure used in the real system.

*Containers picking interaction*

Ship’s data obtained from bill of lading is used as a foundation for SA to stipulate customs categories of every container i.e. green line and red line. Containers are grouped in green line if they are considered as safety and need of no special treatment. The other extreme applies for red line which consists of next two categories i.e. Full Container Load (FCL) and Less than Container Load (LCL). CA will immediately conducting clearances when the containers arrives at CY. Green line containers can pass the clearances or its clearance time is zero. FCL red line containers are inspected in the CY. LCL red line containers are not inspected in the CY but have to be marshalled beforehand to the special area and unloaded. In another words, the LCL red line container is inspected based on its every freight, because one container may comprises of many freights with many owners. The CA then asks SdA to marshall and unload the containers. The SdA calculates the need of SCA to conduct the operations and proposes it to TMA. Based on the TMA’s allocation, the SCA do the operations based on the plan conducted beforehand.

After the operations described above are fully completed, the CA can inspect every freight. In the case of LCL green line, customs clearance time is the CA’s inspecting time add with the SCA’s marshalling and unloading time. Immediately after the customs clearances finished, the CA issues Letter of Information of Containers Releasing (LICR) and send it to the corresponding TA(s). Based on the LICR, the TA(s) can extract information of containers picking time. With the mechanism, the TA(s) will come to the terminal to pick the containers only and if only the LICR received. The policy is to avoid a possible TA(s) waiting lines in the terminal because the containers to be picked have not yet completed their customs clearances.
FIGURE 1
AGENTS INTERACTION PROCESS
ANALYSIS

After the interactions are completely modeled, the next step is analysis to extract phenomena from model development and testing stages. Analysis comprises of two parts i.e. result and performance analysis.

Result analysis

Result analysis discusses costs incurred by the corresponding agents in every interaction process. Cost is one of performance criterias beside the other criteria such as SC’s travel distances. Costs beared by the SA and the SdA during ship’s service time determination interaction is presented in Figure 2.

**FIGURE 2**

SA AND SDA OPERATION COSTS (IN USD)

The SdA is regarded as terminal operators which is responsible in generating income to the container terminal. With this terminology, every profit for terminal operator is difference between cost paid by the SA and cost paid by the SdA. From the terminal operator perspective, cost incurred by SA is equal with revenue for the SdA. The SA cost component is Terminal Handling Cost (THC) and ship cost during delays in the terminal. While the SdA cost component is container terminal operating cost. The SdA’s profit diminishes as the negotiation round runs. This phenomenon is well-suited with the real system where in beginning terminal operators want to get profit as high as possible. But, the terminal users, in this term the SA do not willing to because some added costs have to be beared. Thus, it can be understood that the SA’s cost curve continues to go down. While in the other hand, the SdA’s cost curve is positive monotone that indicates if cost that is charged to the SA in the beginning turns into the SdA’s charge.

Performance Analysis

Jennings et.al. (2000) states that one of performance indicators that can be employed to evaluate multi-agent system model’s performance is by analyzing how fast is every negotiating agent in achieving its utility function. Utility function attainment for the SA and the SdA is exemplified in Figure 3. Both of the SA and the SdA have positive monotone utility functions as the negotiation round runs. It means that model has been consistent to achieve utility function albeit 100% utility function cannot be reached during the maximum five negotiation round. But, with the attainment graphic which is constantly ascend, SA and SdA will attain their utility functions with some additional negotiation rounds. Non-positive monotone utility function attainment is somewhat avoided in the MAS model because the instance may trigger negotiation process ends in no-solution. The SA and the SdA have the same velocity pattern i.e. fast in the beginning and continues to descend in the next rounds. Velocity in the last round is approximately 2% and this value can still be accepted because as the round goes on, utility function value base still ascend. That means utility function expectation value in the next round is still big enough.
The MAS model has successfully included customs clearance process to fill the gap of the past researches. The model is still based on MAS decentralized concept because it is proven to be effective in modelling complex processes as exists in the export/import container terminal operation system. Based on the simulation result, agents’ behaviour is appropriate with the real system. The agents tend to maximize their profit in the early period and decrease it along with the negotiation process to attain a common agreement. The velocity of utility function attainment is about 2-5%, but because of the descend monotonic function, negotiation agreement is guaranteed to be attained. The customs clearance is more effective than the existing system because the trucks can only come to the terminal when the corresponding containers have been completely inspected. In addition, the communication method are also able to include consideration from the entire corresponding agents in decision making, not only for agents who are directly involved in discussion.

In the next stages, it is suggested to consider the entities such as containers empty depot, forwarder, finance institutions and government in the examined system. In the real system, those entities are inseparable and could make great impact to the whole system’s performance.

REFERENCES


A HYBRID GENETIC ALGORITHM FOR A DYNAMIC LOT-SIZING AND DISPATCHING PROBLEM WITH DELIVERY TIME WINDOWS AND HETEROGENEOUS VEHICLE TYPES

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ABSTRACT

This paper considers a single-product problem for inbound lot-sizing and outbound dispatching at a third-party warehouse, where the demand is dynamic over the discrete time horizon. Each demand must be delivered into the corresponding delivery time window which is the time interval characterized by the earliest and latest delivery dates of the demand. Ordered products are shipped by heterogeneous vehicles. Each vehicle has type-dependent carrying capacity and the unit freight cost depends on each vehicle type. The total freight cost is proportional to the number of each vehicle type employed. Also it is assumed that related cost functions are concave and backlogging is not allowed. The objective of this study is to simultaneously determine the optimal inbound ordering and shipping, and outbound dispatching plans that minimize the total system cost to satisfy the dynamic demands over the finite time horizon. We characterize the optimal solution properties for the problem. However, the problem is difficult to solve the optimal solution as the problem size becomes large. Therefore, we propose a hybrid genetic algorithm (H-GA) including the marginal freight cost heuristic to determine the number of each vehicle types employed, based on the optimal solution properties. Also, we present results to evaluate computational the performance of H-GA.

KEYWORDS
Dynamic Demand, Dynamic Lot-Sizing and Dispatching, Delivery Time Windows, Heterogeneous Vehicles, Genetic Algorithm

INTRODUCTION

This paper considers a single-product problem for inbound lot-sizing and outbound dispatching at a third-party warehouse, where the demand is dynamic over the discrete time horizon. Each demand must be delivered into the corresponding delivery time window which is the time interval characterized by the earliest and latest delivery dates of the demand. Ordered products are shipped by heterogeneous vehicles. Each vehicle has type-dependent carrying capacity and the unit freight cost depends on each vehicle type. The total freight cost is proportional to the number of each vehicle type employed. Also it is assumed that related cost functions are concave and backlogging is not allowed. The objective of this study is to simultaneously determine the optimal inbound ordering and shipping, and outbound dispatching plans that minimize the total system cost to satisfy the dynamic demands over the finite time horizon. We characterize the optimal solution properties for the problem. However, the problem is difficult to solve the optimal solution as the problem size becomes large. Therefore, we propose a hybrid genetic algorithm (H-GA) including the marginal freight cost heuristic to determine the number of each vehicle types employed, based on the optimal solution properties. Also, we present results to evaluate computational the performance of H-GA.

The dynamic lot-sizing model (DLSM) has stemmed from the work of Wagner and Whitin (1958). The majority of DLSMs have not considered any production-inventory problem incorporating transportation activities. Several articles have attempted to extend the classical DLSM incorporating production-inventory and transportation functions together. Lee (1989) considered DLSM allowing multiple set-up costs consisting of a fixed charge cost and a
freight cost, in which a fixed single container type with limited carrying capacity is considered and the freight cost is proportional to the number of containers used. Lee et al. (2003) extended the work of Lee (1989) by considering heterogeneous vehicle types to immediately transport the finished product in the same period it is produced. It is also assumed that each vehicle has a type-dependent carrying capacity and the unit freight cost for each vehicle type is dependent on the carrying capacity. Lee et al. (2003) considered a dynamic model for inventory lot-sizing and outbound shipment scheduling in the Third-Party Warehousing domain. They presented a polynomial time algorithm for computing the optimal solution.

Lee et al. (2001) was the first paper that studied the DLSM with time windows. They developed two polynomial time algorithms for the case of a backlogging allowed and the case of a backlogging being not allowed. Jaruphongsa et al. (2004) studied a single item, two-echelon DLSM with delivery time window. Wolsey (2006) proposed polynomial time algorithm considering both production and delivery time windows. Hwang (2007) developed an improved algorithm by the model of Lee et al. (2001). Jaruphongsa and Lee (2008) studied the dynamic lot-sizing problem with demand time windows and container-based transportation cost. They classified two sub-cases by the dispatching type within the time windows and proposed only a dynamic programming algorithm for the split demand case with a single container type.

This paper analyzes a dynamic inbound ordering and shipping scheduling, and outbound dispatching problem for a single product that is transported from a supplier to TPL warehouse by various freight vehicles and delivered from TPL warehouse to retailers in a supply chain. Demand is dynamic over the discrete time horizon. Each demand must be delivered into the corresponding delivery time window which is the time interval characterized by the earliest and latest delivery dates of the demand. Each vehicle has type-dependent carrying capacity and the unit freight cost depends on each vehicle type. The total freight cost is proportional to the number of each vehicle type employed. Also it is assumed that related cost functions are concave and backlogging is not allowed. The objective of this study is to simultaneously determine the optimal inbound lot-sizes and the shipment schedule, and outbound dispatching plan that minimize the total cost which consists of ordering, inventory holding, and freight costs.

The paper is organized as follows: In the following section we formulate mathematical models for each case. In Section 3, we design genetic algorithms for the problem. Next, we report the results of computational experiments to evaluate the performances of the genetic algorithms with the best solution under the node-limit using CPLEX package in Section 4. Finally, we conclude the paper with a summary and some directions for future research in Section 5.

MODEL FORMULATION

The following notations are defined to formulate the problem:

- $T$: length of the time horizon,
- $t$: period index ($t = 1,2,\cdots, T$),
- $M$: number of demands,
- $i$: demand index ($i = 1,2,\cdots, M$),
- $N$: number of vehicle types,
- $j$: vehicle type index ($j = 1,2,\cdots, N$),
- $W$: carrying capacity of a container,
- $h_i$: unit inventory holding cost of demand $i$ from period $t$ to period $t+1$,
- $F$: unit freight cost of container in period $t$,
- $x_{ij}$: amount of ordering and shipping by vehicle type $j$ at period $t$,
- $y_{ij}$: number of vehicle type $j$ employed in period $t$,
- $I_t$: amount of inventory at the end of period $t$,
- $d_{it}$: amount of dispatching amount $i$ in period $t$, and
- $d_i$: amount of delivery to demand $i$,

We assume that all products have the same weight and volume specifications. The objective of the problem is to determine $(x_{ij}, y_{ij}, d_i)$ for $t = 1,2,\cdots, T$ and $i = 1,2,\cdots, M$, $j = 1,2,\cdots, N$ so that all demands are satisfied at the minimum total cost. Then we can represent a mixed integer linear programming (MILP) model as follows:
\[(P)\] \[
\begin{align*}
\text{Min} & \quad \sum_{t=1}^{T} \left[ S_t d_t \left( \sum_{j=1}^{N} x_{ij} \right) + p_t \left( \sum_{j=1}^{N} y_{ij} \right) + \sum_{j=1}^{N} f_t y_{ij} + h_t I_t \right] \\
\text{s.t.} & \quad \sum_{j=1}^{N} x_{ij} + I_{t-1} - \sum_{j=1}^{N} d_{ij} = I_i, \quad t = 1, \ldots, T \\
& \quad x_{ij} \leq W_j y_{ij}, \quad j = 1, \ldots, N; \ t = 1, \ldots, T \\
& \quad \sum_{i=1}^{M} d_{ij} = d_j, \quad i = 1, \ldots, M \\
& \quad d_{ij} \geq 0, \quad i = 1, \ldots, M; \ t = E_i, \ldots, L_i, \\
& \quad d_{ij} = 0, \quad i = 1, \ldots, M; \ t = 1, \ldots, E_i - 1, \\
& \quad d_{ij} = 0, \quad i = 1, \ldots, M; \ t = L_i + 1, \ldots, T, \\
& \quad I_0 = I_T = 0, \\
& \quad x_{ij} \geq 0, \ y_{ij} \geq 0, \ I_i \geq 0, \quad t = 1, \ldots, T, \ i = 1, \ldots, M
\end{align*}
\]

The constraints (2)-(9) in the model \(P\) defines a closed and bounded convex set, and the objective function (1) is concave, so that it attains its minimum at an extreme point of the convex set. Although, the above mixed integer programming model is quite solvable for problems of small sizes, it is also obvious that a heuristic alternative will be of great interest for many application as the size of problem increases. Hence, we focus on a genetic algorithm to obtain near-optimal solutions for the problems in a reasonable CPU time.

**FIGURE 1**

**NETWORK REPRESENTATION OF THE MODEL**

**OPTIMAL SOLUTION PROPERTIES**

In order to express effective optimal solution properties, we define several terms.

1. The period \(t\) is a regeneration point, if \(I_t = 0\).
2. The period \(t\) is an ordering point if \(\sum_{i=1}^{M} x_{in} > 0\).
3. The period \(t\) is a partial shipment point, if \(mW_s < x_n < (m+1)W_s\), for some \(n\), where \(m\) is non-
negative integer.

(4) The period $t$ is dispatching point of demand $k$, if $d_k > 0$.

Then we can characterize the optimal solution properties for the model $P$.

**Theorem 1.** In the model $P$, there is the optimal solution which has at most one partial shipment point between two consecutive regeneration points.

**Proof.** Suppose that there exists the optimal solution that has two partial shipment point $b$ and $d$ between two consecutive regeneration points, $u$ and $v$ ($u+1 \leq b < d \leq v$) in the model $P$, and container type 1 and $N$ are partial containers with $mW_x < x_{11} < (m+1)W_x$ and $lW_y < x_{21} < (l+1)W_y$ where $m$ and $l$ are nonnegative integers. In the network of Fig. 1, this case can have unsaturated loop formed by the sequences of nodes $(x_{11}, I_u, \ldots, I_v, x_{21})$. This feasible flow is not an extreme flow by network theory. Therefore, the proof is complete.

**Theorem 2.** In the model $P$, there is the optimal solution which has only one dispatching point for a demand $k$ between two consecutive regeneration points.

**Proof.** In the model $P$, the optimal solution has only one dispatching point for demand $k$ between two consecutive regeneration points, $u$ and $v$. For demand $k$, it is assumed that there is an optimal solution with 2 dispatching points $p$ and $q$, where $u+1 \leq p < q \leq v$. Suppose that $I_{\text{min}} = \min [I_u, I_t = p+1, \ldots, q-1]$. If $I_{\text{min}} < d_{qi}$, a new improved solution is obtained that reduces inventory cost by $d_{qi}^* = d_{qi} + I_{\text{min}}$, $I_t^* = I_t - I_{\text{min}}$, $t = p+1, \ldots, q-1$, and $d_{qi}^* = d_{qi} - I_{\text{min}}$. Then the new one regeneration is occurred additionally between $u$ and $v$. If $I_{\text{min}} \geq d_{qi}$, an improved solution is obtained that reduces inventory cost by $d_{qi}^* = d_{qi} + d_{qi}$, $I_t^* = I_t - d_{qi}$, $t = p+1, \ldots, q-1$, and $d_{qi}^* = 0$. Therefore, the proof is complete. For the cases of with 2 more dispatching points, this property is concluded.

**Theorem 3.** In the model $P$, if period $t$ is an ordering point, period $t$ is also a dispatching point satisfied within the delivery time window of demand $k$, $t \leq t \leq L_k$.

**Proof.** Suppose that period $t$, ($t < t_1$) is the first dispatching point for demand $k$ after an ordering point at period $t$. If the ordering point at period $t$ moves to period $t_1$, an improved solution is obtained that reduces the inventory cost. Therefore, the proof is complete.

**GENETIC ALGORITHM**

**Representation and initialization**

The proper representation of a solution plays a key role in the development of a genetic algorithm. Let $X_r = \sum_i \chi_i$, and we have a set of three decision variables $(x_i, y_i, d_i)$. We first initialize dispatching amount $(d_i)$ and then we initialize the purchasing amount in each period $(X_r)$ using the zero-one encoding, in which $X_r$ is represented by 0 and 1 based on $d_i$. Once the $X_r$ is determined, the vehicle types used in each period $(y_i)$ and its quantity $(x_i)$ for the $X_r$ are determined by a local search heuristic.

**A) Initialization $(d_i)$**: Since the dispatching amounts have two dimension such as planning horizon $t$ and demand $i$, we adopt two-dimensional real representation for initialization as the work of Vigaux and Michalewicz (1991). The procedure of initial chromosome for $d_i$ is described in Fig. 1.
B) Initialization \( (X_i) \): Once \( d_i \) is initialized, the required demand of period \( t \) can be calculated by \( d_i = \sum_{k=0}^{M} d_k \). Based on the required demand of each period \( (d_j) \), we can initialize the purchasing amount \( (X_i) \) to avoid occurring the non-negative inventories \( (I_i) \) for each period. We represent a chromosome for the \( X_i \) using the zero-one encoding. In this representation, we use the string of \( T \) digits (where \( T \) is the number of periods). Each digit takes 0 or 1, in which ‘0’ indicates no order in the corresponding period and a ‘1’ indicates an order in the corresponding period for having the quantity of its demand and the demands of all subsequent periods with a ‘0’ code. Fig. 3 describes a decoding process of the zero-one encoding of a chromosome ‘100101’ for the required demand of 4, 3, 6, 7, 10, and 2 from period 1 to 6, respectively. Since the first gene of the chromosome is ‘1’ and two consecutive genes are ‘0’, the ordering amount of the first period \( X_1 \) is 13. Similarly, \( X_4 \) and \( X_5 \) are 17 and 2, respectively.

**FIGURE 2**
TWO DIMENSIONAL REPRESENTATION OF DISPATCHING AMOUNT

\[
\begin{align*}
\text{Begin} \\
\pi &\leftarrow \{1,2,\ldots,TM\} \\
\forall k &\leftarrow d_i, \text{ for } k = 1, \ldots, M \\
\text{Repeat} \\
&\text{Select a random number } i \text{ from set } \pi; \\
&\text{Calculate corresponding row and column; } \\
&k \leftarrow \left\lfloor \frac{(i-1)}{T+1} \right\rfloor; \\
&t \leftarrow \left\lfloor \frac{(i-1)\mod T + 1}{} \right\rfloor; \\
&\text{Assign dispatching amount } d_\mu \text{ as follow; } \\
&\text{if } E_k \leq t \leq L_k \\
&\quad d_\mu \leftarrow \text{rand}[0, u_s]; \\
&\text{else} \\
&\quad d_\mu \leftarrow 0; \\
&\text{end if} \\
&\text{Update } u_s \text{ and } \pi \text{ as follows; } \\
&\quad u_s \leftarrow u_s - d_\mu; \\
&\quad \pi \leftarrow \frac{\pi}{[\mu]; \\
\text{Until} \ (\pi \text{ becomes empty) }
\end{align*}
\]

**FIGURE 3**
DECODING PROCESS OF THE ZERO-ONE CHROMOSOME

Chromosome: \((1, 0, 0, 1, 0, 1)\)

\[
X = 13 \quad 0 \quad 0 \quad 17 \quad 0 \quad 2
\]

\[
I = 9 \quad 6 \quad 0 \quad 10 \quad 0 \quad 0
\]

\[
\sum_{k=0}^{M} d_k = 4 \quad 3 \quad 6 \quad 7 \quad 10 \quad 2
\]
C) Repairing: To maintain the solution feasibility, the genes of any chromosome are always force to ‘zero’ before the first positive demand and the gene with the first positive demand forces to ‘one’. The repairing process may be executed if an infeasible solution is found after the crossover or mutation operations of \(d_a\) and \(X_a\) is performed. There are two cases of having an infeasible solution, which are the one of the cases that the cumulative order amount is greater than or equal to the cumulative dispatching mount in each period or the other case that the total order amount is greater than dispatching amount. In this study, the forward pass and backward pass repairing method is used by the work of Ozdamar and Birbil (1998).

D) Selection of vehicle types \((y_a)\) for shipping the purchasing amount \((x_a)\): Once the purchasing amount of each period \((X_a)\) is constructed from decoding of 0-1 chromosome, we then have to determine the vehicle types used \((y_a)\) and its quantity \((x_a)\) for the corresponding \(X_a\). The selection of vehicle types is determined by the concept of the marginal cost heuristic per unit-product. To determine the \((x_a, y_a)\), we propose a local heuristic using the marginal freight cost per unit-product for each vehicle. The detailed algorithm for the marginal cost heuristic per unit-product is described in Fig. 4. Since the GA includes a local heuristic, we call our algorithm a hybrid genetic algorithm (H-GA).

**FIGURE 4**
THE ALGORITHM FOR THE MARGINAL COST HEURISTIC PER UNIT-PRODUCT

<table>
<thead>
<tr>
<th>Step 1:</th>
<th>For each selected period (t), calculate the unit-freight cost, (M_y = f_d/w), and select the vehicle type (p) with the lowest (M_y).</th>
</tr>
</thead>
<tbody>
<tr>
<td>Step 2:</td>
<td>Obtain the number of the vehicle type (p), (n_p = \lceil x_p/w \rceil). Set (y_p = n_p) and (x_p = n_p \times w_p). Then update (x_p = x_p - x_w).</td>
</tr>
<tr>
<td>Step 3:</td>
<td>Select the vehicle type (k \in N) with the lowest (F_a) and set (y_a = \lceil x_{a} / w \rceil) and (x_a = x_{a}), other vehicles is not chosen, where (F_a = \begin{cases} f_a, &amp; x_{a} \leq w \ f_a \times \lceil x_{a} / w \rceil, &amp; \text{otherwise} \end{cases}).</td>
</tr>
</tbody>
</table>

**Objective and fitness function**

Once the a set of decision variables \((x_a, y_a, d_a)\) and the depending variable \((I_a)\) is determined based on the \((X_a, d_a)\), we can obtain the objective function value defined by the model \(P\). Since all of the problems under consideration are minimizing problems, however, we have to convert the objective function values to fitness function values of maximization form. We use the simplest procedure to get the fitness value for a chromosome (i.e., \(F_i\)) from the objective function value of the chromosome (i.e., \(Z_i\)) and the maximum objective function value among the population (i.e., \(Z_{max}\)) as follows:

\[
F_i = Z_{max} - Z_i
\]  

(10)

**Reproduction, crossover and mutation**

A simple genetic algorithm that yields good results in many practical problems is composed of three operations: reproduction, crossover and mutation. Reproduction is a process in which individual chromosomes are copied according to their fitness function value. We use the easiest method and the roulette wheel reproduction method where each current string in the population has a roulette wheel slot sized in proportion to its fitness. The crossover operator takes two chromosomes and swaps a part of their genetic information to produce new chromosomes. The crossovers for the dispatching amount \((d_a)\) and the purchasing amount \((X_a)\) are described as follows:

A) The crossover operator

The crossover for the dispatching amount \((d_a)\) is performed using two sub-matrices \((P, Q)\) generated by two parent chromosomes, \(d_i = (d_i')\) and \(d_i = (d_i')\). Fig. 5 describes the detailed algorithm of the crossover for the \(d_a\). While the crossover for the purchasing amount \((X_a)\) is used to the one-cut-exchange which is the one of the easiest and the most classical crossover methods.
FIGURE 5
THE ALGORITHM OF CROSSOVER FOR DISPATCHING AMOUNT

Begin
Select two chromosomes \( d_i = \left( d^i_1 \right) \) and \( d_i = \left( d^i_2 \right) \). The crossover is performed in three steps:

Step 1: Create two temporary matrices \( P = \left( p_u \right) \) and \( Q = \left( q_u \right) \) as follows:
\[
p_u = \left\lfloor \frac{d^i_1 + d^i_2}{2} \right\rfloor \quad \text{and} \quad q_u = \left( d^i_1 + d^i_2 \right) \mod 2.
\]

Step 2: Divides matrix \( Q \) into two matrices \( Q_1 \) and \( Q_2 \) such that
\[
Q = Q_1 + Q_2,
\]
where, \( \sum_{i=1}^r q^i_u = \sum_{i=1}^r q^i_\mod, \) for \( \forall k \).

Step 3: Then we produce two offspring of \( d^*_1 \) and \( d^*_2 \) as follows:
\[
d^*_1 = P + Q_1 \quad \text{and} \quad d^*_2 = P + Q_2.
\]
End

B) The mutation operator

Mutation produces spontaneous random changes in various chromosomes. For the mutation of the dispatching amount \( d^i_\), the entire amount in a chromosome within the delivery time window moves to the one of the periods in the common time window, where the common time window is the co-periods of the time windows of the selected demands. By shifting the dispatching amounts of demands to the common time window, the probability that the amount of order and delivery at the same period increases. Thus, inventory and purchasing costs can be reduced due to shifting the purchasing amounts for the demands from the different time windows into the common time window. The detailed mutation procedure in the dispatching amount \( d^i_\) is described in Fig. 6. Meanwhile, the mutation in the purchasing amount \( X^i_\) uses a random change between 0 and 1.

FIGURE 6
THE ALGORITHM OF MUTATION FOR DISPATCHING AMOUNT

Begin
Repeat
Select a random real value \( r \) from \([0,1]\).
if \( r \leq P_M \),
Step 1: Select a random integer number \( b \) from \([1,M]\).
Step 2: Find \( [E_s, L_s] \) at row \( b \) in \( d \) and change \( E = E_s \) and \( L = L_s \) and choose a moving position \( s \) within a common time window \([E,T]\).
Step 3: Construct a common window
While \( (n \leq N) \)
Step 3.1: Select a random \( p \) from \([1,M]\)
Step 3.2: Find \( [E_s, L_p] \).
Step 3.3:
if \( [E,L] \) and \( [E_s,L_p] \) has a common period, update \( E = \max(E, E_s) \) and \( L = \min(L, L_p) \).
end if
Step 3.4: Increase \( n \) by 1.
End While
Step 4: Select a random period \( e \) at row \( b \) from \([E,T]\)
Step 5: Remove \( d^i_\) from period \( s \) to \( e \) at row \( b \) and add it into \( d^i_\).
end if
End

C) The reproduction operation

Adopting the elitist strategy, the two best chromosomes are excluded from the crossover and mutation procedure and they are directly copied to the next generation. Rest of chromosomes are selected by the roulette wheel

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method after performing the crossover and mutation procedures. The detailed procedure for the reproduction is as follows:

**FIGURE 7**
THE PROCEDURE TO GENERATE REPRODUCTION

| Step 1: | Generate an initial generation $(X,d)$ and set $n_u \leftarrow 0$. |
| Step 2: | Set $n_x = n_x + 1$ and $n_y \leftarrow 0$. |
| Step 3: | Find the vehicle types used $(y)$ and its quantity $(x)$ are determined for $(X,d)$ using the proposed local search heuristic and calculate the fitness of chromosomes. |
| Step 4: | Copy two best chromosome sets for the next generation. |
| Step 5: | Perform the crossover of $d$ if a random number in $[0, 1]$ is less than $P_c$. |
| Step 6: | Perform the mutation of $d$ if a random number in $[0, 1]$ is less than $P_m$. |
| Step 7: | Repair $X$ based on $d$, if the excessive order amount or the negative inventory is found. |
| Step 8: | Select $N-2$ chromosome sets by the roulette wheel method from the current generation. |
| Step 9: | Find the vehicle types used $(y)$ and its quantity $(x)$ are determined for $(X,d)$ using the proposed local search heuristic and calculate the fitness of chromosomes. |
| Step 10: | Copy two best chromosome sets for the next generation. |
| Step 11: | Perform the crossover of $X$ if a random number in $[0, 1]$ is less than $P_c$. |
| Step 12: | Perform the mutation of $X$ if a random number in $[0, 1]$ is less than $P_m$. |
| Step 13: | Repair $X$ based on $d$, if the excessive order amount or the negative inventory is found. |
| Step 14: | Find the vehicle types used $(y)$ and its quantity $(x)$ are determined for $(X,d)$ using the proposed local search heuristic and calculate the fitness of chromosomes. |
| Step 15: | Go to Step 2 if $n_u < N_u$, or stop, otherwise. |

**COMPUTATIONAL RESULTS**

To evaluate the performance of the H-GA, the following experimental conditions were designed:

1. Set the period, $T = 10, 12, 14, 18, 24$ and the demand density, $M = 25%, 50%, 75%$ of each $T$, respectively.
2. Set the number of vehicle types, $V = 3, 4, 5$
3. Set the size of time window, $TW = 30%, 40%, 50%$ of each $T$, respectively,
4. Demands were generated from a normal distribution $N(\mu, \sigma_i)$, where $\mu_i$ was generated from an uniform distribution $U(300,900)$ and $\sigma_i$ was equally likely selected from $\mu_i$ and $\mu_i/5$,
5. $h_i = 1$, $p_i = 7$ and $S_i = TS\mu/2$ was assumed without loss of generality and $TS = 1, 3, 6$ where $TS$ denotes EOQ time supply,
6. Set $W = 100, 200, 300$ and $W_j = W \times j$ and respective unit freight cost was selected from $w_j = w_j(1 - 0.1\times j)$, for $\forall j$. 
7. Crossover probability and mutation probability of a chromosome set $(X,d)$ are $P_c = 0.30$ and $P_m = 0.05$, and the termination numbers of generations are $N_u = 300$ and $N_d = 50$. 

H-GA heuristic was coded using C++ and run on a laptop computer with an Intel(R) Pentium 4 CPU 2.66GHz with 248 RAM. To find the optimal solution, CPLEX 6.0.2 package was used. Four replications were performed for each combination of input parameters. Total 1620 instances were tested in both CPLEX and H-GA heuristic. Due to the limitation of a computer performance, the optimal solution was not obtained within 2 hours for many large-sized test problems having more than or equals to 14 periods. Whereas, for many small-sized test problems having less than or equals to 12 periods, the optimal solution was found. So, CPLEX package was modeled and run so as to find the best solution within 1,000,000 node limits. However, H-GA found the best solution no more than 110 seconds in every instances. To evaluate the performance of the heuristic, the average percent gap between the best solution and the heuristic solution was computed as follows:
\[(Z_B - Z_h)/Z_h \times 100, \quad (11)\]

where \(Z_B\) is the objective value of the best solution and \(Z_h\) is the objective value of the heuristic solution.

Tables 1, 2, and 3 present the average percent gap between the best solution and the heuristic solution in time window size of 30%, 40%, and 50% of the length of planning period, respectively. The negative value of the average percent gap implies that the heuristic solution is better than the best solution on the average. The differences of the average percent gaps between the best solution in CPLEX and the solution in H-GA vary from -0.16 to 2.52. H-GA works more efficient as \(T\) and \(M\) increases because CPLEX gives poor solutions due to termination by node-limits. The tables show that the average gap becomes large as the number of vehicle types and container size increases.

The tables show that the average gap becomes smaller as the freight cost under same container weight increases, which means that the heuristic become less effective when freight cost per weight has less critical effect on the total cost. In this case, it may not necessary to contain products fully to save freight cost. Since we use the zero-one-two encoding for the purchasing amount, there is more possibility that the products are fully contained to meet container capacity. Therefore, the H-GA using the zero-one encoding results in a poor performance when freight cost per weight is not significantly effect on the total cost. The average gaps provide the minimum at the window size 40% of planning horizon by showing 0.17%. This reason is that it is easy to obtain the optimal solution when the window size is small. Meanwhile, the searching space in the heuristic becomes larger within the common time window and is difficult to obtain a good solution, when the window size is too large. In an average sense, the heuristic offers good solutions within 0.29%, 0.17%, and 0.37% in comparision with the best solution.

**TABLE 1**

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Average 0.29
**TABLE 3**

**AVERAGE GAP FROM THE BEST SOLUTION FOR 50% TIME WINDOW**

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In previous study, we studied a single-product control problem for inbound ordering and shipping, and outbound dispatching with single vehicle mode. At that time, we proposed a similar GA for heuristic. The basic difference on the GA in the single vehicle mode and the multi-vehicle mode is the encoding of the purchasing amount. We applied 0-1-2 encoding instead of 0-1 encoding in the previous study. If we apply 0-1 encoding in single vehicle mode, we could not guarantee the solution space that includes the optimal solution. Table 4 presents the comparison between GA in single vehicle mode and H-GA in multiple vehicle modes under three delivery time windows. Both cases show the best performance at 40% of delivery time window in Table 4. Throughout the cases, except 40% of delivery time window, the performance in multi-vehicle mode is better than single vehicle mode. Also the multi-vehicle mode provides less standard deviation than the single vehicle mode. This means that the H-GA in multiple vehicles provides more robust than the GA in single vehicle mode.
TABLE 4
COMPARISON BETWEEN GA IN SINGLE VEHICLE MODE AND H-GA IN MULTIPLE VEHICLE MODES
WITH THREE DELIVERY TIME WINDOW TYPES

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CONCLUSION

This paper analyzed a dynamic inbound ordering and shipping scheduling problem for a single product that is transported from a supplier to TPL warehouse by various freight vehicle types and dispatched to retails in a supply chain. Since the large-sized problem could not find an optimal solution using the conventional optimization solvers, we proposed a hybrid GA heuristic based on the optimal solution properties. To evaluate the performance of the heuristic, we presented the computational results from a set of simulation experiment. In an average sense, the heuristic offered good solutions within 0.29%, 0.17%, and 0.37% in comparison with the best solution for given test problems. Compared GA approach of single vehicle mode, it provided more robust solutions among instances with short CPU time. As a further research, we will extend this problem into the multi-product case.

REFERENCES

COMPETITION IN MULTI-ECHelon DISTRIBUTIVE SUPPLY CHAINS WITH LINEAR DEMAND

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SUPPLY CHAINS WITH LINEAR DEMAND

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ABSTRACT

We study competition in multi-echelon supply chains with a distributive structure. Firms in the supply chain are grouped into homogeneous sectors that contain identical firms with identical production capabilities that all produce exactly one undifferentiated product. Each sector may distribute its product to several different downstream sectors, and each sector is only supplied by a single upstream sector. The demand curves in final markets are assumed to be linear, as are the variable costs of production in all sectors. Competition is modeled via the Successive Cournot model in which firms choose production quantities for their downstream market so as to maximize their own profits, given prices for the input. Under these assumptions, equilibrium prices, quantities, and firm-level profits for any multi-echelon distributive network can be derived. We discuss certain network transformation properties, and using these properties, we examine the effect of demand parameter changes and cost changes on any firm's equilibrium price, quantity, and profit. The examination of lateral effects in these networks provides some novel insights. An important insight is that prices represent a compromise between the prices in the perfect discrimination case. We also explore the effects of concentration and market power on profits. While upstream concentration has the expected effect, the consequences of downstream concentration on upstream sectors, and therefore on sectors in parallel (lateral) paths can be quite counter-intuitive. Many of these results are consequences of the distributive network structure.

KEYWORDS
Mutli-Echelon, Supply Chain, Competition, Distributive Network

INTRODUCTION

In many industries it is common to see multi-stage supply chains, in which different companies occupy different stages of the chain. The number of entrants at any level of a supply chain can vary quite substantially. Supply chains also exhibit considerable structural variation across industries. Basic goods and commodity products are often purchased by several distinct sectors. For example, steel is purchased by the automotive industry as well as by the construction industry. Goods can also be sold in more than one geographically distinct marketplace. Such examples display a distributive structure. In other cases, the supply network can have an assembly structure where many inputs may be required to assemble a product. Of course, both of these characteristics can also be present simultaneously.

In this paper we address competition in multi-echelon distributive supply chains, a generalization of the serial chain model of Corbett and Karmarkar (2001). Firms are grouped into sectors where all firms within a sector are identical. Each sector produces exactly one product and uses exactly one input. A product may be purchased by many sectors. The resulting system can be pictured as a network which has a multi-echelon or arborescent structure in which each sector is represented by a node. Each node is supplied by a unique node, but may be a supplier to more than one node. The network representation of such distributive structure is sketched in Figure 1.
Our purpose is to study system-wide equilibrium behavior while considering vertical and horizontal interactions among sectors in the whole network as well as the competition between firms within each sector (node). We develop models of competition where each individual firm in each sector of a large multi-echelon distributive network acts as a decision maker optimizing its own profit. This model allows us to examine the impact of cost structure, network (distribution) structure and sector concentration on prices, quantities and profits. As in Corbett and Karmarkar (2001) we model competition using the Successive Cournot framework. We provide explicit expressions for equilibrium prices, quantities and firm-level profits. We construct network transformation methods that can compress networks to simpler forms, or expand them to particular (binary) forms. By using these transformation methods, we are able to analyze the impact of cost and demand parameters without having to deal with the complexity or specific form of the network structure. Importantly, we are also able to study the effect concentration in any sector in the network on any other sector. These effects are in some cases quite non-intuitive. Conventional wisdom and earlier studies in the literature state that lower concentration (a larger number of firms) in a market generally causes the total output of that market to increase, the consumer price to decrease, and each incumbent's profit to decrease (Seade 1980a). These results are indeed obtained in the serial and assembly cases, under assumptions similar to those of this paper. However, we find that for the distributive case, with the consideration of vertical and horizontal interactions, firm-level profit for incumbents could increase or decrease with changes in concentration. This result is due to the combined effect of competition and upstream resource price changes.

Examples of distributive network structures abound. Perhaps the most obvious case is that of simple geographical distribution, where goods from a plant are sold in more than one region, with no cross-selling across regions (due to distance and cost). Distributive structures also occur in many process industries, where one product is used in more than one distinct “downstream” production process to make different products. Examples include metals (steel, aluminium, copper), agricultural products (milk, wheat, corn), petro-chemicals (leading to a vast range of sectors including polymer plastics like PVC and HDPE, fibers like polyester and chemicals like methanol, ethylene and olefins), and electronic components (like memory chips) going into different boards and products.

Cement production provides a good example of a two-tier distributive network. The first stage is the production of clinker from limestone. At a second tier, clinker is ground, blended with fillers like slag, and packaged into the final product. The grinding plants tend to be closer to market regions and so are geographically distributed, while clinkering must be done close to the sources of raw material (limestone and coal). Grinding plant costs are an order of magnitude smaller than clinker plants, so that there can be many more entrants at the lower tier than at the upper. In some regions, a third tier in this sector is distribution to retail locations, which happens in countries with many small contractors who buy cement locally.

Changes in costs, concentration, technology, network structure, or demand can have both vertical and lateral effects in distributive systems. For example, an increased demand for gasohol affects prices and production of corn, and thus of starch, corn syrup, and hundreds of other foods, cosmetics and industrial products. The magnitudes of the changes in any sector depend on many, perhaps all, other sectors. Methods for understanding and estimating these changes, and for solving large problems, are not readily available. If multiple concurrent changes occur in these systems, it is not easy to assess the composite effects of those changes. And in some cases, the changes can be counter-intuitive even in terms of direction.
We note that the (post-entry competition) model of this paper is a pre-requisite not only for entry decisions, but also for other types of analyses. For example, a facility location decision in the context of a supply chain could use the post-entry production model to understand the consequences of alternative location choices. Ho et al. (2004) study competitive location with a simpler imbedded one-tier Cournot model of production competition after location choice. But in many sectors, for example cement, petrochemicals, or food processing, there are multiple tiers involved. This more complex and realistic location problem remains to be investigated. As another example, consider the consequences of process improvement at some stage in an industry to reduce variable costs. The results of such changes can ripple to upstream, downstream and lateral sectors. The tools to analyze such changes do not exist today. Vertical integration decisions can be analyzed in a manner similar to the example in Corbett and Karmarkar (2001) for the serial chain case. In all these examples, the fast solution of the competitive model is a necessary pre-requisite.

The distributive model can also be combined with the assembly model of Carr and Karmarkar (2004) to study more complex production networks. However, this extension is not trivial, and the solution approach may not be general, since it can depend on the specific structure of the network being considered.

RESEARCH REVIEW

Our analysis is in the tradition of the Successive Cournot oligopoly literature, though most previous research has been limited to the two tier serial case with only one or two entrants at each tier. In fact, the upstream tier is often taken to consist of a single (monopolist) firm. Furthermore, most of the existing literature is directed towards policy issues related to vertical integration and market foreclosure, often in a setting with the upstream monopolist integrating forward. Our approach is directed at the modeling, analysis and solution of large-scale networks, in order to understand the implications for production decisions (quantities), the resulting prices, and the effects of changes in network structure, variable cost structure across the network, end demand, and concentration at network stages.

Machlup and Taber (1960) present an early discussion of successive oligopoly and vertical integration. Greenhut and Ohta (1979) and Abiru (1988) show that vertical integration by a monopolist in the supplying sector, by and large leads to higher outputs and lower prices. The seeming paradox here is that a monopolist integrating forward, can drive out competitors from downstream markets, and yet social welfare can be increased. Essentially, this happens because vertical integration avoids double marginalization. Quan and Rogers (2004), follow an approach similar to Corbett and Karmarkar (2004) to examine a two-tier network of a telecommunications firm purchasing software tools from an upstream vendor; the firm then employs the tools to produce both a product (programmed queries) and services.

Tyagi (1999) studies the effects of downstream entry in a two tier serial setting when the upstream tier consists of a monopolist and the downstream tier consists of identical firms. He finds that downstream entry could affect the (upstream) price charged to the downstream firms. Depending on the consumer demand functions, this change of upstream price could have negative or positive effect on the profits of downstream incumbents. This effect occurs for certain demand conditions, and cannot occur for linear demand in a serial chain. In this paper we show that it can occur in distributive chains even when the end market demand is linear, due to an entirely different mechanism that has to do with the distributive structure rather than with the shape of the end market demand curve.

Other related economic literature includes Ziss's (1995) study of horizontal mergers within a setting of two tiers with two entrants in each tier, Vickers's (1995) study of regulation in serial chain competition and Seade's (1980) study on the effects of concentration and entry. As we have mentioned, none of these papers considers a network where there are multiple tiers of distributors or manufacturers, or a distributive structure.

Our paper is closest in methodology and spirit to Corbett and Karmarkar (2001) who study multi-tier serial supply chains. Also closely related is the paper by Carr and Karmarkar (2005) that analyzes multi-echelon assembly networks. The distributive and assembly settings are complementary generalizations of the serial case. There are significant differences in the two generalizations that derive from the different underlying network structures. In the assembly case, a key advance was in representing how quantity matching takes place across supplying sectors (corresponding to bill-of-materials relationships). In the distributive case, an important insight is that upstream firms have to strike a balance between multiple downstream sectors when discrimination is not possible. This compromise then has implications for the consequences of changes in parameters or structure.
The ability to analyze the equilibrium behavior of large-scale distributive networks distinguishes our paper from previous work, and as far as we are aware, this is the first paper to address this setting.

THE TWO-TIER DISTRIBUTIVE MODEL

In the two-tier case, there is a single upstream sector (consisting of several homogenous firms) and multiple sectors in the lower tier (each with several firms) as shown in Figure 2.

Firms at each downstream sector $i$ face an independent consumer market, where the price and the aggregate production quantities are linearly related by $p_i = a_i - b_i Q_i$. Here, $a_i$ is the market reservation price, the supremum price at which demand will be positive. The other parameters $b_i$ is price sensitivity of the market. We also define $B_i := 1 / b_i$ for convenience.

We use the following notation:

- $v_i$, the variable cost of production and distribution in sector $i$, $i=0, 1, ..., k$.
- $n_i$, (a positive integer), the number of firms in sector $i$. For convenience, we also use a parameter $N_i$ defined by $N_i := n_i / (n_i + 1)$.
- $p_i$, the common price charged by all firms in sector $i$ to all downstream sectors.
- $q_i$, the quantity chosen by a single firm in sector $i$. As in a standard one sector Cournot model, all firms within a sector produce the same quantity at equilibrium, so the individual firms’ production quantities can (at equilibrium) be expressed as $q_i = \frac{Q_i}{n_i}$.
- $\pi_i$, the profit of a single firm in sector $i$.

We assume that firms in each lower tier sector compete in the Cournot sense, and competition in the network follows the Successive Cournot framework (Machlup and Taber, 1960). That is to say, each firm in each lower tier sector chooses production quantity to maximize its profit, given a demand curve and a price for the input supplied by the upstream sector. For the upstream sector the aggregate quantity across all downstream (lower tier) sectors as a function of the resource price, establishes a demand curve for the resource supplying (upstream) sector. Firms in that sector compete in the Cournot sense by choosing quantities given this demand curve. Costs of resources or inputs at this sector are assumed to be exogenous to the model.

The following two criteria define equilibrium. For every sector:

1. Given the demand curve faced by the sector and the resource price charged by the upstream sector, no firm in the sector has an incentive to unilaterally deviate from its production quantity.
2. The aggregate quantity produced in every sector is balanced with the aggregate quantity of the required resource (i.e., markets clear).

The optimal production quantities and equilibrium prices for this system are as follows.
Proposition 1

The equilibrium prices, production quantities, and profits for the two-tier distributive network in figure 2 are

\[ p_0 = (1 - N_0)a_0 + N_0v_0 \]
\[ Q_0 = B_0(a_0 - p_0) = N_0B_0(a_0 - v_0) \]
\[ \pi_0 = (1 - N_0)^2Q_0^2 / (B_0N_0^2) = B_0(1 - N_0)^2(a_0 - v_0)^2 \]
\[ p_i = N_i[(1 - N_0)a_0 + N_0v_0] + [(1 - N_i)a_i + N_iy_i], \quad i = 1...k \]
\[ Q_i = B_i(a_i - p_i) = N_iB_i[a_i - v_i - v_0 - (1 - N_0)(a_0 - v_0)], \quad i = 1...k \]
\[ \pi_i = (1 - N_i)^2Q_i^2 = (1 - N_i)^2B_i[a_i - v_i - v_0 - (1 - N_0)(a_0 - v_0)]^2, \quad i = 1...k \]

where \( a_0 := \sum_{i=1,k} N_iB_i(a_i - v_i) / \sum_{i=1,k} N_iB_i \) and \( B_0 := \sum_{i=1,k} N_iB_i \).

The proof is given in the Appendix. An important property of this proposition is that the equilibrium price for the resource supplied by the upstream tier is related to the prices that would be charged in the perfect discrimination case, in a specific way. Suppose that perfect discrimination were possible, i.e. that in the Cournot setting the upper tier could determine the quantities supplied to each downstream sector (node) independently. The system can then be decomposed into \( k \) separate serial systems. Let \( p_0 \) be the resource price in the \( j \)th such system. Then we have

Proposition 2

The resource price \( p_0 \) is a convex combination of the perfect discrimination prices \( p_{0j}, j=1, ..., k \):

\[ p_0 = \sum_{j=1,k} N_jB_j p_{0j} / \sum_{i=1,k} N_iB_i. \]  \hspace{1cm} (1) \]

The proof is given in the Appendix. The qualitative insight from this result is that the resource price in the distributive case is a compromise between the prices that could have been obtained from each downstream purchasing sector, under perfect discrimination. So for example, the appearance of another potential buyer of the resource will create a price shift, which could be in either direction, depending on the price and the weighting given to the new sector. Note that the weights in the convex combination term depend on the \( N_i \)s which are measures of the concentration of a sector, and on the \( B_i \)s which are a measure of the price sensitivity of the imputed demand curve of the sector. From this result it is straightforward to investigate the impact of changes in concentration, or demand curve parameters in the downstream sectors, on the resource price, and hence on profitability.

THE MULTI-TIER CASE

We now consider general distributive supply networks as exemplified by Figure 1. We restrict attention to situations in which the aggregate production quantity along each arc of a given network is strictly positive at equilibrium.

The arborescent structure of distributive networks implies that each network has a single root sector. We label the sectors of network top down with the root sector as sector 1. For each sector \( i \) (node \( i \)), we define:

\( D_i \) as the set of all the sectors downstream of sector \( i \). For example, in figure 1, \( D_1 = \{2, 3, 4, 5, 6\} \) and \( D_2 = \{5, 6\} \).

\( S_i \) as the set of sectors immediately downstream of sector \( i \). In figure 1, \( S_1 = \{2, 3, 4\} \).

\( \phi_{is} \) as the set of sectors along \((i, s)\), the path from sector \( i \) to sector \( s \). In figure 1, path \((1, 5)\) is the path from sector 1, through sector 4, to sector 5; and \( \phi_{1,5} = \{1, 4, 5\} \).

Proposition 3

For a given distributive network, the derived demand curve for any upstream sector \( i \) is

\[ p_i = a_i - b_iQ_i, \text{ or } Q_i = B_i(a_i - p_i), \]  \hspace{1cm} (2) \]

where the parameters \( B_i, a_i, \text{ and } b_i \) are computed iteratively tier by tier.
The proof is similar to the proof for Proposition 1 and is omitted here. The expressions in (2) provide some interesting properties of the derived demand curves seen by upstream sectors. As in the serial supply chain case (Corbett and Karmarkar, 2001), \( B \) decreases going upstream. That is to say, the quantities demanded at upstream sectors are less sensitive to upstream price than sectors which are closer to the markets. Note also that the reservation price \( a_i \) seen by a tier \( i \) is equal to the weighted average of the reservation prices along \( i \)'s downstream arcs, \( a_s - v_s, s \in S_i \). In the extreme case when \( a_s - v_s \) is the same along each branch, \( a_i \) equals \( a_s - v_s \). In such situations, \( a_i \) does not change with \( B_i \) or \( N_s \). This property is crucial for our later discussion of the effect of downstream entry to the prices and profits in upstream sectors.

Using Proposition 3, we can iteratively derive the demand curve for each sector, starting from the sectors facing final consumers. From these curves, the equilibrium price condition for each sector can be derived. All the price conditions together comprise a system of independent linear equations, which is solvable. The equilibrium quantities are then derived by substituting the prices back into demand curves. This solution method can be conveniently expressed in matrix notation, as given in the following proposition.

**Proposition 4**  
Equilibrium prices of sectors in a distributive network are the solution to

\[ T \cdot \tilde{p} = R \]

where \( \tilde{p} \) is the vector of prices (one element per sector), \( R \) is a column vector (one element per sector) with each element

\[ R_i = (1 - N_j)a_i + N_jv_j, \]

and \( T \) is a lower triangular matrix, populated with element

\[ T_{ij} = \begin{cases} 1 & \text{if } i = j \\ -N_i & \text{if } i \in S_j \\ 0 & \text{otherwise} \end{cases} \]

The proof is omitted as it follows from the above discussion. Note that \( T \) can be inverted to give \( T^{-1} \) with elements

\[ T^{-1}_{ij} = \begin{cases} 1 & \text{if } i = j \\ N_j / N_i & \text{if } i \in D_j \\ 0 & \text{otherwise} \end{cases} \]

where \( N_{i,j} \) is defined as \( N_{i,j} := \prod_{s \in p_{j,i}} N_s \). Applying \( T^{-1} \) gives the following corollary.

**Corollary 4**  
At equilibrium, the price of sector \( i \) in a distributive network is

\[ p_i = \sum_{j \in p_{i,j}} (N_{j,i} / N_j)(1 - N_j)a_j + N_jv_j \]

(3)

where \( N_{j,i} \) is defined as \( N_{j,i} := \prod_{s \in p_{j,i}} N_s \).

As in Carr and Karmarkar (2005), \( T \) is a structure matrix that captures the relationship between the structural features of a distributive network (i.e., the sector connections, concentrations, and demand functions) and the equilibrium competition prices. In the following section we further explore the structural properties of distributive networks using Proposition 4 and Corollary 4.

**STRUCTURAL PROPERTIES OF DISTRIBUTIVE NETWORKS**

Thus far we have described the structure of distributive multi-echelon networks, a representation method, and the computations required to solve for equilibrium prices through the structure matrix for any such network. We now investigate...
how changes to a network’s structure or to its parameters influence these equilibrium values. We present certain structural properties of distributive networks and address such questions using these properties.

**Equivalence**: We say that two sub-networks or two sets of nodes are equivalent with respect to the rest of the network if, after substituting one network (set of nodes) for the other, the rest of the network has the same equilibrium prices, quantities, and firm-level profits. Noting that a subnetwork essentially communicates to the rest of the network through the demand curve that is provided to the subnetwork’s root node, this means that two sub-networks are equivalent when they show the same demand curve to the rest of the network.

**Expandability**: Defining dummy sector d as a node that is described by \( N_d = 1 \) and \( v_d = 0 \), a network expanded by inserting dummy sectors is equivalent to the original network with respect to all of the non-dummy sectors and customers. Figure 3 illustrates a network (a) and an equivalent expanded version (b).

Network expandability can be established by showing that the equilibrium prices of sectors 1, 2, 3, and 4 in Figure 3(b) are exactly the same as the equilibrium prices of their counterparts in Figure 3(a).

**Compressibility**: A sub-network that is downstream of a sector can be compressed into a single market without affecting the equilibrium price, quantity, and firm-level profits of the sector. Specifically, in any network, let sector \( i \) be the root node of a subnetwork. If all nodes below sector \( i \) are replaced with a market having demand parameters \( a_i \) and \( b_i \) (or \( B_i \)), then the modified network is equivalent to the original network.
Turning to comparative statics, we now consider the sensitivity of a sector's equilibrium prices, profits, and quantities to other sectors' parameters where \( i \) will be the sector at which a change occurs, and we consider how this affects another sector \( s \).

**Proposition 5** Suppose \( s \) is any sector not upstream of sector \( i \), and let \( u \) be the first node encountered that is upstream of both \( i \) and \( s \). Then, a parameter change at \( i \) is completely communicated to sector \( s \) through \( p_u \). That is, at equilibrium, \( p_s \) increases iff \( p_u \) increases (as a result of the change at \( i \)) and, equivalently, \( \pi_s \) decreases iff \( p_u \) increases.

The proof is omitted. Using this proposition together with compressibility and expansibility allows us to analyze the effect of parametric changes very simply. We only need to examine the sectors along the path \((1, i)\) to discuss the effects of parameter changes in sector \( i \). Using the compressibility property, the rest of the network can be compressed to single sectors without changing the equilibrium solution to the network. Therefore, the general multi-tier distributive network can be compressed to a simple binary tree as shown in Figure 5(b). In the following discussion, we focus on the equilibrium prices, quantities, and profits of the sectors along the path \((1, i)\) in the binary structure shown in Figure 5(b). The other sectors are distinguished by a prime (‘). In the figure, we assume the market parameters \((a_s \text{ and } B_s)\) of the leaf sectors (sector \( i' \), \( i' \), ... \( 2' \) and sector \( i \)) are given.
The following proposition shows how $v_i$ influences equilibrium prices and profits in each sector along the path $(1, i)$.

**Proposition 6** (Illustrated by Figure 5(b).) Suppose that $v_i$, the variable production cost in sector $i$, increases. At equilibrium:

1) $p_i$ increases, $Q_i$ and $\pi_i$ decrease.

2) If sector $j$ is upstream of $i$ ($j \in \mathcal{F}_{1,i}$), then $p_j$ increases; $Q_j$ and $\pi_j$ decrease.

3) If sector $j$ is downstream of $i$ then $p_j$ decreases; $Q_j$ and $\pi_j$ decrease.

4) Otherwise (i.e., $j$ is neither upstream nor downstream of $i$) $p_j$ decreases; $Q_j$ and $\pi_j$ increase.

The effects of changes in $v_i$ are intuitive in that increased production cost for firms in a sector increases selling prices and lowers profits. It also decreases the prices and firm-level profits of upstream sectors in the whole supply chain, which means the cost increase is passed along the supply chain eventually resulting in lower prices, lower production, and lower profit margins for all upstream sectors. Interestingly, however, for sectors in the network that are not along the path from the root to $i$, if the resource prices charged by their connecting nodes decrease, the firms in those sectors become more profitable.

**Proposition 7** Suppose that $a_i$ increases (at a sector $i$ supplying a consumer market). At equilibrium:

1) $Q_i$, $p_i$, and $\pi_i$ all increase.

2) If sector $j$ is upstream of $i$ then $Q_j$, $p_j$, and $\pi_j$ all increase.

3) If sector $j$ is not upstream of $i$ then $p_j$ increases, $Q_j$ and $\pi_j$ decrease.

So, increased profit margins can be passed upstream along the chain, causing prices to increase in resource markets and profits to increase in upstream firms. However, to firms in the "substitute channels" of the network, an increase in $a_i$ has negative effects: their prices increase and profits decrease as a result of the change.

**THE EFFECTS OF SECTOR CONCENTRATION**

The dependence of equilibrium outputs, prices and profits on industry concentration is a fundamental issue in economic analysis. Conventional wisdom holds that with lower concentration (more firms), industry price ought to decline and per firm output and profit ought to decrease. In single tier Cournot competition, this claim holds for most general demand conditions. In multi-tier networks, we might expect that lower concentration in a lower tier would lead to higher market power and higher profits in an upper (supplying) tier. However, these expectations may be violated in distributive networks. The following discussion shows that even with linear demand there exists a range of demand conditions for which an increase in the number of firms in a sector (lower concentration) increases the profits of the sector's existing firms and decreases the profits of upstream firms. This surprising result occurs when entry decreases the potential upstream market, and causes the upstream price to decrease; this then permits the profit margin of the downstream firms to increase. If the effect of upstream price outweighs the effect of increased competition due to the entry, the incumbents' profits in the sector with entry can go up. We note that this seemingly perversive effect is not necessarily a common phenomenon. It occurs for certain parameter ranges, and can disappear with further entry. However, what it underlines is that the distributive structure has characteristics which are specific to that structure, and which lead to consequences not seen in the pure serial and assembly cases.

In the following discussion of entry effects, we start with two-tier case to derive explicit results. Then, we extend the analysis to the multi-tier case and show that certain properties generalize simply while other effects can be more complex. The following proposition summarizes the effects of sector concentration on equilibrium prices, outputs, and profits for two-tier networks.

**FIGURE 6**

\[
\text{EFFECT OF INCREASES IN } N_2 \text{ ON } P_1 \text{ AND } \Pi_1
\]

\[
\begin{align*}
N_2 &\uparrow & N_2 &\uparrow & N_2 &\uparrow \\
p_1 &\downarrow & p_1 &\downarrow & p_1 &\downarrow \\
\frac{\alpha - v_i}{2} &\quad & \frac{\alpha - v_i}{1 + \beta'} &\quad & a_2 - v_2
\end{align*}
\]

where \( \beta = N_2 B_2 / (N_2 B_2) \)
**Proposition 8** The effects of concentration changes (entry or exit) in the two-tier network of Figure 4(a) are:

1) An increase (decrease) in \( n_1 \) and \( N_1 \) causes \( p_1, \ p_2, \ \pi_1 \) to decrease (increase), and causes \( Q_1, \ Q_2, \ \pi_2 \) to increase (decrease).

2) An increase (decrease) of \( N_2 \) due to entry (exit) in that downstream sector causes \( p_2 \) to decrease (increase).

3) However, with an increase of \( N_2, p_1 \) and \( \pi_1 \) could increase, decrease or remain constant depending on the relative demand parameters (as shown in Figure 6):

   For \( p_1 \): if \( a_2 - v_2 > a_1 \) (i.e., \( a_2 - v_2 > a_3 - v_3 \)), \( p_1 \) increases with \( N_2 \); if \( a_2 - v_2 = a_1 \) (i.e., \( a_2 - v_2 = a_3 - v_3 \)), \( p_1 \) remains constant; if \( a_2 - v_2 < a_1 \) (i.e., \( a_2 - v_2 < a_3 - v_3 \)), \( p_1 \) decreases with \( N_2 \).

   For \( \pi_1 \): if \( a_2 - v_2 - v_1 > (a_1 - v_1)/2 \), \( \pi_1 \) increases with \( N_2 \); if \( a_2 - v_2 - v_1 = (a_1 - v_1)/2 \), \( \pi_1 \) remains constant; if \( a_2 - v_2 - v_1 < (a_1 - v_1)/2 \), \( \pi_1 \) decreases with \( N_2 \). \( a_2 - v_2 - v_1 \) is always greater than \((1-N_1)(a_1 - v_1)\) and smaller than \((a_1 - v_1)(1+N_1N_3B_3/(N_2B_2))\) due to the regularity condition.

4) Moreover, \( \pi_2 \) could increase, decrease, or remain constant with the increase of \( N_2 \). Specifically

   \[
   \pi_2 \text{ increases with } N_2. \text{ Otherwise, } \pi_2 \text{ decreases with } N_2 \text{ (or remains constant when the above expression holds with equality).}
   \]

Parts 1) and 2) of Proposition 8 state that lower concentration or an increased number of firms in a sector, leads to lower prices in the sector. More interesting and quite counter-intuitive findings are the effects of \( N_2 \) on \( p_1, \pi_1, \) and \( \pi_2 \) as stated in parts 3) and 4) of Proposition 8. Contrary to conventional wisdom, reduced concentration (entry) in a downstream sector can cause the resource price charged by the upstream suppliers to go up under certain demand and cost conditions. Moreover, for a certain range of demand parameters, the profit of upstream suppliers could go down as a result of the downstream entry. Similarly, incumbents in the same sector (sector 2 in our analysis) could see profits increase.

The last phenomenon is not pervasive. It only happens when the effect of resource price decrease overwhelms the effect of competition. Furthermore, notice that the right hand side of the inequality condition (4) monotonically decreases in \( N_2 \). With continued entry in sector 2, the anomalous effect goes away. However, it illustrates a characteristic of distributive systems. The underlying reason for these effects is the nature of upstream resource price, which as shown in Proposition 2, is a compromise between the resource prices that would be seen with perfect discrimination. The weight of the balance is controlled by the concentration (\( N_i \)). For a sector in which the resource price under perfect discrimination is higher, entry intensifies the weight, and makes the equilibrium resource price higher, and vice versa.

To examine the effect of concentration changes at a sector \( i \) in a multi-tier network, we only need to focus on the behavior of sectors along the path \((1, i)\). We note that, the reservation prices for upstream sectors \( a_j \) \((1 \leq j \leq i)\) play a key role in the changes of prices, outputs and firm-level profits. In the following proposition, we summarize the direction of change of \( a_j \) with respect to \( N_i \).

**Proposition 9** The direction of change of the market reservation price \( a_j \) at sector \( j, \ j \in \varphi_{1,i} \), with respect to \( N_i \) can be captured by its first derivative as

\[
\frac{\partial a_j}{\partial N_i} = \frac{N_{j+1,i-1}B_i}{B_j}(a_j - v_{j+1,i} - a_j)
\]

where \( N_{j+1,i-1} = \prod_{s=j+1}^{i-1} N_s \) (if \( j=i-1 \), \( N_{j+1,i-1} = 1 \)) and \( v_{j+1,i} = \sum_{s=j+1}^{i} v_s \).

Thus the reservation price for an upstream sector increases, decreases, or remains the same depending on the relative value of the reservation prices along the channel where entry occurs and the reservation price of the market, which is the weighted average value of each downstream channel as discussed earlier. This result, which is different from the cases in serial chains (Corbett and Karmarkar, 2001) or assembly networks (Carr and Karmarkar, 2005), enables us to examine the price changes of any sector with the change of \( N_i \).
Proposition 10  In a multi-echelon distributive network, the price at tier $i$, $p_i$, decreases monotonically with $N_i$. Using (3), $p_j$, the price charged by the upstream sectors $j$, can be expressed as

$$p_j = \sum_{k=1}^{j-1} N_{k+1,j} [(1 - N_k) a_k + N_k v_k]$$

Since each individual "$a$" is a function of $N_i$, the directive of $p_j$ to $N_i$ can be expressed as

$$\frac{\partial p_j}{\partial N_i} = \sum_{k=1}^{j-1} N_{k+1,j} (1 - N_k) \frac{\partial a_k}{\partial N_i}$$

$$= \sum_{j=1}^{j-1} N_{k+1,j} (1 - N_j) \frac{N_{k+1,i-1} B_j}{B_k} (a_i - v_{k+1,i} - a_k).$$

Next, profit of sector $j$ can be expressed as

$$\pi_j = B_j (1 - N_j)^2 (a_j - v_j - p_{j-1})^2,$$

and the first differentiation then gives

$$\frac{\partial \pi_j}{\partial N_i} = 2B_j (1 - N_j)^2 (a_j - v_j - p_{j-1}) \left( \frac{\partial a_j}{\partial N_i} - \frac{\partial p_{j-1}}{\partial N_i} \right).$$

We can thus see that upstream market price and profit could decrease, increase or remain constant with downstream entry. Furthermore, the trends in these strategic variables can be even more complicated since they depend on the changes of any upper tier's reservation price and equilibrium price. For example, a sector's price could increase even when the sector's reservation price decreases.

VERTICAL INTEGRATION IN DISTRIBUTIVE NETWORKS

Corbett and Karmarkar (2001) have examined vertical integration in two tier serial networks, assuming that the numbers of firms in both tiers are the same, to permit comparison of the integrated and un-integrated cases. They find that when each tier has a single firm (monopoly), integration results in higher profits. However, when there are two or more firms in each tier, then the total profits of the network decline.

FIGURE 7

VERTICAL INTEGRATION

In the distributive case, there are many more structural alternatives that might be considered with respect to integration – too many to really consider all. However, as in the serial case, the modeling approach developed here allows for any specific case to be analyzed. What is more, the distributive structure leads to phenomena which do not occur in the serial case. Consider a sector that supplies two downstream sectors (Figure 7). We can then have a situation where the upstream sector might integrate forward with one of the downstream sectors but not the other. As in the serial case, we can look at what happens relative to that downstream market. However, here there will also be lateral effects on the other downstream sector. Recalling the result of proposition 2, one can see that after integration, the upstream sector will no longer have to bal-
ance the downstream sectors in its pricing decisions, and will take different action with respect to the second (unintegrated) sector. From the point of profitability, the upstream sector will see two sources of profit changes: that from integrating forward, and that from changing its actions with respect to the second downstream sector. In turn, the second un-integrated downstream sector may see either an increase or a decrease in resource price and therefore its profits could either go up or down. The latter (lateral) effect is of course a characteristic of distributive network structure.

**Proposition 11** Assume there are same number of firms in sector 1 and 2 in the two-tier, three-sector case (as in Figure 7). Vertical integration of sector 1 and sector 2 always causes \( Q_2 \) to increase. Moreover, if \( a_2 - v_2 > a_3 - v_3 \), the resource price \( p_1 \) decreases; if \( a_2 - v_2 = a_3 - v_3 \), \( p_1 \) remains unchanged; and if \( a_2 - v_2 < a_3 - v_3 \), \( p_1 \) increases. \( Q_3 \) and \( \pi_3 \) increase (decrease) iff \( p_1 \) increases (decreases). Finally, the total profit of the integrated firms, \( \pi_1 + \pi_2 \), increases when \( n_2 = 1 \); otherwise, \( \pi_1 + \pi_2 \) decreases when \( n_2 > 1 \).

In the case where there are more than two downstream sectors, integration of the upper tier with one of the downstream sectors can lead to a wide range of possible outcomes, depending on the specifics of the system.

**CONCLUSION**

In this paper, we have analyzed competition in pure distributive multi-echelon supply networks, using the Successive Cournot model for oligopolistic competition with multiple tiers. We developed explicit expressions for equilibrium prices and quantities as the solutions to a set of linear equations that can be derived from the structure of the network. The equilibrium solution is obtained in two steps: 1) Iteratively calculate all the upstream markets’ demand parameters; 2) Solve a system of linear equations that involve the demand parameters. We demonstrated certain network transformation principles that allow a network to be compressed or to be expanded to a binary tree structure. These transformations make it straightforward to examine the effects of parametric changes on the equilibrium solution to any distributive network.

Finally, we present some comparative statics results and discuss the effects of entry on equilibrium prices, quantities and firm-level profits. Changes in the variable costs of production have expected effects, as do changes in demand parameters. However, the effects of changes in sector concentration are not as obvious. If the number of firms in a sector increases, the quantity produced in the sector increases and profit charged by firms in the sector decreases. Downstream effects are also expected. However, the upstream consequences are more complicated in that whether upstream prices increase or decrease depends on the demand conditions of the sector where the entry occurs relative to parallel paths. If entry occurs along the channel with less than the average reservation price of the upstream market, the upstream price could decrease rather than increase. With certain demand conditions, the decreased resource price provides a larger profit margin for downstream incumbents and this positive impact on profits can outweigh the competition effect due to entry and thus cause equilibrium profits to increase with entry. Decreased prices in upstream can also cause upstream firms to profit less (although for the two-tier case with a monopoly supplier in the upstream tier, upstream profits always increase with downstream entry). For those firms not along the path between the root sector and the sector with entry, their equilibrium prices, quantities, and profits change according to the change in the price of the connecting node i.e. the sector that connects the firms with the path in question. Thus, we see that some existing intuitions, largely derived either from serial supply chains or from models with a single competitive sector, do not all survive the extension to more complex distributive networks.

The present analysis not only provides results for large-scale distributive supply chains, but also suggests directions for the analysis of other network structures. In ongoing research, we are investigating the analysis of acyclic multi-echelon networks that have a mix of assembly, distributive, and non-arborescent network topologies. The eventual target of this stream of research is to provide robust techniques to analyze competition in large-scale supply chains and networks with general structures.
REFERENCES


APPENDIX

*Proof of Proposition 1*

Starting with sector $i$ of the downstream tier, the first equilibrium criterion means that each firm in the sector selects a production quantity $q_i$ that maximizes its profits given that the firms in the sector purchase products at a cost of $p_0$ and incur a variable cost $v_i$ for every unit produced. A single firm thus seeks to maximize revenue of $q_i(p - p_0 - v_i)$, where $p_i$ equals $a_i - b_iQ_i$. Differentiation gives us the firm's first order optimality condition which is to select quantity that solves

$$q_i = B_i(a_i - v_i - p_0) / 2 - Q_{-i} / 2, \quad i = 1, \ldots, k$$

where $Q_i$ is the aggregate quantity produced by all the other firms in sector $i$. The production decision of each firm in sector $i$ follows this same condition as well due to the identical cost structure of all firms in the sector. This gives us a system of $n_i$ independent linear equations for each sector $i$. A symmetric solution can be calculated in which every firm produces quantity

$$q_i = B_n(a_i - v_i - p_0) / (n_i + 1), \quad i = 1, \ldots, k$$

and the entire sector produces an aggregate quantity,

$$Q_i = n_iq_i = N_iB_n(a_i - v_i - p_0), \quad i = 1, \ldots, k$$  \hspace{1cm} (A1)

We now substitute (A1) into sector $i$'s demand curve to get the sector $i$ equilibrium price condition

$$p_i = (1 - N_i)a_i + N_i(v_i + p_0), \quad i = 1, \ldots, k$$  \hspace{1cm} (A2)

Next we look at the supplier tier, sector 0. Our second equilibrium criterion requires the supply and demand quantities to be balanced, so the aggregate quantity produced at sector 0 should be equal to the aggregate equilibrium quantities in each of its distributive downstream sector, i.e., $Q_0 = Q_1 + \ldots + Q_k$. Taking in the equilibrium aggregate quantity $Q_i$ from (A1), we can derive the demand curve for sector 0 firms as
\[ Q_0 = \sum_{i=1,k} N_i B_i (a_i - v_i - p_0) = \left( \sum_{i=1,k} N_i B_i \right) \left( \sum_{i=1,k} N_i B_i (a_i - v_i) / \sum_{i=1,k} N_i B_i - p_0 \right) \equiv B_0 (a_0 - p_0) \]

where \( a_0 := \sum_{i=1,k} N_i B_i (a_i - v_i) / \sum_{i=1,k} N_i B_i \) and \( B_0 := \sum_{i=1,k} N_i B_i \).

Now analyzing the production decisions for sector 0 firms gives the equilibrium production quantities as

\[ q_0 = (1 - N_0) B_0 (a_0 - v_0), \]
\[ Q_0 = n_q q_0 = N_0 B_0 (a_0 - v_0). \]

Also, we can derive the sector 0 equilibrium price as

\[ p_0 = (1 - N_0) a_0 + N_0 v_0. \quad (A3) \]

Equations (A2) and (A3) taken together are a system of independent linear equations, and can be easily solved to get the equilibrium prices \((p_0)\) is already the equilibrium price,

\[ p_i = N_i [(1 - N_0) a_0 + N_0 v_0] + [(1 - N_i) a_i + N_i v_i], \quad i = 1...k. \]

Furthermore, substituting these prices into the relevant demand curves gives the equilibrium aggregate production quantity for each sector. Firm level profits can then be derived by substituting back the optimal prices and quantities. Q.E.D.

**Proof of Proposition 2**

From proposition 1, \( p_{0j} = (1 - N_0) a_{0j} + N_0 v_0 \), where \( a_{0j} := a_j - v_j \). Thus, (1) can be derived.

**Proof of Proposition 6**

We know for the distributive network in figure 5(b), the prices and profits of each individual firm in sector \( j \) (1 \( \leq j \leq i \)) are:

\[ p_j = (1 - N_j) a_j + N_j (v_j + p_{j-1}), \]
\[ Q_j = N_j B_j (a_j - v_j - p_{j-1}), \]
\[ \pi_j = (1 - N_j)^2 B_j (a_j - v_j - p_{j-1})^2. \]

Moreover, it is straightforward to derive the following expression,

\[ \partial a_j / \partial v_i = -N_{j+1,i} B_i / B_j, \quad \text{for} \ j \in [1, i-1]. \]

To prove 1), note that

\[ \partial p_i / \partial v_i = N_i (1 + \partial p_{i-1} / \partial v_i), \]
\[ Q_i = -N_i B_i (1 + \partial p_{i-1} / \partial v_i), \]
\[ \pi_i = -2 (1 - N_i)^2 B_i (a_i - v_i - p_{i-1})(1 + \partial p_{i-1} / \partial v_i), \]

we only need to show that \( \partial p_{i-1} / \partial v_i > -1 \). This can be done by induction. First, for sector 1,

\[ \partial p_1 / \partial v_i = -N_{2,1} (1 - N_1) B_1 / B_i > -N_{2,1} (1 - N_1) B_1 / B_1 \times N_1 / (1 - N_1) = N_{1,1} (1 - N_1) B_1 / B_1 > -1. \]

Assume the condition holds for sector \( i-2 \). Then, for sector \( i-1 \), we have
\[
\frac{\partial p_{i,j}}{\partial v_i} = (1 - N_{i-1})(\frac{\partial a_i}{\partial v_i}) + N_{i-1} \frac{\partial p_{i,j-1}}{\partial v_i} \\
> -(1 - N_{i-1}) \frac{N_i B_i}{B_{i-1}} - N_{i-1} \frac{N_i B_i}{N_i B_i + N_i B_i} > -1.
\]

Thus, (1) is proved.

Now we use induction to establish (2). Starting from sector 1, we can derive the first derivatives with respect to \( v_i \) as

\[
\frac{\partial p_i}{\partial v_i} = (1 - N_i)(\frac{\partial a_i}{\partial v_i}) = -N_{2,i}(1 - N_i)B_i / B_i < 0,
\]

\[
\frac{\partial Q_i}{\partial v_i} = B_i N_i(\frac{\partial a_i}{\partial v_i}) = -N_{2,i} B_i < 0
\]

\[
\frac{\partial \pi_i}{\partial v_i} = 2(1 - N_i)^2 B_i(a_i - v_i)(\frac{\partial a_i}{\partial v_i}) = -2(1 - N_i)^2 N_{2,i} B_i(a_i - v_i) < 0
\]

Assuming these properties hold for sector \( j-1 \), we have the following expressions for \( p_j, Q_j, \) and \( \pi_j \),

\[
\frac{\partial p_j}{\partial v_j} = (1 - N_j)(\frac{\partial a_j}{\partial v_j}) + N_j \frac{\partial p_{j-1}}{\partial v_j} < 0
\]

\[
\frac{\partial Q_j}{\partial v_j} = B_j N_j(\frac{\partial a_j}{\partial v_j} - \frac{\partial p_{j-1}}{\partial v_j}) = B_j N_j[\frac{\partial a_j}{\partial v_j} - (1 - N_{j-1})(\frac{\partial a_{j-1}}{\partial v_j} - N_{j-1} \frac{\partial p_{j-2}}{\partial v_j})]
\]

\[
= B_j N_j[-(\frac{N_{i,j-1} B_i}{B_{j-1}} - \frac{N_{i,j} B_i}{B_{j-1}}) + N_{j-1} \frac{\partial a_{j-1}}{\partial v_j} - \frac{\partial p_{j-2}}{\partial v_j}].
\]

Since \( N_{i,j-1} B_i / B_j > N_{i,j} B_i / B_{j-1} \), we have \( \partial Q_j / \partial v_j < 0 \).

As to the profits of sector \( j \),

\[
\frac{\partial \pi_j}{\partial v_j} = 2B_j (1 - N_j)^2 (a_j - v_j - p_{j-1})(\frac{\partial a_j}{\partial v_j} - \frac{\partial p_{j-1}}{\partial v_j}) < 0.
\]

Thus (2) is proved. It is straightforward to derive (3) and (4) from (2) and proposition 5. Q.E.D.

**Proof of Proposition 7**

The proof is analogously similar to proposition 6, and is omitted here.

**Proof of Proposition 8**

1) For the three-sector two-tier network of figure 4(a), according to proposition 1, the price and profit of each individual firm in sector 1 and 2 are given by:

\[
p_i = (1 - N_1)a_i + N_1 v_i,
\]

\[
p_2 = (1 - N_2)a_2 + N_2(p_i + v_2),
\]

\[
Q_1 = N_1 B_i(a_i - v_i),
\]

\[
Q_2 = N_2 B_2(a_2 - v_2 - p_i),
\]

\[
\pi_1 = b_i q_i^2 = (1 - N_1)^2 B_i(a_i - v_i)^2,
\]

\[
\pi_2 = b_2 q_2^2 = (1 - N_2)^2 B_2(a_2 - v_2 - p_i)^2.
\]
Treating \( N_1 \) as a continuous variable and taking the first derivative of these expressions with respect to \( N_1 \), we can easily show 1).

2) Differentiating \( p_2 \) with respect to \( N_2 \), we get

\[
\frac{\partial p_2}{\partial N_2} = -(a_2 - v_2 - p_1) + N_2 \frac{\partial p_1}{\partial N_2} \\
= -(a_2 - v_2 - p_1 - (1 - N_1)(a_i - v_i)) + (1 - N_1)N_2B_2[(a_2 - v_2 - v_i) - (a_i - v_i)] / B_1 \\
= -(N_2B_3 + N_1N_2B_2)(a_2 - v_2 - v_i) / B_1 + (1 - N_1)N_3B_3(a_i - v_i) / B_1
\]

Due to the regularity condition, \( Q_1 > 0, Q_2 > 0 \), and \( Q_3 > 0 \). Taking \( Q_1, Q_2, \) and \( Q_3 \) from proposition 1 and simplifying the expressions, we have

\[
a_i - v_i > 0 \\
a_2 - v_2 - v_1 > (1 - N_1)(a_i - v_i) \\
a_2 - v_2 - v_1 < [1 + N_1N_3B_3 / (N_2B_2)](a_i - v_i)
\]

Therefore,

\[
\frac{\partial p_2}{\partial N_2} < - N_2B_3 + N_1N_2B_2(1 - N_1)(a_i - v_i) + N_1B_3(1 - N_1)(a_i - v_i) \\
= - N_2B_3(N_2 - (1 - N_1)(a_i - v_i)) < 0.
\]

3) To show the effect of \( N_2 \) on \( p_1 \), we take the first derivative of \( p_1 \) with respect to \( N_2 \) as

\[
\frac{\partial p_1}{\partial N_2} = (1 - N_1) \frac{\partial a_1}{\partial N_2} = (1 - N_1) \frac{N_2B_3B_2}{B_1^2}[(a_2 - v_2) - (a_3 - v_3)].
\]

Thus, if \( a_2 - v_2 > a_3 - v_3 \), \( \partial p_1 / \partial N_2 > 0 \); \( a_2 - v_2 < a_3 - v_3 \), \( \partial p_1 / \partial N_2 < 0 \); \( a_2 - v_2 = a_3 - v_3 \), \( \partial p_1 / \partial N_2 = 0 \).

To show the effect of \( N_2 \) on \( \pi_1 \), we have

\[
\frac{\partial \pi_1}{\partial N_2} = B_2(1 - N_1)^2(a_i - v_i)^2 + 2B_1(1 - N_1)^2(a_i - v_i) \frac{\partial a_1}{\partial N_2} \\
= B_2(1 - N_1)^2(a_i - v_i)^2 + 2B_1(1 - N_1)^2(a_i - v_i) \frac{B_2}{B_1}(a_2 - v_2 - a_i) \\
= B_2(1 - N_1)^2(a_i - v_i)[2(a_2 - v_2 - v_i) - (a_i - v_i)]
\]

Therefore, if \( a_2 - v_2 - v_1 < (a_i - v_i) / 2 \), \( \partial \pi_1 / \partial N_2 \) is negative, i.e., \( \pi_1 \) decreases with \( N_2 \). If \( a_2 - v_2 - v_1 > (a_i - v_i) / 2 \), \( \pi_1 \) increases with \( N_2 \).

4) To show the effect of \( N_2 \) on \( \pi_2 \), we take the first derivative of \( \pi_2 \) with respect to \( N_2 \),
\[
\frac{\partial \pi_2}{\partial N_2} = -2B_2(1-N_2)(a_2-v_2-p_1)^2 - 2 B_2 (1-N_2)^2 \left(a_2 - v_2 - p_1\right) \frac{\partial p_1}{\partial N_i} \\
= -2B_2(1-N_2)(a_2-v_2-p_1) X,
\]

where \( X \) is defined as

\[
X := (a_2 - v_2 - p_1) + (1-N_2)(1-N_i) \frac{B}{B_1} [(a_2 - v_2 - v_i) - (a_i - v_i)]
\]

\[
= [a_2 - v_2 - v_i - (1-N_i)(a_i - v_i)] + (1-N_2)(1-N_i) \frac{B}{B_1} [(a_2 - v_2 - v_i) - (a_i - v_i)]
\]

\[
= [1 + (1-N_2)(1-N_i) \frac{B}{B_1}] (a_2 - v_2 - v_i) - [1 + (1-N_2) \frac{B}{B_1}] (1-N_i)(a_i - v_i).
\]

Notice that \([1 + (1-N_2)(1-N_i) \frac{B}{B_1}]\) is always smaller than \([1 + (1-N_{i+1})B_i / B_i]\). Therefore, if \(a_2 - v_2 - v_i\) is very close to its lower bound \((1-N_i)(a_i - v_i)\), \(X\) could be negative, which means \(\frac{\partial \pi}{\partial N_2} > 0\). More specifically, \(\pi_2\) decreases with \(N_2\). Otherwise, \(\pi_2\) increases with \(N_2\). Q.E.D.

**Proof of Proposition 9**

Applying proposition 3 iteratively along the path \((j, i)\) gives

\[
B_j = N_{j1}B_{j1} + N_{j+1,i}B_{j+1,i} - N_{j1}B_j + \sum_{j<i} N_{j+1,s}N_{s}B_s + N_{j,s}B_{j,i},
\]

\[
a_j = \frac{N_{j1}B_{j1}(a_j - v_{j1})}{B_j} + \frac{N_{j+1,i}B_{j+1,i}(a_{j+1,i} - v_{j+1,i})}{B_j}
\]

\[
= \frac{N_{j1}B_j(a_j - v_{j1})}{B_j} + \sum_{j<i} \frac{N_{j+1,s}N_{s}B_s(a_s - v_{j,s} - v_s)}{B_j} + \frac{N_{j+1,s}B_{j+1,i}(a_{j+1,i} - v_{j+1,i})}{B_j}.
\]

where \(v_{j+1,i} := \sum_{k=j+1}^{N_j}N_{k} \). In \(a_j\), only \(N_{j+1,i}\) and \(B_j\) change with the increase of \(N_i\) and all the other parameters remain constant. Therefore,
\[
\frac{\partial a_j}{\partial N_i} = \frac{\partial}{\partial N_i} \left( \frac{N_{j,i+1} B_j (a_i - v_{j,i+1})}{B_j} + \sum_{j \neq i} N_{j,i+1} B_j (a_i - v_{j,i+1} - v_j) + \frac{N_{j,i+1} B_j (a_j - v_{j,i+1})}{B_j} \right) \\
= \frac{1}{B_j} \left( \frac{N_{j+1,i} B_j (a_i - v_{j,i+1})}{B_j} + \sum_{j \neq i} N_{j,i+1} B_j (a_i - v_{j,i+1} - v_j) + \frac{N_{j,i+1} B_j (a_j - v_{j,i+1})}{B_j} \right) \\
= \frac{N_{j+1,i} B_j}{B_j} (a_i - v_{j,i+1} - a_j) \\
\]

where \(N_{j+1,i} = 1\), if \(j = i - 1\). Q.E.D.

**Proof of Proposition 10**

As in (3), \( p_i = \sum_{r=1}^{i} [N_{r+1,i} (1 - N_r) a_r + N_r v_r] \). Note both \(N_{r+1,i}\) and \(a_i\) change with \(N_r\). Taking first derivative of \(p_i\) with respect to \(N_i\) and applying (4) give

\[
\frac{\partial p_i}{\partial N_i} = \sum_{r=i}^{i} [N_{r+1,i} (1 - N_r) a_r + N_r v_r] - (a_i - v_i) + \sum_{r=i}^{i} N_{r+1,i} (1 - N_r) \frac{\partial a_r}{\partial N_i} \\
= \sum_{r=i}^{i} [N_{r+1,i} (1 - N_r) a_r + N_r v_r] - (a_i - v_i) + \\
\sum_{r=i}^{i} N_{r+1,i} (1 - N_r) \frac{N_{r+1,i} B_j}{B_j} (a_i - v_{r+1,i} - a_j) \\
\]

This can be further simplified as

\[
\frac{\partial p_i}{\partial N_i} = \sum_{r=i}^{i} N_{r+1,i} (1 - N_r) (a_r - v_{r,i}) - (a_i - v_i) + \sum_{r=i}^{i} (1 - N_r) \frac{N_{r+1,i} B_j}{B_j} [(a_i - v_{r,i}) - (a_r - v_{r,i})]. \quad (A4)
\]

To prove that \(p_i\) decreases with \(N_r\), we only need to show that \(\frac{\partial p_i}{\partial N_i}\) is always negative. We do this in two steps: 1) we construct a series of upper bounds \(U_i, U_{i+1}, \ldots, U_2\), and show that \(\frac{\partial p_i}{\partial N_i}\) is smaller than \(U_i\); 2) we show that \(U_i < U_{i+1} < \ldots < U_2 < 0\).

First, we develop a few inequalities used in the relaxation. According to the regularity condition, for a feasible distributive network, \(Q_1, Q_2, \ldots, Q_i\) are strictly positive. Thus we have

\[
Q_r = B_j (1 - N_r) (a_j - v_r - p_{i-r}) \\
= B_j (1 - N_r) (a_j - v_r - \sum_{r=i}^{i} N_{r+1,i} [1 - N_r] a_i + N_r v_i]) \\
= B_j (1 - N_r) [((a_i - v_{i+1,i}) - \sum_{r=i}^{i} N_{r+1,i} (1 - N_r) (a_r - v_{r,i})] > 0
\]

which gives us the following inequality,
Similarly,
\[
a_i - v_{i,j} > \sum_{r=1}^{i-1} N_{r+1,i-1} (1-N_r)(a_r - v_{i,r}).
\]

It deserves to be mentioned that the above inequalities hold only when \(a_r - v_{i,r} > 0\), which is true for the distributive network to be feasible.

Moreover, since for any sector \(r > 1\), \(B_{r-1} = N_r B_r + N_{r-1} B_{r-1} > N_r B_r\), we can derive the following inequalities:
\[
\frac{N_{2r-1} B_i}{B_i} < \frac{N_{2r-1} B_i}{B_2} < \cdots < \frac{N_{r+1} B_i}{B_{r+1}} < \frac{N_r B_i}{B_r} < 1
\]
(A6)

1. Using (A5), we relax \(\frac{\partial p_i}{\partial N_j}\) by eliminate \(a_i - v_{i,j}\) term in (A4) to reach its upper bound \(U_i\). In general, the upper bound is constructed as \(\forall j \in [2,i]\),
\[
U_j = \sum_{r=1}^{i-1} \left( \sum_{k=1}^{j-1} \frac{N_{k+1,j-1} N_j B_i (1-N_k)}{B_k} - \frac{N_{r+1,j-1} N_j B_i}{B_j} \right) N_{r+1,j-1} (1-N_r)(a_r - v_{i,r}),
\]
where we define \(N_{k,k+1} = 1\). For \(j = i\),
\[
U_i = \sum_{r=1}^{i-1} \left( \sum_{k=1}^{i-1} \frac{N_{k+1,i-1} N_i B_i (1-N_k)}{B_k} - \frac{N_{r+1,i-1} N_i B_i}{B_j} \right) N_{r+1,i-1} (1-N_r)(a_r - v_{i,r}).
\]

Now, we need to prove \(\frac{\partial p_i}{\partial N_j}\) is bounded by \(U_i\). By combining the \(a_i - v_{i,j}\) terms in (A4), \(\frac{\partial p_i}{\partial N_j}\) can be further expressed as
\[
\frac{\partial p_i}{\partial N_j} = \left[ -1 - \sum_{r=1}^{i-1} (1-N_r) \frac{N_{r+1,i-1} N_i B_i}{B_r} (a_r - v_{i,r}) + \sum_{r=1}^{i-1} N_{r+1,i-1} (1-N_r) \frac{B_r - N_{r+1} B_i}{B_r} (a_r - v_{i,r}) \right].
\]
(A7)

The coefficient of \(a_i - v_{i,j}\) in (A7) is
\[
-1 + \sum_{r=1}^{i-1} (1-N_r) \frac{N_{r+1,i-1} N_i B_i}{B_r}
\]
\[
= -1 + \frac{N_i B_i}{B_{i-1}} (1-N_{i-1}) + \frac{N_{i-1} B_i}{B_{i-2}} N_{i-1} (1-N_{i-2}) + \cdots + \frac{N_{2} B_i}{B_1} N_{2} (1-N_{1})
\]
\[
< -1 + \frac{N_i B_i}{B_{i-1}} (1-N_{i-1}) + \frac{N_{i-1} B_i}{B_{i-2}} N_{i-1} (1-N_{i-2}) + \cdots + \frac{N_{1} B_i}{B_1} N_{1} (1-N_{1})
\]
\[
= -1 + \frac{N_i B_i}{B_{i-1}} (1-N_{i-1}) < 1 + \frac{N_i B_i}{B_{i-1}} < 0,
\]
where all the inequalities come from (A6). Therefore, we can relax (A7) using (A5) as
\[
\frac{\partial p_i}{\partial N_i} = \sum_{j=3}^{i-1} N_{r+1,j-1} (1 - N_{i,j-1}) \frac{B_{j-1} - N_{r+1,j-1} B_{j-1}}{B_{j-1}} (a_{r,j-1} - v_{i,j-1}) \\
+ (-1 + \sum_{k=1}^{i-1} (1 - N_{k}) \frac{N_{k+1,j-1} N_{j,k} B_{k}}{B_{k}} \sum_{j=3}^{i-1} N_{r+1,j-1} (1 - N_{i,j-1}) (a_{r,j-1} - v_{i,j-1})) \\
= \sum_{j=3}^{i-1} \frac{N_{r+1,j-1} B_{j-1}}{B_{j-1}} + \sum_{j=3}^{i-1} \frac{N_{r+1,j-1} N_{j,k} B_{k}}{B_{k}} \sum_{j=3}^{i-1} N_{r+1,j-1} (1 - N_{i,j-1}) (a_{r,j-1} - v_{i,j-1}) \\
= U_{i-1}.
\]

2). We use induction to show that \( U_i \) increases as \( j \) decreases.

i). We prove \( U_i < U_{i,j-1} \). Separating \( a_{r,j-1} - v_{i,j-1} \) term in \( U_i \) provides

\[
U_i = \left[ -\frac{N_{r+1} B_i}{B_{i-1}} + \sum_{k=1}^{i-1} (1 - N_{k}) \frac{N_{k+1,j-1} N_{j,k} B_{k}}{B_{k}} \sum_{j=3}^{i-1} N_{r+1,j-1} (1 - N_{i,j-1}) (a_{r,j-1} - v_{i,j-1}) \right] \\
+ \sum_{j=3}^{i-2} \frac{N_{r+1,j-1} B_{j-1}}{B_{j-1}} + \sum_{j=3}^{i-1} \frac{N_{r+1,j-1} N_{j,k} B_{k}}{B_{k}} \sum_{j=3}^{i-1} N_{r+1,j-1} (1 - N_{i,j-1}) (a_{r,j-1} - v_{i,j-1}) \\
= \sum_{j=3}^{i-2} \frac{N_{r+1,j-1} B_{j-1}}{B_{j-1}} + \sum_{j=3}^{i-1} \frac{N_{r+1,j-1} N_{j,k} B_{k}}{B_{k}} \sum_{j=3}^{i-1} N_{r+1,j-1} (1 - N_{i,j-1}) (a_{r,j-1} - v_{i,j-1}) \\
= U_{i-1}
\]

where the equality comes from collecting and simplifying the \( a_{r,j-1} - v_{i,j-1} \) terms.

ii). We prove \( U_j < U_{i,j} \) for \( 2 \leq j \leq i \). Separating \( a_{r,j} - v_{i,j-1} \) term in \( U_j \) provides

\[
U_j = \left( \sum_{k=1}^{i-1} \frac{N_{k+1,j-1} N_{j,k} B_{k}}{B_{k}} (1 - N_{i,j-1}) (a_{r,j} - v_{i,j-1}) \right) (1 - N_{i,j-1}) (a_{r,j} - v_{i,j-1}) \\
+ \sum_{j=3}^{i-2} \left( \sum_{k=1}^{i-1} \frac{N_{k+1,j-1} N_{j,k} B_{k}}{B_{k}} (1 - N_{i,j-1}) \right) (1 - N_{i,j-1}) (a_{r,j} - v_{i,j-1}) \\
= \sum_{j=3}^{i-2} \frac{N_{r+1,j-1} B_{j-1}}{B_{j-1}} + \sum_{j=3}^{i-2} \frac{N_{r+1,j-1} N_{j,k} B_{k}}{B_{k}} \sum_{j=3}^{i-2} N_{r+1,j-1} (1 - N_{i,j-1}) (a_{r,j} - v_{i,j-1})
\]

Since
\[
\sum_{i=1}^{k} N_{k,i} N_i B_i (1 - N_i) - N_{j,i} N_j B_j \\
= -N_i B_i N_{j-1} N_{j-1} / B_{j-1} + N_i B_i N_{j-2} N_{j-1} / B_{j-2} + \ldots + N_i B_i N_1 N_{j-1} / B_1 \\
< N^2_{j-1} N_i B_i N_{j-1} / B_{j-1} < 0,
\]

we have

\[
U_j < \left( \sum_{i=1}^{k} N_{k,i} N_i B_i (1 - N_i) - N_{j,i} N_j B_j \right) \left(1 - N_{j-1}\right) \sum_{r=1}^{k} N_{r+1,j-2}(1 - N_r)(a_r - v_{j,r}) + \sum_{i=1}^{k} \left[ \sum_{j=1}^{k} N_{k,j} N_i B_i (1 - N_i) - N_{j,i} N_{j-1} N_{j-1} N_{j-1} / B_{j-1} \right] \left(1 - N_{j-1}\right) (a_r - v_{j,r}) \\
= \left( \sum_{i=1}^{k} N_{k,i} N_i B_i (1 - N_i) - N_{j,i} N_j B_j \right) \left(1 - N_{j-1}\right) (a_i - v_i) \\
= U_{j-1}.
\]

Now, if we can show \( U_2 < 0 \), the proof is completed.

\[
U_2 = \left( \frac{N^2_{2,i} N_i B_i (1 - N_i) - N^2_{2,j} N_j B_j}{B_1} \right) (1 - N_i)(a_i - v_i) \\
= -N_i N^2_{2,j} N_{j-1} B_j (1 - N_i)(a_i - v_i) < 0
\]

**Proof of Proposition 11**

First, from proposition 1, before integration, \( Q_2 \) is \( N_2 B_2[a_2 - v_2 - v_1 - (1 - N_j)(a_i - v_i)] \). After integration, it is easy to show that \( Q_2 \) is \( \frac{N_2 B_2[a_2 - v_2 - v_1]}{1 - N_j} \), and thus, \( Q_2 \) always increases with integration. Similarly, \( p_i \) changes from \((1 - N_j)a_i + N_i v_i\) to \((1 - N_j)(a_i - v_i) + N_i v_i\), where \( a_i = \frac{N_2 B_2(a_2 - v_2) + N_1 B_1(a_3 - v_3)}{N_2 B_2 + N_1 B_1} \). Therefore, if \( a_2 - v_2 > a_3 - v_3 \), the resource price \( p_i \) decreases; if \( a_2 - v_2 = a_3 - v_3 \), \( p_i \) remains unchanged; and if \( a_2 - v_2 < a_3 - v_3 \), \( p_i \) increases. \( Q_2 \) and \( \pi_i \) increase (decrease) iff \( p_i \) increases (decreases).

As to the profit \( \pi_1 + \pi_2 \), before integration,

\[
\pi_1 + \pi_2 = (1 - N_j)^2 [B_2 N_2 B_3 N_3 (a_i - v_i)^2 + B_2 (a_2 - v_2 - v_1 - (1 - N_j)(a_i - v_i))^2].
\]

After the integration, it changes to \( \pi_{\text{joint}} = (1 - N_j)^2 [B_2 N_3 (a_3 - v_3 - v_1)^2 + B_2 (a_2 - v_2 - v_1)^2] \). Define \( (a_2 - v_2 - v_1) / (a_i - v_3 - v_1) \) as \( x \). After collect terms, we have
\[ \Delta = \pi_{\text{joint}} - (\pi_1 + \pi_2) \]
\[ = \frac{(1 - N_2)^2}{(B_2N_2 + B_3N_3)^2} \left( B_2N_2 \left[ B_2N_2(1 - N_2 - N_2^2) + B_3N_3(2 - 3N_2) \right] x^2 \right. \\
\left. + 2B_3N_3(B_3N_3 - B_2N_2^3 - 2B_3N_2N_3)x + B_3N_3(B_2N_2^2 + 3B_3N_2N_3 - B_4N_3 - B_5N_2^2N_3) \right) \]
\[ = \frac{(1 - N_2)^2(a_3 - v_3 - v_i)}{(B_2N_2 + B_3N_3)^2}(\tau x^2 + \beta x + \epsilon). \]

where \( \tau := B_2N_2 \left[ B_2N_2(1 - N_2 - N_2^2) + B_3N_3(2 - 3N_2) \right] \), \( \beta := 2B_3N_3(B_3N_3 - B_2N_2^3 - 2B_3N_2N_3) \), and \( \epsilon := B_3N_3(B_2N_2^{2} + 3B_3N_2N_3 - B_4N_3 - B_5N_2^{2}N_3) \).

Note that when \( n_2 = 1 \) (i.e. \( N_2 = 0.5 \)) , we have \( \tau > 0 \) and \( \beta^2 - 4\tau\epsilon = -B_2B_3, N_3 / 4 < 0 \). Therefore, for any \( x, \Delta < 0 \).

When \( n_2 \geq 2 \) (i.e. \( N_2 \geq 2 / 3 \)) , we have \( \tau < 0 \) and

\[ \beta^2 - 4\tau\epsilon = 4B_3N_3[B_2N_2^{2}(N_2^{2} + N_2 - 1) + B_3N_3(1 - 2N_2)^{2}] > 0. \]

Therefore for any \( x, \Delta > 0 \).
Production, Operation, and Maintenance
MULTI-RESOURCE MAINTENANCE PLANNING
BY JOINT SCHEDULING APPROACH

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MULTI-RESOURCE MAINTENANCE PLANNING BY JOINT SCHEDULING APPROACH

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ABSTRACT

In most of the production scheduling problems, it is a common practice to schedule fixed maintenance tasks for a single resource (machine) periodically. However, it may not be sufficient to improve production system reliability as a whole. Production usually involves more than one resource and different resources require maintenance with different intervals and durations. For example, in a plastics production system, the frequency of the breakdown of injection mold is even higher machine-related one. In that case, planned production operations will usually be interrupted seriously because of the mismatch among the maintenance periods of different resources. In this connection, this paper proposes to jointly schedule production and maintenance tasks of multi-resources in order to improve production system reliability by reducing the mismatch among various processes.

KEYWORDS
Multi-Resource, Maintenance Planning, Production Scheduling

INTRODUCTION

Typically, production scheduling and maintenance planning are executed independently and production schedules are often interrupted by equipment failures, which could be prevented by proper preventive maintenance. The mismatch of two activities will induce costly emergency maintenance activities. In this connection, the importance of maintenance planning becomes more significant in the entire production scheduling process. Such integration can increase the effectiveness of management (Nikolopoulos, et al. 2003). Without considering maintenance during
production scheduling, the planned production operations will be seriously interrupted because of the mismatch among various processes, deteriorating the production system reliability (Chan et al. 2006).

Some researchers attempted to consider maintenance in production scheduling. Qi et al. (1999) considered preventive maintenance in a single-machine scheduling problem that is proved to be NP-hard problem. They proposed heuristic algorithms and a branch and bound algorithm for the problem with an objective of minimizing total completion time. Lee and Chen (2000) studied machine-scheduling problem in which machine maintenance must be completed within a certain period. Benbouzid et al. (2003) proposed a Genetic Algorithms (GA) approach for flow shop scheduling problem where each machine must be maintained periodically with intervals of known times. Liao et al. (2005) considered a two parallel-machine problem with machine availability constraint, aiming to minimize the makespan. They assumed that one machine is not available during a time period. Liao et al. (2007) again solved a two parallel-machine problem with availability constraint. At that time, instead of fixing the maintenance periods, they assumed that machine is not available after processing a fixed number of jobs. Mellouli et al. (2006) proposed three exact methods to minimize the total completion time in a parallel-machine problem where machines must be maintained once during the planning horizon. Ji et al. (2007) considered a single-machine scheduling problem where each maintenance activity is performed after a periodic time interval with an objective of minimizing makespan. Xu et al. (2008) proposed a heuristics algorithm named BFD-LPT for a parallel machine scheduling problem under an almost periodic maintenance scheme to minimize makespan. Sun and Li (2010) identified two production-maintenance scheduling problems in two identical parallel machines and design efficient heuristic algorithms for the problems. For the first problem, maintenance activities were performed periodically with fixed maintenance time. For another problem, maintenance activities were scheduled jointly with jobs with fixed maintenance time. They showed that there was a research gap about the scheduling problem on two parallel machines with jointly scheduled maintenance in the literature. In the joint-scheduling problem, idle time on machines could be eliminated. Also, they proved that the joint-scheduling problem is NP-hard in a strong sense. Moreover, there is a definite need for studies on machine scheduling with various maintenance times (Mosheio Sidney 2010). It is because maintenance time may depend on the running time of factory resources during production. In a real situation, the later the maintenance activity is performed, the worse the resource conditions are, and therefore, it requires more time and effort for maintenance. As a result, this paper adopts a Joint-Scheduling (JS) approach and develops two time-dependent deteriorating maintenance schemes for injection machine and mold.

Most of the studies on the production-maintenance integration approach only considered the availability of machine. They usually ignore the availability of other important resources such as injection molds. In plastic industry, however, breakdown of mold often causes disruptions to current production. The proportion of mold-related downtime is even higher than machine-related downtime (Menges, et al. 2001). Thus, the significance of this paper is to integrate such important consideration with production scheduling. In literature, similar idea for mold consideration may appear in the area of tools management. Although tools related issues are often ignored in production scheduling problems, earlier works attempted to handle part assignment in Flexible Manufacturing System (FMS) scheduling problems with tool consideration such as tool allocation (de Werra, Widmer 1991; Chen, Chung 1991). Tool scheduling plays a critical role in tool management (Veeramani, et al. 1992). The objective of tool scheduling is to minimize unnecessary delays by coordinating the flows of jobs and the tools required. Turkcan et al. (2007) considered machining conditions selection and tool selection decisions simultaneously in FMS problem, aiming to minimize the production cost and total weighted tardiness. Zeballos (2010) proposed a constraint programming to solve FMS problem by considering tool planning and allocation, machine assignment, part routing, and task timing decisions. Realistic limitations such as number of tools, lifetime of tools, and tool magazine capacity are also considered in the proposed approach. Although there are many studies related to maintenance and tool life management, those studies assume the time intervals and the number of replace or repair actions are known in advance. This assumption will give privilege to maintenance activities comparing to production activity, fixing the maintenance periods in production schedule.

In this paper, two types of resources (injection machine and mold) are selected for maintenance planning. A Production Scheduling with Mold Scheduling (PS-MS) problem is modeled to demonstrate the integration of multi-resource maintenance planning and production scheduling. The start times of maintenance tasks are considered as decision variables like scheduling on production jobs. As a result, production jobs, machine maintenance tasks and mold maintenance tasks are jointly (but not sequentially) scheduled. A GA approach is applied to deal with the PS-MS problem subject to machine and mold maintenance constraints. The optimization objective is to minimize makespan by scheduling and integrating machine and mold maintenance activities with production activities.
PROBLEM DESCRIPTION

The problem is formulated as an integer program to find optimal solutions. The notations used in this paper are summarized as the followings:

<table>
<thead>
<tr>
<th>Index</th>
<th>Descriptions</th>
</tr>
</thead>
<tbody>
<tr>
<td>i</td>
<td>Index for job, $i = 1, \ldots, I$, where $I$ is the number of job</td>
</tr>
<tr>
<td>m</td>
<td>Index for machine, $m = 1, \ldots, M$, where $M$ is the number of machines</td>
</tr>
<tr>
<td>o</td>
<td>Index for mold, $o = 1, \ldots, O$, where $O$ is the number of molds</td>
</tr>
<tr>
<td>t</td>
<td>Index for time slot, $t = 1, \ldots, T$, where $T$ is the maximum time horizon</td>
</tr>
<tr>
<td>$\lambda_{imo}$</td>
<td>Operating time of job $i$ on machine $m$ with mold $o$</td>
</tr>
<tr>
<td>$\alpha$</td>
<td>Maximum machine age</td>
</tr>
<tr>
<td>$\beta$</td>
<td>Maximum mold age</td>
</tr>
<tr>
<td>$S_i$</td>
<td>Starting time of job $i$</td>
</tr>
<tr>
<td>$C_i$</td>
<td>Completion time of job $i$</td>
</tr>
<tr>
<td>$C_{\max}$</td>
<td>Makespan of jobs</td>
</tr>
<tr>
<td>$X_{imo}$</td>
<td>$= 1$, if job $i$ is allocated on machine $m$ with mold $o$ $= 0$, otherwise</td>
</tr>
<tr>
<td>$\delta_{imot}$</td>
<td>$= 1$, if job $i$ occupies time slot $t$ on machine $m$ with mold $o$ $= 0$, otherwise</td>
</tr>
</tbody>
</table>

The PS-MS model consists of $M$ injection machines and $O$ injection molds with a number of jobs ($I$). Each machine ($m$) can perform various jobs ($j$) with specific mold ($o$) and operating time ($\lambda_{imo}$). Each machine and mold is subjected to their maximum age, machine age ($\alpha$) and mold age ($\beta$). Age is a measurement of the cumulated operating time of a resource. When resource age reaches its maximum age, failure or breakdown will occur.

In the PS-MS model, when a machine age reaches $\alpha$, maintenance has to be carried out for the particular machine after the completion of the current job. Similarly, if a mold age reaches $\beta$, maintenance has to be carried out for the injection mold after the completion of the current job. After each maintenance task, machine or mold age will be reset to 0, which means that the condition of the machine or mold is assumed to be as good as new after maintenance (perfect maintenance). Since the frequency of mold breakdown is higher than machine breakdown (Menges, et al. 2001), the maximum age of mold ($\beta$) is shorter than machine ($\alpha$). Besides, in a real production system, the earlier the maintenance task is performed, the less maintenance time is needed (Mosheio, Sidney 2010). Thus, in the PS-MS problem, different decisions on time interval of maintenance action may vary the duration of maintenance operations. This allows for the consideration of short maintenance actions when maintenance is performed early.

In the PS-MS problem, it is assumed that $I$, $M$, $O$ and $\lambda_{imo}$ are given. The decision variables are $X_{imo}$ and $\delta_{imot}$. With the solutions ($X_{imo}$ and $\delta_{imot}$) obtained, the values of $S_i$ and $C_i$ can be calculated. The objective is to minimize the makespan of jobs as shown in the following:

$$ Objective : MIN \{ C_{\max} \} \quad (1) $$

The problem is subjected to the following constraints:
Processing time constraints:

\[ C_i - S_i = \sum_{mo} X_{imo} \lambda_{imo} \]  
\[(i = 1, 2, \ldots, I) \]  
\[ \sum_{mot} \delta_{mot} = \sum_{mo} X_{imo} \lambda_{imo} \]  
\[(i = 1, 2, \ldots, I) \]  

Constraint (2) defines that once a job starts, it will be finished without interruption. Constraint (3) indicates that the allocated time slot equals the required operation time.

Job constraints:

\[ \sum_{mo} X_{imo} = 1 \]  
\[(i = 1, 2, \ldots, I) \]  

Constraint (4) defines that each job should be carried out on one machine throughout the horizon.

Processing job constraints:

\[ \sum_{mo} \delta_{mot} \leq 1 \]  
\[(i = 1, 2, \ldots, I; t = 1, 2, \ldots, T) \]  

Constraint (5) defines that each job can only be carried out on one machine at each time unit.

Machine capacity constraints:

\[ \sum_{Io} \delta_{mot} \leq 1 \]  
\[(m = 1, 2, \ldots, M; t = 1, 2, \ldots, T) \]  

Constraint (6) defines that each machine can carry out only one job at a time unit.

Mold capacity constraints:

\[ \sum_{iom} \delta_{mot} \leq 1 \]  
\[(o = 1, 2, \ldots, O; t = 1, 2, \ldots, T) \]  

Constraint (7) defines that each mold can carry out only one job at a time unit.

**OPTIMIZATION METHODOLOGY**

To strengthen the genetic search, many researchers proposed different kinds of adaptive GAs for their particular problems. One of the successful approaches that adopts in this paper is named Genetic Algorithms with Dominant Gene (GADG), which has been proposed by the authors as published in the paper (Chan, et al. 2006). GADG is proven to work better than various approaches including simple GAs, Petri Nets, and Ant Colony. The idea of GADG is to identify and record the best genes in each chromosome, and corresponding structure so that no determination of optimal crossover rates is needed.

**A. Encoding of chromosome**

Each gene composes of 5 parameters, representing Machine, Job, MAchine maintenance, MOld maintenance, and Domination (MJAOD). The M and J parameters represent the allocation of job on a machine. The A and O parameters decides the start of maintenance activity on either machine or mold after the current operation. Machine will be maintained if the A parameter is denoted as 1 and mold will be maintained if O parameter is denoted as 1. Otherwise, they are denoted as 0. Lastly, when a gene is identified as a dominant gene, D parameter will be denoted by 1, otherwise 0.
B. Basic genetic operation

At the beginning, a set of chromosome are randomly generated in the initial solution pool. In this stage, all chromosomes must be valid. To prevent the loss of the best chromosome during evolutions, elitist strategy is applied. Thus, the best chromosome in every generation will be identified and recorded.

The fitness value of a chromosome $k$ is calculated by one minus the makespan of the chromosome $k$ divided by the summation of all the makespan of all the $r$ chromosomes in the solution pool as shown:

$$
f_k = 1 - \left( \frac{C_{\text{max}}^k}{\sum_r \{C_{\text{max}}^r\}} \right)
$$

(8)

C. Crossover Operation

In the initial stage of GADG, some genes are randomly assigned as DGs into initial pool. They represent as the critical structure of the chromosomes in the pool. During evolution, the strengthened chromosomes will survive and its critical structure, i.e. DGs, will perform crossover to form a pair of offspring.

D. Mutation operation

To enhance the ability of local searching, mutation operation will perform during evolution. In this approach, there are two types of one-point mutation. In the first mutation, a gene will be randomly selected and swapped among its chromosome and other parameters will remain unchanged. It rearranges production sequence of chromosome in order to find a better solution. In the second mutation, one of the parameter $M$, $A$, or $O$ will be changed from a random-selected gene. Parameter $J$ will remain unchanged in order to avoid the change of job sequence which is similar to Mutation 1.

E. Genetic Evolution

Firstly, a number of chromosomes will be randomly generated to form an initial solution pool. They will be evaluated by fitness function defined to measure the strength of each solution. After that, they will undergo evolution process in which the crossover and mutation operations will perform alternatively. Again, the offspring solutions will be evaluated by the fitness function. Next, Roulette Wheel Selection and Elitist Strategy will be performed to select some chromosomes for mating pool generation. Lastly, GA will decide whether the generation is completed according to predefined stopping condition. If the stopping condition is satisfied, the best solution found will be the final output. Otherwise, the generation process will continue.

NUMERICAL EXAMPLE

The purpose of the numerical example is to test the performance of Joint-Scheduling (JS) approach under the considerations of multi-resource maintenances. For the sake of comparison, a Fixed Maintenance-interval (FM) approach is introduced in which no maintenance schedule will be considered in the PS-MS problem and the maintenance activities will be performed when machine age or mold age reaches its maximum operating limit. A hypothetical problem is generated and solved by GADG which is implemented in a VBA environment on a personal computer with Intel Core 2 Duo 2.13GHz CPU. The operation time of molds is randomly generated between 30-55 units of time. The batch size of jobs is randomly generated between 2 - 6 units. It will be run for 10 times independently. The solution pool size is 50 and the number of evolution is 1000, which is long enough to obtain a steady solution. The performance indicator adopted in this paper is the makespan of each solution.

The minimum makespans of FM and JS approaches are 3050 and 2250 unit of time respectively. There is 26% improvement by considering both maintenances in production scheduling (JS approach). The detailed production schedules for the optimal result are shown in Fig. 1. In the schedules, although machines 1 and 2 in FM operate with no idle time, machine 3 frequently stops for waiting the mold needed. In addition, when the system applies FM, the total maintenance time is relatively longer than JS. It is because the resources in FM are maintained only when they reach their maximum ages, whereas the resources in JS can be maintained according to the schedule. Based on the concept of time-dependent deteriorating maintenance, the earlier resource is maintained, the more maintenance time may be saved in the particular maintenance activity. In this connection, jointly scheduling both machine and mold maintenances before their maximum ages can have better performance in the PS-MS problem.
CONCLUSION

In this paper, the PS-MS problem has been modeled to demonstrate the idea of multi-resource production and maintenance scheduling. A GA approach has been developed to solve the hypothetical PS-MS problem. Comparing with the traditional Fixed Maintenance-interval (FM) approach, the experiment showed that jointly scheduling production and maintenance activities can improve production efficiency with shortened makespan.

ACKNOWLEDGEMENTS

The work described in this paper was substantially supported by a grant from the Research Gants Council of the Hong Kong Special Administrative region, China (Project No. PolyU 510410); and a grant from the Innovation and Technology Commission of the Hong Kong Special Administrative region, China (Project No. UIT/105). The authors also thank the editor and the reviewers for their valuable comments and suggestions that have led to substantial improvement of the paper.

REFERENCES


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<tr>
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<th>JS</th>
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<td>1</td>
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<tr>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>6</td>
<td>6</td>
</tr>
</tbody>
</table>

**Figure 1:** The production schedules of FI and JS approaches.
CLASS RANKING FOR PERFORMANCE EVALUATION: A CASE

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by

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ABSTRACT

Evaluation is an effective means for pushing a unit to pursue excellence. When there are several objectives to consider, how to rank the general performance of different units is always controversial. This paper proposes an idea of class ranking to stratify the units into classes of different levels. Units in the same class are not comparable with each other and are better than those in lower classes. As an empirical study, the management colleges of 34 universities in Taiwan are stratified into 13 classes from the aspects of faculty, teaching, research, extension services, administration, and general impression. Since this method favors universities with special emphasis, it encourages diversification of universities. The results are persuasive. More importantly, the intermediate targets for a university to go through to reach the highest class are obtainable from a dual formulation of the proposed model.

KEYWORDS
Multiple Criteria Analysis, Data Envelopment Analysis, Performance Measurement, Ranking

INTRODUCTION

In ranking a number of organizations that are evaluated under a common set of noncommensurable criteria, a variety of methods have been proposed (Goicoechea et al. 1982). The choice of which method to use depends on the characteristics of the problem faced. It is important that the ranking procedure meets the decision maker’s desirability, problem context, and is considered as reasonable and fair by the participating members (Stewart 1992). Since every organization should focus on their strong area to develop a distinct characteristic, the conventional way of aggregating the performance in all aspects to form one composite index for ranking is inappropriate. An organization is dominated by another if it performs worse in all aspects. Those organizations which are not dominated by other universities or their convex combinations are Pareto optimal, or efficient (Zeleny 1982, Stewart 1992). Within this context, all Pareto optimal organizations should be ranked the same while the dominated ones should be ranked lower.
Consider a simple case of six organizations labeled as $A$, $B$, $C$, $D$, $E$, and $F$ which are being evaluated under the criteria of Product $Y_1$ and Product $Y_2$. Their scores on these two criteria are $A=(1,5)$, $B=(4,4)$, $C=(5,1)$, $D=(3,4)$, $E=(4,2)$, and $F=(3,1,3,1)$ as depicted in Figure 1. When the two criteria are of equal importance, $B$ is the best because it has the largest total score of 8. The second is $D$, with a total score of 7; $F$ is the third, with a total score of 6.2; and the other three, $A$, $C$, and $E$, are tied for fourth, with an equal score of 6. Apparently, assigning different weights to the two criteria will result in different rankings. Suppose $Y_1$ and $Y_2$ are incomparable. This is equivalent to seeking for nondominated organizations. The nondominated ones belong to the class of the same level and those dominated ones belong to the class of a lower level. For the six organizations in Figure 1, $A$, $B$, and $C$ are the nondominated ones and are Pareto optimal. They belong to the same class of higher level. The remaining three, $D$, $E$, and $F$, are dominated by $B$ and thus belong to the class of a lower level. It is possible that $D$, $E$, and $F$ are not directly dominated by $A$, $B$, or $C$, but indirectly via the linear combination of $A$, $B$, and $C$. This dominance relationship can be identified by connecting the units on the northeast frontier such that all other organizations lie inside the frontier. In Figure 1, the frontier is composed of the piecewise line segments $A'BCC'$. The Pareto optimal organizations are those lying on the frontier, which are $A$, $B$, and $C$. The organizations lying inside the frontier, viz., $D$, $E$, and $F$, are dominated ones. This graphical approach is applicable only for cases of two criteria. When there are more than two criteria, some mathematical method must be relied on.

There are several methods for generating the nondominated set for continuous cases (Goicoechea et al. 1982). Under discrete circumstances, the data envelopment analysis (DEA) methodology (Charnes et al. 1978) has demonstrated to be suitable for identifying nondominated units. Suppose there are $n$ units to be evaluated under $m$ criteria. Let $Y_{ij}$ denote the measure of the $i$th unit in the $j$th criterion. Kao (1994) uses the following DEA model without input to identify the Pareto optimal units:

$$E_k = \max \sum_{j=1}^{m} Y_{kj} w_j$$

s.t. \[ \sum_{j=1}^{m} Y_{ij} w_j \leq 1, \quad i=1, \ldots, n \]

$$w_j \geq 1, \quad j=1, \ldots, m,$$  \hspace{1cm} (1)

Each unit selects the most advantageous weights to calculate the composite index $E_k$. The weights are variable, rather than fixed for all units. If $E_k$ is 1, then unit $k$ is Pareto optimal; if it is less than 1, then it is Pareto-nonoptimal.

Conceptually, $E_k$ is the ratio of the observed performance to the expected performance. It could be used for ranking. However, since the basis for calculating the expected performance need not be the same for every dominated unit, it is not suitable to use it for ranking (Adler et al. 2002). In our example, the reference points for calculating the expected performance for $D$ are $A$ and $B$ while for $E$ are $B$ and $C$. It is, therefore, not appropriate to compare $D$ with $E$ by using $E_D$ and $E_E$ calculated from Model (1). To compare $D$, $E$, and $F$, the same idea of dominance can be applied. From Figure 1, it is clear that the frontier constructed from $D$, $E$, and $F$, when $A$, $B$, and $C$ are removed, is the piecewise line segment $D'D'EE'$, where $D$ and $E$ are Pareto optimal and $F$ is Pareto-nonoptimal. In other words, $D$ and $E$ belong to the same class and are incomparable while $F$ belongs to a lower class. In sum, the six organizations are stratified into three classes: $A$, $B$, and $C$ in the first, $D$ and $E$ in the second, and $F$ in the third. The first class is higher than the second and the second is higher than the third. Organizations in the same class are of the same rank. The same idea has also been proposed by Barr et al. (2000) and Seiford and Zhu (2003) in the DEA context.

**PERFORMANCE EVALUATION- A CASE**

Taiwan is a small island of 36,000 square kilometers. On such a small land there are approximately 23 million people and 152 universities. To maintain the quality of these universities, the Ministry of Education (MOE) of the Republic of China in Taiwan makes evaluates every once for a while. The evaluation is based on five criteria: faculty, teaching, research, extension services, and administration. In addition to these five criteria, the general impression of the evaluators perceived in the on-site visit regarding the attitude of the dean, preparation of the documents, contacts with the students and faculty members, etc., is another criterion for grading.
### TABLE 1

**GRADES OF THE MANAGEMENT COLLEGES OF 34 UNIVERSITIES IN TAIWAN**

<table>
<thead>
<tr>
<th>University</th>
<th>Faculty</th>
<th>Teaching</th>
<th>Research</th>
<th>Administration</th>
<th>General Impression</th>
<th>Total</th>
<th>Class</th>
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<td>2. N Cheng Kung U</td>
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<td>4</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>29</td>
<td>1</td>
</tr>
<tr>
<td>3. N Sun Yat-sen U</td>
<td>5</td>
<td>4</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>29</td>
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</tr>
<tr>
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<td>4</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>29</td>
<td>1</td>
</tr>
<tr>
<td>5. N Central U</td>
<td>5</td>
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<td>5</td>
<td>4</td>
<td>4</td>
<td>27</td>
<td>2</td>
</tr>
<tr>
<td>6. N Chiao Tung U</td>
<td>5</td>
<td>4</td>
<td>5</td>
<td>4</td>
<td>4</td>
<td>27</td>
<td>2</td>
</tr>
<tr>
<td>7. N Chung Cheng U</td>
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<td>3</td>
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<tr>
<td>9. N Dong Hwa U</td>
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<td>4</td>
<td>4</td>
<td>3</td>
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<td>3</td>
<td>4</td>
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<td>23</td>
<td>4</td>
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<td>12. Yuan Ze U</td>
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<td>3</td>
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<td>4</td>
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<tr>
<td>13. N Chi Nan U</td>
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<td>4</td>
<td>3</td>
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<td>14. Feng Chia U</td>
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<td>16. N Taipei U</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>4</td>
<td>3</td>
<td>19</td>
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<tr>
<td>17. I-Shou U</td>
<td>3</td>
<td>3</td>
<td>4</td>
<td>3</td>
<td>3</td>
<td>19</td>
<td>6</td>
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<tr>
<td>18. Fu Jen Catholic U</td>
<td>4</td>
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<td>4</td>
<td>3</td>
<td>2</td>
<td>18</td>
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<td>19. Chung Yuan Christian U</td>
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<td>3</td>
<td>3</td>
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<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>18</td>
<td>7</td>
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<tr>
<td>21. Da Yeh U</td>
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<td>3</td>
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<td>1</td>
<td>2</td>
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</table>

This study describes the evaluation of 34 management colleges evaluated in 2002-2003. Table 1 shows the grades of the thirty-four universities in six categories expressed in numbers of stars (Ministry of Education 2004) as evaluated by the members of a evaluation committee. The second to last column shows the total number of stars from the six categories. There are 17 distinct numbers of stars, ranging from 8 to 29. The MOE reiterated that different categories were not comparable and the universities should not be ranked by the total number of stars from the six categories. The universities and the public should look at the result of each category independently; that is, which universities are performing better in teaching, which universities are performing better in research, etc. However, the universities and the
public are still interested in and curious about the rankings of the universities in an aggregate sense. Without additional information, the method of class ranking is used to rank the 34 universities.

By applying the procedure discussed in this paper, thirteen classes are stratified as indicated in the last column of Table 1. The first class has four universities, each having 29 stars. They are National Cheng Chi University, National Cheng Kung University, National Sun Yat-sen University, and National Taiwan University, where the last three have the same score in every category. National Central University and National Chiao Tung University belong to the second class. They perform the same in every category, with a total of 27 stars and are clearly dominated by National Cheng Kung University. The third class has four universities. They perform differently in the six categories. Notably, Chang Gung University has two stars less than the other three universities. However, since it is not dominated by any other universities in this class and those of lower classes, it is stratified into Class 3. In Class 4, there are two universities: National Changhua University of Education and Yuan Ze University. Interestingly, National Changhua University of Education is dominated by National Defense University in Class 3 while Chang Gung University is not dominated by any university in Class 3 or those of lower classes.

Starting from Class 5, the results of class ranking are consistent with those from equal-weight method, only that universities in the same class may have a different total number of stars. Referring to Table 1, the universities in Class 5 have 20 or 19 stars, the universities in Class 6 have 19 or 18 stars, the universities in Class 9 have 16 or 15 stars, the universities in Class 10 have 15 or 13 stars, and the universities in Class 13 have 9 or 8 stars. It is also possible that universities with the same total number of stars be stratified into different classes. The case of National Taipei University (No. 16) and I-Shou University (No. 17) is an example. While they both have 19 stars, the former has been stratified into Class 5 and the latter stratified into Class 6. The reason, again, is domination: I-Shou University is dominated by National Chi Nan University in Class 5 while National Taipei University is not dominated by any university in Class 5 or lower. This situation also happens at Fu Jen Catholic University (No. 18), which has 18 stars yet is stratified into a class higher than other universities with 18 stars, and Tunghai University (No. 26), which has 15 stars yet is stratified into a class higher than other universities with 15 stars.

Of the 34 universities, 12 are national universities. Due to government support, national universities in Taiwan, in general, perform better and are more prestigious than private universities. The performance of management colleges follows this tendency. The universities in Table 1 are ordered in descending classes and number of stars. The nine leading universities are public. The first private university to appear is Chang Gung in Class 3. Then we have Yuan Ze University of Class 4 and Feng Chia University and Tamkang University, both of Class 5. All of the universities in Class 6 or lower are private universities. The worst public universities are National Taipei University and National Chi Nan University, both belonging to Class 5. Surprisingly, National Defense University of Class 3, which is a military academy, has a rank higher than several public civil universities.

**PERFORMANCE IMPROVEMENT**

Model (1) is essentially a DEA model without input. Hence, the target point on the frontier for each university to compare with can be obtained from the following dual formulation of Model (1):

\[
E_k = \min \sum_{i=1}^{n} \lambda_i
\]

s.t. \[
\sum_{i=1}^{n} Y_{ij} \lambda_i \leq Y_{kj}, \ j=1,\ldots, m
\]

\[\square, \ s_j \geq 0, \ i=1,\ldots, n; \ j=1,\ldots, m.\]  \( (2) \)

The optimal objective value \( E_k \) calculated from this model is exactly the same as that calculated from Model (1); however, this model provides more information, i.e., the coordinate of the target, for the \( k \)th university to make improvement. Denote \( \square = \sum_{i=1}^{n} \lambda_i \). The target is \( (Y_{kj} + s_j)/\square, \ j=1,\ldots, m \), which lies on the frontier. The conventional one-stage DEA model only provides the ultimate goal. The multi-stage class-ranking model, on the other hand, provides all intermediate goals. For a university belonging to the \( f \)th class, it can calculate \( f//1 \) targets in the previous \( f//1 \) stages. Each target shows how much this university should be improved in each category to become a member of the corresponding class.
### Table 2
**Intermediate Targets for Tatung University at Different Classes**

<table>
<thead>
<tr>
<th>Class</th>
<th>Faculty</th>
<th>Teaching</th>
<th>Research</th>
<th>Extension</th>
<th>Administration</th>
<th>General Impression</th>
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</table>

Table 2 shows the targets at twelve classes for Tatung University (No. 34) of Class 13. In reality, it is impossible for a university of Class 13 to improve to Class 1 in a short period. The intermediate targets at different classes show the short-term goals for this university to achieve. The university is aware of which class it has achieved when specific values of the criteria are attained. Referring to Table 2, if Tatung University improves *faculty*, *extension services*, and *general impression* by one star, respectively, then it can be raised to Class 12. If *extension services* is further improved by one star, then Tatung can be raised to Class 11. The intermediate targets serve as a road map to guide a university to improve to Class 1 step by step. The targets also indicate which universities Tatung should treat as benchmarks. For example, its benchmark university at Class 9 is Providence, at Class 6 is I-Shou, at Class 4 is Changhua, and at Class 1 is Cheng Chi.

### CONCLUSION

Evaluation is an effective way for pushing an organization to pursue excellence. This paper proposes a class ranking method to rank organizations of different performance. The management colleges of 34 universities in Taiwan were used for illustration.

The results of the evaluation were expressed on a scale of five stars for six categories, including faculty, teaching, research, extension services, administration, and general impression. This paper applies the concept of Pareto optimality to dichotomize the universities into dominated ones and nondominated ones. The nondominated universities are not comparable with each other yet are better than those dominated ones. There are only four universities in the nondominated class. By removing these four nondominated universities, the concept of Pareto optimality is applied again to the 30 remaining universities to identify the nondominated class in this set of universities. There are only two universities in this class. This procedure is repeated until all universities are categorized and finally there are 13 classes being stratified. The universities being stratified in the earlier stage are considered to be better than those stratified in later stages.

The idea of class ranking via dominance resolves the difficulty encountered in incomparability among the criteria. More importantly, this method favors universities which perform better than others in at least one category. In other words, it favors universities with special emphasis. This property reinforces the policy of the Ministry of Education, Republic of China, of encouraging diversification of universities. From the results, there are three points to be noted. Firstly, the universities being stratified into the same class need not have the same total number of stars. Secondly, universities with the same total number of stars may be stratified into different classes. Thirdly, a university with fewer stars could be stratified into a higher class than those with more stars. Finally, it is also noted that in Taiwan public universities perform significantly better than private universities.

The class-ranking procedure is able not only to rank universities under incomparable criteria, but also to provide intermediate goals for a university to become efficient in stages via the DEA-type model. Thus, a university being stratified into Class \( f \) is aware of the intermediate targets to achieve higher classes. Insufficiently, the universities being stratified into the same class are incomparable. Although the paper by Adler et al. (1992) describes several ways for...
ranking the universities in the same class, each method has different weaknesses. A direction for future research is to suitably rank the universities in the same class so that exact rankings of all the universities can be obtained.

REFERENCES


TRUCK DRIVER’S SATISFACTION AND ITS EFFECTS ON SAFETY OUTCOMES

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ABSTRACT

The present paper extracts satisfaction factors of occupational truck drivers and uncovers their characteristics. We identified positive contributions of the satisfaction factors to organizations’ safety outcomes using the actual incident records. A questionnaire-based survey on truck drivers’ satisfaction was conducted in 2009, collecting 1028 driver responses (54% of response rate) from 49 trucking companies in Japan. Incident statistics between 2004 and 2008 were obtained from 21 companies as safety outcome records. Principal component analysis yielded four factors on driver satisfaction with 63% of the cumulative variance accounted for: (1) satisfaction with work and organization; (2) own competence; (3) training; and (4) vehicle. Significant correlations were observed for several factors with the rate of injury incidents and the total damage. This result suggests that safer driving can be facilitated by improving driver satisfaction, particularly satisfaction with driving vehicle as well as with their work and company.

KEYWORDS
Employee Satisfaction, Trucking Industry, Safety Management, Incident Statistics

INTRODUCTION

Safety is a great concern for all organizations where employees are engaged in occupational driving (Newnam et al., 2011). Looking into the last ten year statistics in Japan, the fatal accident rate for commercial vehicles, e.g., trucks, buses and taxicabs, was three times higher than that of private automobiles based on the number of fatal accidents per 10,000 vehicles in Japan (IATSS, 2010).

It has been well acknowledged that employee satisfaction is one of the key issues for effective organizational management in any industrial sector (Matzler et al., 2007). Sufficient evidences suggested that employee satisfaction contributes positively to job performance (Ang et al., 1997; Lashbrook, 1997; Ostroff, 1992), quality (Llorente et al., 2005; Yee et al., 2008) and financial outcomes through increased individual productivity, decreased rate of absenteeism and turnover (intention to leave), and reduced human fallibility (Lévy-Garboua et al., 2007; Ostroff, 1992). Despite the importance of employee satisfaction for organizational issues, there are few rigorous empirical evaluations of drivers’ satisfaction and their impacts on work-related driving outcomes. Thus, the present study developed an assessment framework of occupational drivers’ satisfaction and to examine its impact on safety outcomes in the trucking industry.

METHODS

Questionnaire and respondents

A questionnaire (which was originally written in Japanese) was developed to measure employee satisfaction. It comprised fifteen closed-response question items and a demographic section. Closed-response questions included truck drivers’ satisfaction with current job, work schedule, work systems, restraint at work, performance evaluation system, regular feedback, salary, safety training, basic truck operation training, vehicle maintenance, vehicle presently driving, truck operation instructors’ skills for inexperienced drivers, drivers’ own skills and ability in handling normal operations or emergency. Respondents were asked to rate their satisfaction or dissatisfaction with each statement on a five-point Likert-type scale between 1 and 5, ranging from “strongly dissatisfied” to “strongly satisfied”.

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15-17 December 2011, Kurumba Maldives Resort, Male, Maldives
We distributed a total of 1901 questionnaires to truck drivers working for forty-nine trucking companies with a pre-stamped return envelope. When a respondent filled out the questionnaire, he/she returned it directly to the researchers, who were not affiliated with the participant’s employer in order to keep strict confidentiality. We collected a total of 1,028 responses, yielding an overall response rate of 54%. The number of responses returned from each class of driver attributes and its percentage is shown in Table 1. The survey samples consisted of 98% male and 2% female drivers. The majority of respondents were in the 30’s (35%) and 40’s (31%). A mean working years at the current companies was 7.8 (SD=7.8) with a mean occupational driver experience of 14.1 years (SD=9.4). A majority (78%) of respondents were employed by the companies for which they worked, i.e., regular employees.

### TABLE 1
**NUMBER OF QUESTIONNAIRE RESPONSES COLLECTED FROM 49 TRUCKING COMPANIES.**

<table>
<thead>
<tr>
<th>Age class</th>
<th>Regular employees</th>
<th>Non-regular employees</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>20’s</td>
<td>92</td>
<td>15</td>
<td>107</td>
</tr>
<tr>
<td>30’s</td>
<td>296</td>
<td>64</td>
<td>360</td>
</tr>
<tr>
<td>40’s</td>
<td>266</td>
<td>56</td>
<td>322</td>
</tr>
<tr>
<td>50’s</td>
<td>122</td>
<td>30</td>
<td>152</td>
</tr>
<tr>
<td>Older than 60</td>
<td>23</td>
<td>29</td>
<td>52</td>
</tr>
<tr>
<td>N/A</td>
<td>2</td>
<td>33</td>
<td>35</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>801</strong></td>
<td><strong>227</strong></td>
<td><strong>1,028</strong></td>
</tr>
</tbody>
</table>

**Incident statistics**

We collected actual incident records as safety outcome data, which were used for correlation analysis with driver satisfaction. Annual incident statistics between 2004 and 2008 were obtained from 21 companies surveyed. The incident statistics were calculated for each company as an annual rate per million kilometer driving distance for each of injury, non-injury and total incidents (sum of the former two), as well as total damage (money lost by incidents in Japanese yen; 1 USD was equivalent to about 83 JPY, Feb. 2011). These incident indices from all 21-company data are shown each in Table 2. None of these companies suffered a fatal accident during those five years, and all injury incidents were minor.

### TABLE 2
**INCIDENT STATISTICS COLLECTED FROM 21 COMPANIES**
**(FIGURE: THE NUMBER OF INCIDENTS OR DAMAGED COST PER MKM DRIVING DISTANCE).**

<table>
<thead>
<tr>
<th>Incident indices</th>
<th>2004</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
<th>'04~'08</th>
</tr>
</thead>
<tbody>
<tr>
<td>Injury incident</td>
<td>0.498</td>
<td>0.376</td>
<td>0.601</td>
<td>0.261</td>
<td>0.253</td>
<td>0.355</td>
</tr>
<tr>
<td>Non-injury incident</td>
<td>2.374</td>
<td>2.770</td>
<td>3.367</td>
<td>2.976</td>
<td>3.516</td>
<td>3.613</td>
</tr>
<tr>
<td>Total incident</td>
<td>2.872</td>
<td>3.145</td>
<td>3.969</td>
<td>3.237</td>
<td>3.769</td>
<td>3.967</td>
</tr>
<tr>
<td>Total damage (JPY)</td>
<td>1,654,441</td>
<td>954,176</td>
<td>1,720,162</td>
<td>1,052,477</td>
<td>1,222,340</td>
<td>1,330,943</td>
</tr>
</tbody>
</table>

**Analysis**

Principal component analysis (PCA) was applied to abstract the construct of employee satisfaction. Mann-Whitney test was used to examine differences by drivers’ attributes (age, experience, employee type) in terms of employee satisfaction. In addition, correlation analysis (Pearson’s r) was conducted performed to explore the linkage between employee satisfaction and safety outcomes.

**RESULTS AND DISCUSSION**

**Construct of satisfaction factors**

Principal component analysis using the Varimax rotation was applied to all responses to the satisfaction question items. The analysis results are summarized in Table 3. Four satisfaction factors were extracted with 63% of the cumulative variance accounted for. Eigen values for all the four factors were higher than 1.0. Cronbach’s alpha, was high enough, i.e., between 0.72 and 0.85 for each of the four factors, compared to a common acceptance level of 0.7 (Spiliotopoulos, 2009).
As for the first principal component, which explained 23% of variance, the following items were highly and positively loaded: “total hours spent at work”, “working system”, “work schedule” and “your current job”. All of these items are statements related to “work”. The other component items of this factor were associated with organizational issues such as “performance evaluation system”, “regular feedback on daily performance” and “salary including bonus”. Accordingly, we interpreted this principal component as “satisfaction with work and organization”. In this way, all four principal components were labeled based on highly loaded items as follows: satisfaction with (1) work and organization, (2) own competence, (3) training, and (4) vehicle.

### TABLE 3
SATISFACTION FACTORS ELICITED BY PRINCIPAL COMPONENT ANALYSIS

<table>
<thead>
<tr>
<th>Satisfaction factors</th>
<th>Items highly loaded (component items)</th>
<th>Loading</th>
</tr>
</thead>
<tbody>
<tr>
<td>I. Satisfaction with work and organization.</td>
<td>Q10. Total hours spent at work (restraint at work)</td>
<td>0.785</td>
</tr>
<tr>
<td></td>
<td>Q9. Working system (day &amp; night shift, etc.)</td>
<td>0.784</td>
</tr>
<tr>
<td></td>
<td>Q14. Work schedule (days-off, work days, etc.)</td>
<td>0.771</td>
</tr>
<tr>
<td></td>
<td>Q8. Your current job</td>
<td>0.650</td>
</tr>
<tr>
<td>[23% (23%)] α=0.85</td>
<td>Q15. Your company’s performance evaluation system for truck drivers</td>
<td>0.644</td>
</tr>
<tr>
<td></td>
<td>Q13. Regular feedback (or evaluation) on your daily performance from the management</td>
<td>0.564</td>
</tr>
<tr>
<td>II. Satisfaction with own competence.</td>
<td>Q12. Your own skills and ability in handling emergencies</td>
<td>0.845</td>
</tr>
<tr>
<td>[14% (38%)] α=0.82</td>
<td>Q11. Your own skills and ability in handling normal truck operations</td>
<td>0.844</td>
</tr>
<tr>
<td></td>
<td>Q5. Your own basic truck operation instructors’ skills for inexperienced employees</td>
<td>0.761</td>
</tr>
<tr>
<td>III. Satisfaction with training.</td>
<td>Q2. Safety training that you received within or out of the company</td>
<td>0.853</td>
</tr>
<tr>
<td>[14% (52%)] α=0.77</td>
<td>Q1. Your own basic truck operation training received in this company</td>
<td>0.837</td>
</tr>
<tr>
<td>IV. Satisfaction with vehicle.</td>
<td>Q6. Truck itself that you are driving</td>
<td>0.841</td>
</tr>
<tr>
<td>[12% (63%)] α=0.72</td>
<td>Q7. Maintenance of the truck that you are driving</td>
<td>0.810</td>
</tr>
</tbody>
</table>

**Correlations with safety outcomes**

In this section, we examine contributions of driver satisfaction to safety outcomes, using the incident statistics mentioned in Sec. 2.2. Selecting the eleven companies, each of which included ten or more questionnaire responses, we applied Pearson’s r to the eleven-company sample.

Pearson’s r and its significance level of each satisfaction factor are shown in Table 4, taking both the mean rate of injury incidents and the mean total damage (lost money) over the last five years as safety outcome measures. Significantly negative correlations of the rate of injury incidents were observed with satisfaction with own competence and driving vehicle. Taking the total damage as a safety outcome measure, significant correlations were also identified with training, in addition to driving vehicle. Driver satisfaction with work and organization was not observed significant impacts on safety outcomes, but its correlation coefficient with total damage was close to the ordinary significance level ($p=0.06$). Thus, it may be suggested that driver satisfaction with organizational issues such as vehicle and training as well as work and organization themselves contributes to actual level of safety in the trucking industry.
TABLE 4
CORRELATIONS OF SATISFACTION FACTORS WITH SAFETY OUTCOME MEASURES
(FIGURES: PEARSON’S $R$)

<table>
<thead>
<tr>
<th>Satisfaction factors</th>
<th>Injury incident (/Mkm)</th>
<th>Total damage (/Mkm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I. Satisfaction with work and organization</td>
<td>-0.449</td>
<td>-0.578</td>
</tr>
<tr>
<td>II. Satisfaction with own competence</td>
<td>-0.604</td>
<td>*</td>
</tr>
<tr>
<td>III. Satisfaction with training</td>
<td>-0.544</td>
<td>#</td>
</tr>
<tr>
<td>IV. Satisfaction with vehicle</td>
<td>-0.912</td>
<td>***</td>
</tr>
</tbody>
</table>

#: $p<0.10$; *: $p<0.05$; **: $p<0.01$; ***: $p<0.001$

CONCLUSION

The present paper uncovered construct of truck drivers’ satisfaction from the results of the questionnaire-based survey and its correlation with the five-year incident statistics. One of the major outcomes obtained in this study is to develop the construct of occupational drivers’ satisfaction. Driver satisfaction was suggested to be measured and assessed in the following four aspects: satisfaction with (1) work and organization, (2) own competence, (3) training, and (4) vehicle. In addition, we successfully identified significant correlations of their satisfaction to safety outcomes by use of the actual incident statistics. In particular, truck drivers’ satisfaction with vehicle was negatively correlated with the rate of injury incidents as well as total damage by incidents. Satisfaction with own competence and satisfaction with training were also significantly correlated with the rate of injury incidents and total damage respectively.

Based on the results obtained in this study, it is evident that the improvement of employee satisfaction might result in less injury incident involvement and total damage. Therefore, we would suggest the continuous measurement of employee satisfaction and its proactive use can be an effective tool for safety management in safety-critical organizations.

REFERENCES


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ABSTRACT

Journal rankings have been used as a mechanism to assist academic decision making. This paper complements the study by Theocharakis et al. (2007) and provides journal rankings for an extensive list of journals that publish Production and Operations Management (POM) research, based on the perceptions of researchers located worldwide. This list contains both academic and practitioner journals. Specifically, the paper provides rankings on journal quality and relevance based on a number of different factors including the nature of research work, society membership, research productivity, geographical location, and seniority. The findings clearly indicate that the above factors affect the way researchers perceive journal quality and relevance in the POM field. These results strengthen prior research that highlights the methodological and conceptual richness of the POM field and point towards the need to further investigate the underlying reasons behind this diversity.

KEYWORDS
Production, Operations, Management, Journal

INTRODUCTION

Driven by the expansion of academic research and scholarly activity in the POM discipline over the past few years, a number of journal evaluation studies have appeared in the literature (Barman et al., 1991, 2001; Soteriou et al., 1999; Vokurka, 1996; Goh et al., 1996). Despite of the methodology used — based either on peer perceptions (e.g. Saladin, 1985; Barman et al. 1991, 2001), citation analysis (Goh et al., 1996, 1997; Vokurka, 1996; Stonebraker et al., 2011) or some combination (Gorman and Kanet, 2005; Petersen and Aase, 2011) — these journal evaluation studies can be helpful in academic decision making, including the establishment of criteria for promotion, tenure and merit compensation.

An important limitation that most of these studies share, which is often a source of criticism, is that the diversity of POM research is rarely addressed in journal rankings. Some researchers have already acknowledged the existence of different “schools of thought” and different approaches within the field of POM, relating among others, to differences in research traditions, methods of research, qualitative vs. quantitative approaches and integration vs. reductionism (Drejer et al., 2000; Sanders, 2009). In a rhetoric essay, Meredith (2009) acknowledges the evolvement of the POM field “…from optimisation (artificial reality) to empirical positivism (other people’s reality) and now, apparently, interpretivism (direct reality)” (p.47). He concludes in his rhetoric that “…there is a role for all groups in the field” and that “…the natural roles of MS/OR, positivist, empiricism, and interpretivism will gradually emerge and feel much more natural and be easier to implement” (p.47). Existing journal evaluation studies rarely consider such important issues that directly
impact journal evaluation and assist researchers in the POM field to appreciate and understand the concerns and approaches of their colleagues.

In an attempt to do so, Theoharakis et al. (2007) examine journal evaluation differences that stem not only from methodological and philosophical differences, but also from other differences such as geographical location, professional society membership and the nature of research itself. Based on examination of 11 journals, they show that differences exist in the way journal relevance and quality are viewed by: (i) modelers vs. empiricists, (ii) researchers in different geographical regions, (iii) members and non-members of POM-related professional societies, and (iv) level of publication in a journal. Their study exposed the heterogeneity present within the POM community with respect to quality and relevance of journals, and concluded that this heterogeneity should be taken into consideration when using journal evaluation.

This paper presents findings that complement the study by Theoharakis et al. (2007) in a number of ways. Important work in POM has appeared in a wide spectrum of journals beyond the limited list shown in the Theoharakis et al. (2007) study. This paper presents rankings based on an expanded list of 41 journals that publish POM-related work. The rankings presented in this paper also include practitioner oriented journals that were excluded by Theoharakis et al. (2007). Often, POM-related research that appears in practitioner oriented journals affects decision making in the business community. The rankings presented in this paper further strengthen and highlight the findings by Theoharakis et al. (2007), which call for caution when using journal rankings given the heterogeneity present among the POM community. Most importantly, this paper helps colleagues in the POM field appreciate and understand different approaches and points of view, a prerequisite for strengthening cooperation and teamwork that leads to the creation of knowledge.

The rest of this paper is organized as follows: Section 2 briefly presents the research methodology followed, followed by our findings and a related discussion. Section 3 presents concluding remarks.

JOURNAL RANKINGS

Research Methodology

The research methodology for obtaining the rankings of POM journals is described in detail in Theoharakis et al. (2007). A survey instrument study was developed following the works of Barman et al. (1991) and Soteriou et al. (1999) as shown in Theoharakis et al. (2007). Researchers rated 41 POM-related journals on their relevance and quality. Respondents were also asked to identify their work as predominantly modeling or empirical in nature.

The study considered 11921 members of the main societies affiliated with the field of POM, namely INFORMS, the Decision Sciences Institute (DSI), the European Operations Management Association (EurOMA), and the Production & Operations Management Society (POMS), in 2002. After evaluating the responses, a total of 888 usable questionnaires were obtained in 52 countries.

Journal Rankings by Geographic Region

The overall (worldwide) results of the journal rankings for relevance are shown in Table 1 and for quality in Table 2. These tables present journal rankings as perceived by researchers in the three main geographic regions - North America, Europe, and Asia.

INSERT TABLES 1, 2 HERE

To test whether there were differences in the rankings across regions we examined the commonality and the correlation between the rankings of the top-12 and top-5 journals provided by each pair of regions. Commonality is measured by the number of journals common to a particular ranking set, for example, the top-5 or top-12, in each paired set of data examined. Each pair was tested for rank order correlations. Given the ordinal nature of the data, Spearman’s rho was used to test for significant correlations between rankings. The data in Table 3a show that for the top-12 journals there is high commonality and a significant correlation between the rankings provided by European and North American respondents, both in relevance and quality. A similar picture prevails regarding quality between Asia and the other two regions. When it comes to ranking the top-5 journals, there is high commonality between all pairs of regions, except for the case of relevance provided by North Americans and Asian researchers. For the case of quality, Management Science and Operations Research are ranked as the top two journals in all geographic regions, but differences are observed in the next three journals of the regional lists. For relevance, the differences are greater. For example, researchers in North America rank Management Science higher than Operations Research, whereas the reverse is true for European and Asian researchers.
America have ranked the *Journal of Operations Management* as the most relevant journal in the field, while European researchers have clearly showed a preference for *International Journal of Operations and Production Management*, by ranking it first.

In summary, we conclude that there are similarities in the way North American and European researchers rank POM journals in terms of quality and relevance (as evident from the commonalities in the top-5 and top-12 lists). However, although we don’t observe many differences regarding the content of the top of the lists, each journal is ranked differently by North American and European researchers.

### INSERT TABLE 3 HERE

Table 4 provides a single ranking of journals where both quality and relevance carry equal weights, an approach also followed by Soteriou et al. (1999). Journals that have received high ratings for relevance or quality maintain their positions in the top of the list. The journals of *Management Science*, *Journal of Operations Management*, and *Production and Operations Management* maintain their position in the top five, a finding consistent with that of Soteriou et al. (1999) and Goh et al. (1997).

### INSERT TABLE 4 HERE

#### Journal Rankings of Empirical Researchers vs. Modelers

There is considerable heterogeneity amongst research approaches in any discipline and Operations Management is no exception. To address this, we asked the participants in the survey to describe the majority of their work, either modeling or empirical in nature.

Tables 5 and 6 present journal relevance perceptions, while Tables 7 and 8 present journal quality perceptions of modelers and empiricists located both worldwide and in the three geographic regions of North America, Europe and Asia. A comparison of the information in these two tables reveals that there are differences in the way modelers and empiricists evaluate journals on relevance and quality.

Modelers located worldwide view *Manufacturing and Service Operations Management* as the most relevant journal, while as empiricists view the *Journal of Operations Management* as the most relevant one. Furthermore, modelers located worldwide view *Management Science* as the journal with the highest quality, where as empiricists place the *Journal of Operations Management* on the top of their quality list. Differences are also present among modelers and empiricists within regions. For example, modelers based in the US view *Manufacturing and Service Operations Management* as the most relevant journal, while empiricists located in the US place the *Journal of Operations Management* on top of their relevant list.

We examined the correlation between the rankings of the top-5 and top-12 journals for modelers and empiricists. The results in Table 3b show that there is low commonality and no significant correlations, providing evidence that empiricists and modelers rank journals differently for both relevance and quality.

### INSERT TABLES 5-8

It is also interesting to note that there are clear differences in journal rankings provided by empiricists and modelers in the middle and lower parts of the journal lists. In terms of quality, empiricists rated more highly many journals that are considered of high quality in other disciplines, such as the *Academy of Management Journal*, *Strategic Management Journal*, *Administrative Science Quarterly*, and *Organization Science*. On the other hand, modelers rated journals with strong quantitative content more highly than empiricists. The *European Journal of Operational Research* and the *International Journal of Production Economics* is a case in point: although ranked highly by empiricists it is ranked even higher by modelers. However, some journals, such as the *International Journal of Operations and Quantitative Management*, maintain their high position in terms of relevance both for empiricists and modelers.

We now examine whether these differences are sustained at the regional level. We examined commonality and rank order correlation of rankings of modelers and empiricists in each region (Table 3c). We observe that the number of common journals in the top-5 and top-12 lists is limited. However, modelers across regions appear to be consistent in their evaluation. For example, nine of the top ten journals ranked for quality are common for modelers in the three main geographic regions (Table 7), and the first ten journals ranked by modelers for relevance are common between North America and Europe (Table 5).
Journal Rankings by Society Membership

Journal relevance and quality ratings obtained by society members of INFORMS, DSI, POMS and EurOMA, appear in Tables 9 and 10. The data in Table 3d show high commonality for the top-12 journals and the presence of significant correlation between rankings for all societies on both quality and relevance. There are greater differences in the rankings of the top-5 journals. For quality these differences are confined to EurOMA whose rankings do not correlate with INFORMS or POMS. For example, IJOPM, which is the journal affiliated with EurOMA, is ranked higher by EurOMA members than by members of INFORMRS or POMS. This may reflect potential differences in research approach of European researchers from their North American counterparts (Drejer et al. 2000).

INSERT TABLE 9-10 HERE

Journal Rankings by Research Productivity

Earlier research suggests that only the most active researchers publish more than one refereed article per year in the Barman et al. (1991) list of journals (Young et al., 1996, p.53). To examine the perceptions according to research productivity, we used the following classification: (a) researchers with more than 1.51 articles per year on average, (b) between 1.01 and 1.5, (c) between 0.51 and 1.00, and (d) between 0 and 0.5. Journal perceptions for these four groups are shown in Tables 11-12. Following the approach discussed above, we examined commonality and rank order correlation, as presented in Table 3e. For the top-12 journals there is high commonality in all groups, a significant correlation between all groups on quality, but only some correlations in relevance. For the top-5 journals, the commonality is again high. It is interesting to note that eight of the ten most relevant journals are common to all four groups of researchers.

INSERT TABLES 11, 12 HERE

Journal Rankings by Academic Rank and Background

We investigated differences between rankings obtained by senior and junior researchers. Tables 13 and 14 present the relevance and quality ratings of the two groups. Analysis of commonality and rank order correlation (Table 3f) show that there is both high commonality and similarity of rankings between seniors and juniors in the top-12 journals. We note that for the case of journal relevance, the first 11 journals are common to both groups of researchers. There is also high commonality in the top-5 journals. In summary, the findings of the study suggest that there are no significant differences in the perceptions of senior and junior faculty regarding the relevance and quality of the journals of the POM field.

INSERT TABLES 13, 14 HERE

Tables 15 and 16 summarize the relevance and quality ratings by subject area of the highest academic degree of the respondents. Respondents have been classified in four groups whose highest academic degree is in Business Administration, Industrial Engineering (IE), Operations Research/Management Science (OR/MS) and POM. Analysis of commonality and rank order correlation (Table 3g) show different patterns for relevance and quality. For relevance there is high commonality among both the top-12 and top-5 lists. Strong rank order correlation also exists between all the groups in the top-12 list. This suggests that the relevance ratings of a POM journal obtained by researchers with a particular academic training are not different from those obtained by researchers of other academic training.

For quality there is a more complex pattern, although Management Science and Operations Research have been placed on the top of the list by all four groups of academics. However, differences exist in the top-12 list of the respondents whose background is business administration, and respondents with IE and OR/MS background. For example, while academics with a business administration and POM background place the Journal of Operations Management in the third and fourth positions, in the quality rankings, academics with an IE or an OR/MS background place it in the ninth and eleventh positions, respectively. In addition, academics with an IE or an OR/MS background have ranked Mathematics of Operations Research in the third place of the quality rankings. This points that the quality ratings of a POM journal obtained by researchers with a particular academic training could be different from those obtained by researchers of other academic training.

INSERT TABLES 15-16 HERE
CONCLUDING REMARKS

As research in POM expands globally, it is imperative to capture the heterogeneity of scholarly activity in journal evaluation studies, which are used as a mechanism to assist academic decision making. This paper complements the study by Theocharakis et al. (2007) and provides quality and relevance journal rankings for 41 academic and practitioner journals that publish Production and Operations Management (POM) research, based on the perceptions of researchers located worldwide. The paper provides rankings on journal quality and relevance based on such factors as the nature of research work (empiricist vs. modelers), society membership, research productivity, geographical location, academic background and seniority.

In line with Theocharakis et al. (2007) the findings suggest that the above factors affect the way researchers perceive journal quality and relevance in the POM field. In particular, differences exist in journal rankings provided by researchers in the three main geographical regions of the study, North America, Europe and Asia. Differences are also evident when one considers factors such as the nature of research (empirical vs. modeling), research productivity, society membership and academic background.

A classic criticism of studies that present journal rankings is that they myopically promote comparisons among journals based on a single dimension, that is the perception of the researcher. The contribution of this paper lies not in the presentation of journal rankings in the form of absolute numbers, but rather in capturing an overall “feeling” of the POM community for its journals. More importantly, the paper shows that such rankings are affected by a number of factors, including the ones mentioned above.

These differences may stem from a number of sources, including differences in research traditions, methodological approaches but also others that need to be identified. Regardless of the source of these differences, our research shows that these do exist; as a result, our emphasis should now turn not only towards understanding their sources, but also towards understanding and appreciating the heterogeneity that characterizes our field. Drejer et al. (2000) argue that different research traditions have much to learn from one another, which can lead to major breakthroughs and advances in the POM field. They also suggest a number of practical ways that this learning can be achieved. Our paper further highlights these differences and points towards the need of POM researchers to acknowledge and understand the work of our counterparts and distant ourselves from non-constructive criticism.

REFERENCES


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**TABLE 1: JOURNAL RELEVANCE RATINGS BY GEOGRAPHIC REGION.**
# TABLE 2

## JOURNAL QUALITY RATINGS BY GEOGRAPHIC REGION.

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**Table 3b.** Differences between modellers and empiricists overall.

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**Table 3c.** Differences between modellers vs. empiricists by region.

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**Table 3e.** Comparison between different publication rates.

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**Table 3f.** Seniors versus Juniors.

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**Table 3g.** Subject of first degree.

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** Spearman’s Rho significant at the .01 level.
* Spearman’s Rho significant at the .05 level.
### TABLE 4
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TABLE 16
JOURNAL QUALITY RATINGS BY HIGHEST ACADEMIC FIELD.

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<tr>
<th>Journal List</th>
<th>BUS Rank Mean # of Ratings</th>
<th>IE Rank Mean # of Ratings</th>
<th>ORMS Rank Mean # of Ratings</th>
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THE IMPACTS OF LEAN PRODUCTION ON SUPPLY CHAIN: IDENTIFICATION OF EXPERT OPINIONS BETWEEN EU AND THAI COMPANIES

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ABSTRACT

Lean production and sustainability of supply chains management has been adopted in Thailand for a period of time with small amount of research to assess the impact of Lean production on supply chains as opposed to manufacturing or distribution conducted, due to the inadequacy of quantitative data. Our study attempts to identify the impacts of Lean production on the sustainability of supply chains, investigate similar or different impacts caused by Lean production between European and Thai companies, and develop new policy measures to support sustainable distribution in Thailand. Qualitative and Quantitative data analyses are conducted in this study. Delphi survey technique for qualitative analysis is applied with online data survey to address two panels: 1) Thai expert panel and 2) EU expert panel, where major finding lies in the areas of: partner relationships, location, scheduling, cost, information technology, warehouse, delivery transport, and environmental impacts. Preliminary result of Delphi survey shows the importance of long term relationship between suppliers and manufacturers. As for quantitative analysis, Classification tree is implemented to identify key factors that impact panels’ decision for both Thai expert panel and EU expert panel. The result demonstrates different perspective between European and Thai companies such as ICT investment, Milk-run transport, empty run transport, inventory management, and relationship management.

KEYWORDS

Lean, Production, Supply Chain Management

INTRODUCTION

Lean Manufacturing was designed by Toyota in Japan during the 1950’s and 1960’s. Lean uses variety of techniques which are intended to eliminate all kinds of waste during the production process. Lean Manufacturing focus on customer needs by using the pull system. Thus, the waste can be eliminated and the response to customer is rapid. During the second half of the 20th century, Eastern innovations such as Just-In-Time (Sahoo, Singh et al. 2007) have become worldwide production systems in the automotive. JIT is a one of Lean techniques, which aims to minimize the inventory level by requiring a small batch size from suppliers. To ensure the quality of Lean production, the organization is required to create a long term relationship with trusted suppliers in order to form a reliable supplier network (Greasley 2009). Lean production in Thailand is generally implemented in manufacturing sector. The gross domestic product (GDP) in manufacturing sector since 1993 has grown from 32% to 40% of overall GDP in Thailand, which imply that Thailand’s economic has been driven by manufacturing sector, and thus, Lean production is an important key to success in Thai Manufacturing.

In 2015, ASEAN Economic Community (AEC) shall be integrated. To utilize the full advantage of AEC, a study regarding Lean production in Thailand comparing to Lean production in other Economic Communities and their transition period is necessary. European Union (EU) is one of the recognized unions in term of politics and economics. Therefore, EU would be a good candidate to conduct a comparison study regarding Lean production. Little research on
the significance of Lean production has been conducted in Thailand. Moreover, there is no research conducted to
compare the different impacts caused by Lean production between European and Thai company. To understand the
impacts of Lean production on supply chain in economic communities as well as prepare to shift into the AEC, this study
aims to investigate the concepts, issues, factors, and impacts of Lean production on the supply chain in the developed
(Europe) and developing (Thailand). The scope and focused of this study lie on the impact of Lean production on supply
chain in transport sector. Two main phases which are 1) the investigation of the impacts of Lean production on supply
chain, and 2) the investigation similar or different impacts caused by Lean production between European and Thai
companies are included in this study. In the first phase, the literature review reveals the impacts of Lean production on
supply chain. Delphi method was adopted to gather opinions from the expert. Internet survey was conducted to collect
expert opinions from different locations. In the second phase, classification analysis, one of the most widely used
classification analysis, was employed to identify key factor of Lean concept.

DATA COLLECTION

Online questionnaires were sent to Delphi panel. Kaplan et al. (1950) defined Delphi panel as a person who has
reputation, influence, and skills in managing interpersonal. In this study, a listed of Delphi panel in EU is obtained from
Newrail contact list while listed of Delphi panel in Thai is obtained from Thai logistic directory (2007,2008). Since our
study interest in impact of Lean production on supply chain, the Delphi panel list is drawn from experts involve in freight
and logistics, automotive manufacturers, 3PLs, consultants. From the first round Delphi, 33 EU experts and 31 Thai
experts expressed their opinions on the impacts of Lean production on supply chain where the EU panel composed of
experts in transport services or regulation (33%), academics (23%), rail and transport industry (12.5%), and automotive
(10.0%) while the Thai panel composed of experts in automotive (56%), academics (12%), rail and transport industry
(9%) and transport policy (9%). Note that, there is no standard requirement for the size of Delphi panel. Dalkey and
Helmer (1963) stated that the minimum requirement for panel size lies between 15 to 20 members while Tersine and
Riggs (1976) suggested that, to deliver effective results, a number of panel members between ten and fifteen is
satisfactory.

METHODOLOGY

Overview

As stated earlier, the main purpose of this study is to investigate the concepts, issues, factors, and impacts of
Lean production on the supply chain in the developed (Europe) and developing countries (Thailand). The proposed
approach consists of two main steps: (1) The first round Delphi survey and (2) Classification Tree.

In the most applications of Delphi survey, the first round survey conducts with open questions where answers
and comments are invited. The steps in of first round Delphi survey are as followed: 1) design a team to attempt and
monitor Delphi on a given subject, 2) select panels associated with the observation, 3) develop the first round
questionnaire, 4) test the questionnaire, 5) distribute the questionnaire to panelist, and 6) analyze the first round
responses. If consensus is reached in both panels, there is no further step required. Otherwise, feedbacks of first round
survey are reformulated and used as input to a classification tree. A classification tree algorithm was employed to
investigate questions used to discriminate specific criteria, i.e. EU vs. Thai, position of panel members, business
categories.

Delphi survey

The Delphi technique is a group communication among an expert panel. The technique allows experts to share
their opinion with a complex problem or task. It includes a series of questionnaire survey sent either by mail, email or via
online survey tools. The questionnaires are conducted to obtain and expand individual responses to the problems posed
(Adler and Ziglio 1996). The main purpose of most Delphi application produces the valuable information to for decision-
making.

The first round questionnaire is in the mixed form of open-ended and close-ended style, a semi-structured
questionnaire. Open-ended question allow participants to explain and describe their opinion in full detail. This allows the
panel members to give their expert opinions on the subject. Nevertheless, a closed-ended question is necessary in this
research in order to obtain quantitative data. The questionnaire consists of three sections. Section I is collection of
personal information which is disclosed due to the confidentiality agreement, however; it is necessary to collect this
information for validation purpose. Section II is the identification of Lean production implemented in the industry sector. Section III is the verification of factor effected supply chain.

Typically, feedbacks of the first round survey are summarized and used to conduct the second round survey. However, the major disadvantages of Delphi survey are such that it does not demonstrate a strong analytical position. Goldschmidt (1975) and Wellington (2003) stated that the validity of Delphi techniques has never been scientifically demonstrated as the result of analysis is not base on traditional empirical methodology. Delphi technique processes without theory and that it focuses on consensus irrespective of historical truth. Thus, this study proposes the use of classification tree as additional tool to analyze the second round Delphi survey data. Classification tree demonstrates a strong analytical ability in order to evaluate expert opinions.

**Classification Tree**

Classification tree is one of the widely used classification methods that partitions the input (feature) space into disjoint hyper-rectangular regions according to performance measures such as misclassification errors, Geni index, and cross-entropy and then fit a constant model in each disjoint region (Breiman 1984). Consider a classification problem with categorical response \( Y \) and inputs \( X_1 \) and \( X_2 \), the recursive binary partitions split the first space into two regions. Variable and split-point are selected to achieve the best fit. Then one or both of these regions are split into two more regions, and this process is continued, until some stopping rule is applied. Majority class of each node models the response in each terminal node. The corresponding classification model predicts \( Y \) as the majority class in node \( m \) (in region \( R_m \)), that is,

\[
\text{class } k(m) = \arg \max_k \hat{P}_{mk} \tag{1}
\]

\[
\hat{P}_{mk} = \frac{1}{N_m} \sum_{i \in R_m} I(y_i = k), \tag{2}
\]

where \( \hat{P}_{mk} \) represents the proportion of class \( k \) observations in node \( m \) and \( N_m \) represents number of observations in node \( m \) (Hastie, Tibshirani et al. 2009).

The best binary split is typically found in term of total minimum of node impurity. For a given node \( m \) and splitting point \( t \), we define a pair of the binary partition as

\[
R_1(j,s) = \{ X \mid X_j = t \} \quad \text{and} \quad R_2(j,s) = \{ X \mid X_j \neq t \}. \tag{3}
\]

Then we seek to find the splitting variable \( j \) and split point \( s \) that solve

\[
\min_{j,s}\left[ \min_{k \in R_1(j,s)} \sum_{x \in R_1(j,s)} Q_1(j,s) + \min_{k \in R_1(j,s)} \sum_{x \in R_2(j,s)} Q_2(j,s) \right] \tag{4}
\]

where \( Q_1 \) represents different measures of node impurity. In this study, the Gini index is selected because of differentiable property which amends to the numerical optimization and the Gini index are more sensitive to changes in the node probabilities than the others

\[
\sum_{k \neq k'} \hat{P}_{mk} \hat{P}_{mk'} = \sum_{k = 1}^K \hat{P}_{mk} (1 - \hat{P}_{mk}). \tag{5}
\]

**RESULT AND DISCUSSION**

**Result from Delphi survey**

The first round responses were analyzed in the following way. First, the average percentage of majority opinions (APMO) was calculated as

\[
\text{APMO} = \frac{(D_a + D_d)}{D_t} \times 100 \tag{6}
\]

where \( D_a \) represents aggregate of majority agreements, \( D_d \) represents aggregate of majority disagreements, and \( D_t \) represents total opinion expressed including unable to comments in order to determine whether consensus has been reached. The APMO of EU and Thai surveys for the first round are approximately 64% and 73%. The result from the first round survey can be grouped into five categories as: partner relationship, location management and planning and scheduling, cost and information technology, warehouse and transportation delivery, and environmental impacts. Table 1
illustrates the result of expert opinions for partner relationship. For example, 65% of EU panel agree on statement-1. Since this number is higher than APMO for EU panel (64%), it can be say that EU panel reach consensus on statement-1. Similarly, 90.32% of Thai panel agree on statement-1 with higher percentage than APMO 73%), thus; Thai panel also reach consensus on statement-1. Because both EU panel and Thai panel are agree upon statement-1, there is no further analysis required. For statement-4, both panes reach their individual consensuses, but the consensuses are a strong contradiction between EU panel (agree) and Thai panel (disagree). Such case is considered as contradicition consensus and required no further analysis as well. In addition, EU panel disagree upon statement-2 while Thai panel disagree upon statement-3. Since both panels do not reach consensus for a given statement, further analysis required. Due to page limitation, the result for all five categories of the first round Delphi survey can be obtain from (Sriariyawat and Zunder 2010)

<table>
<thead>
<tr>
<th>TABLE 1</th>
<th>ANALYSIS OF EXPERT OPINIONS FOR PARTNER RELATIONSHIP (FIRST ROUND)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Statements</td>
<td>EU panel (APMO 64%)</td>
</tr>
<tr>
<td></td>
<td>Agree (%)</td>
</tr>
<tr>
<td>1 Long term supply relationships are essential for implementing Lean concept.</td>
<td>65</td>
</tr>
<tr>
<td>2 Multinational companies do not trust local suppliers.</td>
<td>14.71</td>
</tr>
<tr>
<td>3 Local suppliers do not trust multinational companies.</td>
<td>20.59</td>
</tr>
</tbody>
</table>

There are 18 statements developed for the first round Delphi survey. Six statements reach the similar consensus level by both EU panel and Thai panel while one statement reaches the contradict consensus. Six statements reach a consensus either on EU panel and Thai panel. Five statements do not reach consensus neither on EU panel or Thai panel. Therefore, there are 11 statements reformulated in the second stage analysis.

**Classification Tree**

11 statements from the first round survey were developed into 38 new statements (appendix A). The questionnaires were sent to similar group of experts. Only 20 questionnaires were response from EU panel and 29 responses from Thai panel for a total of 49 responses. Classification tree attempts to identify statements which affect expert decisions. Three models are proposed: 1) Regional Classification, 2) Occupation Classification.

**Regional Classification**

Regional classification identifies the statements that affect EU and Thai expert’s decisions. Regional Classification employs response from each question to construct a classification tree model. Three different responses can be chosen for a given question: agree, disagree, and unable to comment as quotes as 1, 0, and 2 in classification tree, respectively. Figure 1A illustrates the result of regional classification model. Each node of tree specifies conditions that split an existing region. For example, the first split appears by statement-6 (x6 in Figure 1A). The respondents who agree to this statement (x6 = 1) are partition into one group while the respondents who disagree or unable to comment on this statement (x6 in 0, 2) are partition into another. The process repeated iteratively until the final regions which are specified by the terminal nodes (black dots in Figure 1) of the tree are obtained. We can determine the criteria for each terminal node by backtracking up the tree to the top node. For instance, if the respondents agree to statement-6 and disagree on statement-1 (x1 = 0), it can be concluded that the respondents are member of EU panel (labeled “2” at the terminal node). On the other hand, if the respondents agree to statement-6 but unable to comment or agree on statement-1 (x1 in 1, 2), it can be concluded that the respondents are member of Thai panel (labeled “1” at the terminal node). The regional classification model identifies 30 responses as Thai panel and 19 responses as EU panel. This implies that there is one EU panel member misclassified as Thai panel member with 2.04% classification error.
Occupation Classification

Establishing Lean production required similar understanding of Lean concept from all company members. The occupation classification model identifies important statements which separate panel into three groups. Top directors are labeled as “1” in the terminal node. Managers are labeled as “2” while operators are labeled as “3”. The importance of selected statements is that they are partition company members into groups based on responses from a particular statement. Since similar understanding of Lean concept is required, the selected statements are those that organization should focus on ensuring similar understanding in all organization members. The importance of statement can be rank as highest in the top node and reduced down as the tree continues splitting. Figure 1B illustrated the important statements from highest to lowest as: statement-18, statement-34, statement-28, statement-29, statement-19, statement-3, statement-36, statement-27, and statement-22.

FIGURE 2
OCCUPATION CLASSIFICATION TREE
CONCLUSION

This study attempts to identify the factors affect differences in expert opinions between EU panel and Thai panel. The analysis shows that the trust between multination company and local supplier, and the inventory level in Lean production are important factors that discriminate expert opinions between EU panel and Thai panel. In addition, establishing Lean principles and suppliers relationships with or without ICT investment is a major contradiction. The organization needs to ensure that all organization members have similar understanding in this aspect.

REFERENCES


APPENDIX

Second round Delphi statements

Original statement: Multinational companies do not trust local suppliers.
1. A service level agreement is important factor for partnership.
2. A limited knowledge of Lean/supply chain concepts affect the reliability of local suppliers.
3. Multinational companies do not trust small companies.
4. Sometimes, multinational companies take advantage of local suppliers.
5. All companies need to vendor assess their suppliers and have a strong auditing process in place wherever they are.

Original statement: Local supplies do not trust multinational companies.
6. Local suppliers trust larger multinational companies more.
7. The quality of product from multinational sources is higher quality than locally sourced.
8. It is difficult to audit multinational companies.
9. Personal relationships can be more important in business than cost, quality and efficiency.

Original statement: Distance between producer and supplier location is not important to the implementation of the Lean concept.
10. It is not the geographical distance that matters but fast and frequent connections between the partners.
11. The closer the better as it makes the logistic of moving materials more predictable therefore reducing waste.
12. Lean is a workforce culture. It may be harder to implement the further the distance.

Original statement: A foreign supplier is more trustworthy than a domestic supplier.
13. Financial status of supplier is more important than nationality.
14. International suppliers from developed countries are more reliable than local suppliers.
15. It is more important that supplier and producer must be developed together than nationality.
16. Communication is an important factor of trustworthiness.

Original statement: Lean production does not need extra investment in new information technology.
17. The extra investment should be given if required as it may reduce cost in the long term and tighten up processes.
18. Lean principles and suppliers relationships can be established without additional ICT investment.

Original statement: Only a small level of inventory is needed to support Lean production.
19. It depends upon real demand variability.
20. Inventory can be reduced by good communication, short transport distances and repeatable quality.
21. It depends upon the complexity of product.
22. Lean inventory management means zero stock.
23. Due to uncertainty of production process, unstable delivery times, the company should collect a small inventory level.

Original statement: Lean production requires more frequent supply.
24. More frequent supply could drive up cost.
25. Small lot size requires high frequency supplies.
26. Synchronized planning is required for reducing frequent supply.

Original statement: Lean production causes more partially empty transport trips.
27. A milk-run concept can be applied for several pick-ups in a trip and optimise the transport trips.
28. Vehicle size for transport can be reduced therefore a lower transport cost.
29. In real situation, there are a lot of empty run back from delivery.

Original statement: Lean production requires higher transportation cost than traditional mass production.
30. Initial investment might be increased and overall production cost higher than traditional mass production.
31. Lean creates a clear logistic plan and cost reduction planning.

Original statement: Rail transport is not suitable for Lean production in your country.
32. The slow and non integrated railway system in our country makes rail transport for Lean production unsuitable.
33. Railway network is not connected to areas of manufacturing.
34. Rail transport is able to help Lean implementation but should have intermediate depots or external warehouse to stock the parts.

**Original statement: Small and medium enterprise (SMEs) cannot support the costs for reducing environmental impacts.**
35. Establishing a SME group or network can solve empty run deliveries.
36. Size of company is not a matter for reducing environmental impacts.
37. SMEs can contribute in a smaller proportion than big companies.
38. SMEs are mostly devoted to their core businesses not environmental concerns.
GREEN-PRODUCT RETURN SUBSIDY ON DESIGN AND REVERSE MANUFACTURING IN A CLOSED-LOOP SYSTEM

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ABSTRACT
In this paper, we propose a revenue management model with considering a subsidy policy for green products. The remanufacturer makes and sells the remanufactured products in the primary markets and the refurbished products in the secondary market, respectively. In particular, the remanufacturer offers subsidies as a means to promote recycling activity. The collection volume of returned products is proportional to the subsidy that is paid solely to the customers. A numerical example and sensitivity analysis on the optimal results are presented to validate the results of the proposed model. Finally, we find that the introduction of subsidies increases remanufacturing activity and the remanufacturer’s profits.

KEYWORDS
Revenue Management, Subsidy Policy, Remanufactured Products

INTRODUCTION
Remanufacturing is an industrial process where used products are restored to “as-new quality”. Used products are typically collected from numerous sources. The used products then undergo a remanufacturing process involving various remanufacturing operations, such as inspection, cleaning, disassembly, component reprocessing, reassembly, and testing. Then, the remanufactured products are distributed to numerous customers. Due to a number of regulations and international proposals, such as the European Union’s proposal for a directive on Waste Electrical and Electronic Equipment (WEEE), several manufacturers seeking to reduce product recovery and remanufacturing costs have begun modifying product designs and incorporating product reuse concepts into the original product and component design. Additionally, several countries at all levels are developing waste handling prohibitions, regulations, and/or incentive programs to encourage alternative disposal methods for electronic waste. Such policies ensure the producer and consumer have greater responsibility for the safe disposal of products.
In 1996, Ford avoided disposing of more than 67,700 pounds of toner cartridges, saving US$180,000 in disposal costs. Xerox earned over US$80 million by implementing a remanufacturing program in 1997, and is a successful example of the benefits of remanufacturing. Ayres et al. presented several examples and potential remanufacturing processes and their benefits for both the companies and society. Studies have shown that the unit cost of remanufacturing can be approximately 40 to 60% of the original product’s unit manufacturing cost in some industries. In addition to 14 million tons of material savings annually worldwide, an estimated 120 trillion BTUs/year of energy are saved from remanufacturing globally, accounting for approximately 16 million barrels of crude oil and approximately US$500 million in energy costs. This indicates that the value remaining in used products may reach significant levels.

Financial incentives offered to product holders or buy-back campaigns, as mentioned by Klausner and Hendrickson, influence the quantity of returns and thus, numerous companies offer financial incentives to collect more used products. As mentioned by Guide and Jayaraman, offering the correct incentive amount is crucial for a company to ensure a sufficient number of used products for remanufacturing. In addition, several companies are establishing more collection centers near to customers to collect more used products. Though several studies acknowledge the significance of effective incentive mechanisms in the success of remanufacturing and product recovery businesses, very few analytical models consider incentive determination. Savaskan et al. focused on determining the best reverse channel structure to collect product returns. They considered three options for collecting used products: (1) Directly from customers; (2) utilizing retailers; and (3) subcontracting the collection activity to a third party. They assumed deterministic demand and return rates to be functions of prices and incentives, and analyzed how closed-loop supply chain structures influence the incentive to invest in used-product collection and the product return rates. Literature focusing on remanufacturing and closed-loop supply chains is increasing. However, only a minor portion of this literature considers incentive determination. Aras and Aksen developed a mixed-integer nonlinear facility location–allocation model to determine the optimal locations for the collection centers and the optimal incentive values to offer. They developed heuristic algorithms to solve these problems. Aras et al. also considered a similar problem under a pick-up policy assumption. A generic picture of a remanufacturing system is shown in Fig. 1 that is extended from Srivastava.

This study differs from the above studies in the following aspects. Unlike the models assuming a constant demand and qualified rate, we address the more realistic issue of remanufacturing and collection by modeling both the demand and qualified rate as random. Such an implicit assumption is reasonable considering poor-quality items do exist in the collected returns; they are usually identified during the screening process and withdrawn from stock instantly. At the remanufacturing plant, the returned and used items collected by the environmental protection service industries are inspected, tested, and sorted into two groups; the items that qualify proceed to remanufacturing, and the imperfect items are discarded. During remanufacturing, the part must be completely disassembled, cleaned, and examined for wear and damage. Dilapidated, missing, or non-functioning components are replaced with new or rebuilt components. Once the inspection and replacements are completed, the part is reassembled and tested for compliance with performance specifications. Then the remanufacturer sells the “good as new” remanufactured items in the relevant markets. Remanufacturers offer subsidies to promote recycling; and the collection volume of returned items is proportional to the subsidy that is paid to the customers. For remanufactured items, the probability of selling is expressed as a decreasing function of price and availability, thus, not all units will be sold. The assumption is that as availability increases, the probability of selling individual items decreases. Given the problem’s definition, the objective is to determine the optimal unit selling price of the remanufactured items and the optimal unit subsidy of returned items to maximize total profits.
FIGURE 1
BASIC FLOW OF REVERSE LOGISTICS ACTIVITIES

MODEL DEVELOPMENT

The following notations are used:

- $R$ = the return subsidy ($/unit)
- $X$ = the price of the remanufactured item ($/unit), \(0 < R < X\)
- $P$ = the maximum price of the remanufactured item ($/unit$)
- $Y$ = number of collected returns
- $Y_p$ = annual remanufacturing capacity of the manufacturer
- $Y_d$ = the number of defective items
- $z$ = the qualified rate in $Y$
- $f(z)$ = the probability density function of $z$
- $K$ = sensitivity parameter
- $m$ = the remanufacturing cost per item ($/unit$)
- $r$ = the salvage value per defective item ($/unit$), \(r < X\)
- $ETP$ = the expected net profit of remanufactured items

The mathematical models presented in this study have the following assumptions:

1. The unit subsidy paid to customers is $S$, whether the return commodity is new or not.
2. The collection volume $Y$ is proportional to the subsidy, $Y = Y(R) = a + b \cdot R$.
3. The defective items exist in lot size $Y$. The qualified rate, $z$, has a uniform distribution with $[\alpha, \beta]$, where \(0 < \alpha < \beta < 1\).
4. The quality of the remanufactured item equals that of a new item.
5. The price of a remanufactured item is less than that of a new one, \((R < X)\).
6. For remanufactured items, the probability of selling is expressed as a decreasing function of price and availability, thus, not all units will be sold.

In this model, the collected returns are represented by $Y$, which is determined by $Y = Y(R) = a + b \cdot R$; $a$ is the scale parameter and $b$ is the subsidy sensitive parameter. The expression shows that the recycled amount is a linearly increasing function of subsidy. The minimum available volume is $a$ when $R=0$; the maximum available volume is $Y_p$ when $R_p \leq R$. 

---

**Footnotes:**

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The probability of selling a remanufactured item, $\psi$, is provided by \((1 - \frac{X}{P}) \cdot (1 - \frac{z \cdot Y}{K \cdot Y_p})\), where $P$ is the maximum price that can be charged before the probability of selling becomes zero. The expression for the demand for remanufactured items shows that the number of unsold remanufactured items increases nonlinearly with price but exponentially with availability. Hence, the availability of remanufactured items has the same impact as the price on the probability of selling. Demand for remanufactured items or the expected number of sales $Y_m$ is obtained by

$$Y_m = (1 - \frac{X}{P}) \cdot (1 - \frac{z \cdot Y}{K \cdot Y_p}) \cdot z \cdot Y \cdot X$$

The total profit is constructed by the following formula:

$$\text{Total profit} = \text{the revenue for sold remanufactured items} + \text{the salvage value of defective items} - \text{the remanufacturing cost for return items} - \text{the total return subsidy}.$$
NUMERICAL RESULTS

The parameters are as follows: the maximum unit price of remanufactured item, $P = $90/unit; annual capacity of the remanufacturer, $Y_p = 200$ units; sensitivity parameter, $K = 1$; remanufacturing cost, $m = $5/unit; the salvage value of per defective item, $r = $0.5/unit; the scale parameter, $a = 100$; the sensitive parameter, $b = 50$; the percentage qualified random variable, $z$ can take any value in the range $[\alpha, \beta]$ with $\alpha = 0.5$, and $\beta = 0.7$. It is assumed that $z$ is uniformly distributed with its p.d.f. as

$$f(z) = \begin{cases} 5, & 0.5 \leq z \leq 0.7, \\ 0, & \text{otherwise.} \end{cases}$$

The optimal with/without using the Return-Subsidy policy are summarized in Table 1. By solving Eq. (2) with KKT conditions, the optimal solution is: $X^* = $35/unit, $R^* = $1.20/unit. The number of collected returns is: $Y^* = 140$ units. Demand for the remanufactured items is: $Y_{m*} = 31$ units. The expected total profit per year is $725$ and the percentage of profit increase (PPI) is 18.76%. The three-dimensional expected total profit graph is shown in Fig. 2.

<table>
<thead>
<tr>
<th>Description</th>
<th>NRS policy</th>
<th>Result from our model</th>
</tr>
</thead>
<tbody>
<tr>
<td>$X^*$</td>
<td>35.0</td>
<td>35.0</td>
</tr>
<tr>
<td>$R^*$</td>
<td>N.A.</td>
<td>0.75</td>
</tr>
<tr>
<td>$Y^*$</td>
<td>80</td>
<td>80</td>
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<tr>
<td>$Rev^*$</td>
<td>1188</td>
<td>1189</td>
</tr>
<tr>
<td>$ETP^*$</td>
<td>589</td>
<td>489</td>
</tr>
<tr>
<td>$PPI$ (%)</td>
<td>-20.45</td>
<td>-8.87</td>
</tr>
</tbody>
</table>

NRS: the No-Using-Return-Subsidy policy; {} : base column; $PPI$: percentage profit increasing = ($ETP^* - ETP_{NRS}^*) / ETP_{NRS}^*.$

FIGURE 2

GRAPHICAL REPRESENTATION OF A CONCAVE ETP (WHERE $X^* = $35/UNIT, $R^* = $1.20/UNIT).
SUMMARY AND CONCLUSION

In this paper, we propose a remanufacturing model considering a Return-Subsidy policy where the returns amount depends on an incentive offered by the manufacturer. We determine the optimal value of the incentive to offer and the optimal selling price of remanufacturing products in a demand expressed as a decreasing function of price and availability. We have discussed in this paper a pricing model in the context of recycled item, with numerical examples and sensitivity analysis, to maximize the expected profits. As the backordering cost tends to infinity, it is shown that the traditional EOQ and Salameh and Jaber’s modified EPQ/EOQ model are both special cases of our model. Comparative studies in the example show that the expected net profit per year using our model is usually more. Numerical computations show that for all backordering cost \( (b) \) value less than infinity, the percentage profit increasing (PPI) of our model is always greater than zero. This shows the significant of our model.

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REFERENCES


A FINITE CAPACITY MATERIAL REQUIREMENT PLANNING FOR ASSEMBLY JOB SHO

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ABSTRACT

This paper presents a development of practical finite capacity material requirement planning (FCMRP) system for assembly job shop. The proposed FCMRP system is divided into two main parts. First, scheduling rule, priority rule and allocating method are used to determine the sequence and schedule of operations. Second, a linear programming model is used to determine the optimal start time of each operation to minimize the weighted average of total tardiness, total earliness and average flow-time, considering finite capacity of all work centers and precedence constraints of operations. The proposed FCMRP system is tested using an experimental case. Statistical analyses show that important factors, namely, scheduling rule, priority rule, allocating method, and overlapping of batches have significant effects on scheduling performances of the system.

KEYWORDS

Finite Capacity Material Requirement Planning, Scheduling, Optimization, Assembly Job Shop, Linear Programming

INTRODUCTION

One of the well-known production planning and inventory control (P&IC) technique is material requirement planning (MRP), which is used for production planning in discrete part manufacturing. A main objective of the MRP philosophy is to generate the production and purchasing plans according to the customer's demand. So far many features have been integrated to the MRP system that called Enterprise Resources Planning or ERP. However, MRP has a serious drawback in performance especially ignoring capacity and shop floor conditions. Consequently, the production plan from the MRP system may be infeasible. Wuttipornpun and Yenradee [1] stated that there are two main factors that make the MRP system unsuccessful. First, the MRP II system assumes constant production lead times. In practice, the lead times are variable and depend on many factors: for example, the production lot-size, load level of work centre, and job priority. Second, the MRP II system assumes infinite capacity of machines. The production planner has to solve capacity problems manually using other scheduling techniques such as Shop Floor Control (SFC). Taal and Wortmann [2] and Bakke and Hellberg [3] concluded that the SFC system is unable to solve the capacity problems, which are created at the material requirement planning (MRP) calculation stage. They also suggested that the capacity problems should be prevented at the MRP calculation stage using an integrated approach of MRP and finite capacity scheduling. Thus, the finite capacity material requirement planning (FCMRP) system has been developed to solve the capacity problems.

In the area of FCMRP system, the related literature can be classified into two main approaches namely, optimization and non-optimization approaches. The reviews of the optimization approach are as follows. Nagendra and Das [4] presented the MRP progressive capacity analyzer (PCA) in which finite capacity planning and lot sizing are performed concurrently with the MRP bill of material (BOM) explosion process. Wuttipornpun et al., [5] proposed linear programming model to determine the optimal start time of each operation to minimize the weighted average of total earliness, total tardiness, and average flow-time considering the finite capacity of all work centers and precedence of operations.

The non-optimization related works are presented as follows. Harl and Ritzman [6] designed a relatively simple heuristic algorithm to make MRP systems more sensitive to capacity limitations. Simulation results show that the algorithm which is an extension to MRP logic significantly helps overall performance, particularly for customer service. Pandey et al., [7] developed FCMRP algorithm to capacity-based production plans which is executed in two stages.
Firstly, capacity-based production schedules generated from the input data. Secondly, the algorithm produces an appropriate material requirements plan to satisfy the schedules obtained from stage one. Wuttipornpun and Yenradee [8] presented FCMRP system for assembly operations. The proposed FCMRP system can automatically allocate some jobs from one machine to another and adjust timing of the jobs considering a finite available time of all machines. Wuttipornpun and Yenradee [1] developed FCMRP system using heuristics based on schedules of the bottlenecks to adjust release and due dates to ensure capacity feasibility. Furthermore, Wuttipornpun and Yenradee [9] also proposed another FCMRP system which is developed based on TOC philosophy (TOC-MRP) for multi-stage assembly factory that has some bottleneck stations. The proposed TOC-MRP system tries to load and schedule operations on bottleneck stations in a manner that they are free of idle time and overtime.

This paper aims to develop FCMRP system for assembly job shop operation. The proposed FCMRP system is divided to two main parts. First, scheduling rule, priority rule and allocating method are used to sequence the operation effectively. Second, a linear programming model is used to determine the optimal start time of each operation to minimize the weighted average of total tardiness, total earliness and average flow-time, considering the finite capacity of all work centers and precedence constraints of operations.

The objectives of this paper are as follows:
1. To develop a new practical FCMRP system for job shop with assembly operation that can be applied in a real industrial situation.
2. To analyze performances of the developed FCMRP system.

THE PROPOSED FCMRP SYSTEM

The proposed FCMRP system is designed to handle industries with the following characteristics:
- There are multiple products.
- Some products may have assembly operations. Other products may require only fabrication without an assembly operation.
- All parts can be produced by one of two alternative work centers (the first and second priority work centers).
- The structure of a production shop is a job shop with assembly operations.

A block diagram of the proposed FCMRP system is shown in Fig 1. The algorithm is described step-by-step, using a sample data of 6 finished goods, 24 operations, and 4 machines as shown in Table 1, as follows.

Generation of production and purchasing plans using variable lead-time MRP system

The production and purchasing plans are initially generated by the MRP system called Thai SME Production and Inventory Control system (TSPICs). TSPICs has been developed by Sirindhorn International Institute of Technology and implemented in some factories in Thailand. The release time of operations is calculated from the due date minus the total lead-time considering a detailed work calendar of the factory. Thus, the release time of operations from TSPICs is more realistic than that of the conventional MRP system. The release date and time of each operation is calculated using formulas (1) and (2).

\[
\text{Lead-time} = \text{Unit processing time} \times \text{Order quantity} + \text{Set up time} + \text{Set up time}
\]
\[
\text{Release date/time} = \text{Due date/time} - \text{Total lead time}
\]
Note: The set up time does not include a waiting time

Allocate operations to the first priority work centers

The operations may be performed by more than one work center. The most efficient or most appropriate work center is called the first priority work center, and the next most appropriate one is the second priority work center. The aim of this step is to check the capacity requirement on each work center when operations are scheduled on the most appropriate work centers. There are two proposed methods to schedule the operations on the first priority work centers. The first one is to sequence the operations based on their released dates (SR method). The second one is to sequence the operations based on their due dates (SD method). SR and SD methods determine the sequence as shown in Tables 2 and 3, respectively.
FIGURE 1
BLOCK DIAGRAM OF THE PROPOSED FCMRP SYSTEM

1. Generate production and purchasing plans using variable lead-time MRP system
2. Allocate operations to their first priority work centers
3. Rearrange operations that allocated on the same day using priority rules
4. Allocate tardy operations to their second priority work centers, if possible
5. Determine the optimal start time of each operation by the LP model

FIGURE 2
BILL OF MATERIAL
Rearrange operations allocated on the same day by priority rules

There are two priority rules under consideration, namely, earliest release time (ERT) and earliest due time (EDT). The ERT rule will perform the operation with earliest release time first and perform the operation with relatively late release time later. Similarly, the EDT rule will perform the operation with earliest due time first and perform the operation with relatively late due time later. If there are some operations which have the same release time (or due time) on the same day, the sequence of these operations can be determined arbitrarily. The sequence of operations obtained from SR method and ERT rule is shown in Table 4 and the complete schedule in Gantt chart form is shown in Fig. 4.
Note that the operation B2 is done before E3 since B2 has earlier release time than E3 although they have the same release date. The tardiness of each operation is shown in parenthesis over the operation.

**Allocate the tardy operations to the second priority work centers**

After schedule all operations to the first priority work centers, the operation that is completed later than its due date is called a “tardy operation”. This step tries to reduce capacity problems in the first priority work center by moving the tardy operations to their second priority machines. There are two allocating methods. Method 1 does not allow the operation to be started before its release time while method 2 allows it to be started before its release time. Both methods can be explained by a pseudo code in Fig. 3. Based on the schedule in Fig. 4 if the method 1 is used, the resulting schedule is shown in Fig. 5. It is seen that the penalty (calculated by weighted average of total tardiness, total earliness, and average flow time) and total tardiness are reduced. If the method 2 is used, the resulting schedule is shown in Fig. 6. It shows that the total tardiness is further reduced but the total earliness is increased. As a result, the penalty is increased.

### TABLE 4

**SEQUENCE OF OPERATIONS OBTAINED FROM SR METHOD AND ERT RULE**

<table>
<thead>
<tr>
<th>m/c1</th>
<th>A1</th>
<th>C1</th>
<th>D2</th>
<th>B1</th>
<th>G2</th>
</tr>
</thead>
<tbody>
<tr>
<td>m/c2</td>
<td>A3</td>
<td>B5</td>
<td>C2</td>
<td>B2</td>
<td>E3</td>
</tr>
<tr>
<td>m/c3</td>
<td>A2</td>
<td>B3</td>
<td>E2</td>
<td>G5</td>
<td>G1</td>
</tr>
<tr>
<td>m/c4</td>
<td>A4</td>
<td>C3</td>
<td>B4</td>
<td>D4</td>
<td>G4</td>
</tr>
</tbody>
</table>

### FIGURE 3

**PSEUDO CODE FOR ALLOCATING TARDY OPERATIONS TO THE SECOND PRIORITY WORK CENTERS**

Let $M$ be set of all machines

Sort machines in $M$ in descending order of their load levels

Select the machine that is the first order in $M$, called $M^*$

Repeat until all machines in $M$ are considered

Sort operations on machine $M^*$ in descending order their tardiness.

Select the operation that is the first order on machine $M^*$, called $O^*$

Repeat until all operations on $M^*$ are considered

Move $O^*$ to its second priority work center at suitable time slot if

1. The tardiness of $O^*$ is reduced
2. Schedule of other operations on the second priority work center does not change
3. Precedence constraints are not violated
4. For method 1: $O^*$ is not scheduled before its release time
   For method 2: $O^*$ is allowed to be scheduled before its release time

$O^* = O^* + 1$

End Repeat

$M^* = M^* + 1$

End Repeat
Determining the optimal start time of each operation by the linear programming model

This step explains the concept of the linear programming (LP) model to determine the optimal start and due times of each operation. The details of the model can be seen in Wuttipornpun and Yenradee [9]. The objective of the model is to minimize the penalty which is the weighted average of total tardiness, total earliness, and average flow-time.

The constraints are as follows.
1) The work center cannot simultaneously produce more than one operation.
2) The precedence relationship between operations must be satisfied.
3) The overlapping of production batches may or may not be allowed.
4) Constraints to calculate the completion time, tardiness, earliness, and flow-time.
5) Non-negativity condition. All parameters and decision variables are nonnegative.

Based on the schedule in Fig. 6, the LP model is used to determine optimal start times of each operation where the overlapping of production batches is not allowed, and the resulting schedule is shown in Fig. 7. It is seen that the total tardiness and penalty can be reduced significantly. If the LP model allows overlapping of production batches for 80%, the resulting schedule is shown in Fig. 8. It clearly shows that the overlapping of batches results in significant improvement on total tardiness and penalty. The overlapping of batches occurs at only some operations, e.g., B3 and B5, and E2 and E3.

**FIGURE 7**
SCHEDULE AFTER ADJUSTED BY LP MODEL WITH NON-OVERLAPPING OF PRODUCTION BATCHES

**FIGURE 8**
SCHEDULE AFTER ADJUSTED BY LP MODEL WITH OVERLAPPING OF PRODUCTION BATCHES

**DESIGN OF EXPERIMENT**

Experiment to analyze performance of the proposed FCMRP system

The experiment aims to analyze significant effect of different factors on the performances of FCMRP systems. In this experiment, the weights are set based on the opinion of the production planner of the factory under consideration. The weights of total tardiness, total earliness, and average flow time are 0.8, 0.1, and 0.1, respectively. There are four independent variables as follows:
1) Scheduling rules: There are two scheduling rules, namely, SR and SD.
2) Priority rules: There are two priority rules, namely, ERT and EDT.
3) Allocating method: There are two Allocating methods, namely, Method1 and Method2.
4) Overlapping: There are two alternatives, overlapping and non-overlapping.
There are 16 experimental cases based on the combination of the independent variables.

The dependent variables are performance measures of the schedule generated by the FCMRP systems. There are five performance measures, namely, number of early orders, total earliness (in days), and number of tardy orders, total tardiness (in days), and average flow time of all products (in days). Note that the total tardiness and earliness are calculated only from the operations for producing finished products. The flow time of a product is the elapsed time, from the earliest time among the start times of all parts, to the finish time of the finished product.

**Experimental Case**

To illustrate how the proposed FCMRP system solves an industrial problem, a case study in a factory is used. The experiment was performed based on the generated data from the MRP system called Thai SME Production and Inventory Control system (TSPICs). The case study is briefly explained as follows:

1. There are 6 finished products: Products A, B, C, D, E and G. The bill of materials are shown in Fig. 2 and the item master file is shown in Table 1.
2. There are 4 work centers.
3. All parts can be produced by one of two alternative work centers (the first and second priority work centers) as shown in Table 1.
4. All work centers are operated 8 hours a day and overtime is not allowed.
5. There are 30 orders and each one requires only one product.
6. The size of order $i$ is assumed to follow a normal distribution with a mean ($\mu_i$) and a standard deviation ($\sigma_i$) equals to 10% of mean ($\mu_i$). The mean order size ($\mu_i$) and due dates are obtained from real data.
7. Ten data sets are randomly generated based on item 6. Each set has 30 orders.

**RESULTS AND DISCUSSION**

The performances of 16 experimental cases are shown in Table 5

<table>
<thead>
<tr>
<th>Factors</th>
<th>Total tardiness (days)</th>
<th>No. of tardy orders</th>
<th>Total earliness (days)</th>
<th>No. of early orders</th>
<th>Flow-time (days)</th>
<th>Penalty (ranking)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SR×ERT×Method 1×Non-Overlapping</td>
<td>35.5</td>
<td>10</td>
<td>19</td>
<td>14</td>
<td>138</td>
<td>43.631 (9)</td>
</tr>
<tr>
<td>SR×ERT×Method 2×Non-Overlapping</td>
<td>34</td>
<td>10</td>
<td>20.5</td>
<td>14</td>
<td>132.5</td>
<td>42.567 (8)</td>
</tr>
<tr>
<td>SR×ERT×Method 1×Overlapping</td>
<td>30.25</td>
<td>9</td>
<td>20</td>
<td>16</td>
<td>120.5</td>
<td>38.554 (4)</td>
</tr>
<tr>
<td>SR×ERT×Method 2×Overlapping</td>
<td>28.7</td>
<td>8</td>
<td>22.5</td>
<td>17</td>
<td>128.9</td>
<td>38.116 (4)</td>
</tr>
<tr>
<td>SR×ERT×Method 2×Non-Overlapping</td>
<td>33</td>
<td>9</td>
<td>21</td>
<td>15</td>
<td>118.5</td>
<td>39.695 (5)</td>
</tr>
<tr>
<td>SR×ERT×Method 2×Non-Overlapping</td>
<td>30</td>
<td>10</td>
<td>23.5</td>
<td>16</td>
<td>119</td>
<td>38.119 (4)</td>
</tr>
<tr>
<td>SR×ERT×Method 1×Overlapping</td>
<td>26.5</td>
<td>7</td>
<td>25</td>
<td>16</td>
<td>110.1</td>
<td>33.156 (1)</td>
</tr>
<tr>
<td>SR×ERT×Method 2×Overlapping</td>
<td>24.3</td>
<td>7</td>
<td>27.5</td>
<td>18</td>
<td>116</td>
<td>32.976 (1)*</td>
</tr>
<tr>
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<td>33.5</td>
<td>10</td>
<td>20</td>
<td>15</td>
<td>114</td>
<td>39.732 (5)</td>
</tr>
<tr>
<td>SD×ERT×Method 2×Non-Overlapping</td>
<td>30</td>
<td>9</td>
<td>12</td>
<td>15</td>
<td>118</td>
<td>37.143 (3)</td>
</tr>
<tr>
<td>SD×ERT×Method 1×Overlapping</td>
<td>26.9</td>
<td>9</td>
<td>26</td>
<td>14</td>
<td>105.5</td>
<td>33.444 (1)</td>
</tr>
<tr>
<td>SD×ERT×Method 2×Overlapping</td>
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<td>29</td>
<td>16</td>
<td>109.5</td>
<td>33.295 (1)</td>
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<tr>
<td>SD×ERT×Method 1×Non-Overlapping</td>
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<td>14</td>
<td>16</td>
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<td>125</td>
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<td>13</td>
<td>20</td>
<td>15</td>
<td>141.5</td>
<td>39.945 (6)</td>
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<tr>
<td>SD×ERT×Method 1×Overlapping</td>
<td>29.5</td>
<td>11</td>
<td>19.5</td>
<td>16</td>
<td>121.7</td>
<td>34.677 (2)</td>
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<tr>
<td>SD×ERT×Method 2×Overlapping</td>
<td>27.85</td>
<td>11</td>
<td>21</td>
<td>18</td>
<td>133</td>
<td>34.462 (1)</td>
</tr>
</tbody>
</table>

Note: The average values in Table 5 are based on 10 data sets
According to Table 6, all five main effects, namely scheduling rule (S), priority rule (R), allocating method (A), overlapping of batches (O) and data sets (D) are significant. From Table 7, it is clear that for scheduling rules, SD method performs better than SD method, for priority rules, EDT outperforms ERT, for allocating methods, Method 2 outperforms Method 1, and overlapping of batches outperforms non-overlapping of batches.

Based on Table 6, there are 3 two-way interactions that are significant, namely the interaction between scheduling rule and priority rule, priority rule and overlapping, allocating method and overlapping. The interaction effect between scheduling rule and priority rule is interesting and shown in Fig. 9. It shows that the combination of SD and ERT, and SR and EDT generate equally good performance. Although other two interactions are significant, their interaction plots are quite parallel to each other so they are not presented.

Tukey’s multiple range test is performed to divide the 16 experimental cases into 9 homogeneous subsets as shown in parenthesis of the last column of Table 5. Note that subset 1 is the best. There are four experimental cases that are in subset 1. The combination of SR, EDT, Method 2 (allow operations to be started before their release date) and Overlapping of batches results in the lowest average penalty.

**CONCLUSION**

This paper proposes the new FCMRP system for assembly job shop which has an optimization ability and can be applied with industrial problems. The performance of proposed FCMRP system is tested using a case study. Based on the experimental results, all main scheduling rules and options have significant effects on the performance measures. Therefore, various scheduling rules can be designed and selected in order to obtain the desirable scheduling performances. From the experimental results, the best performance is obtained when the operations are allocated to the first priority work centers based on the release date, operations scheduled on the same date is prioritized based on earliest release time, then the tardy operations are allocated to the second priority work centers by allowing them to be started before the release time. Finally, the schedule is adjusted by the LP model that allows overlapping of production batches. For further study, the proposed FCMRP system will be developed to have more heuristic algorithms available as options for the planners. The FCMRP system in this paper has a limitation that it can be applied with only one factory. It will be extended to be applicable for a supply chain network that include supplier and customer factories as well.

**TABLE 6**

**ANOVA RESULTS**

<table>
<thead>
<tr>
<th>Factors</th>
<th>Penalty</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scheduling rule (S)</td>
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</tr>
<tr>
<td>Priority rule (R)</td>
<td>0.000*</td>
</tr>
<tr>
<td>Allocating method (A)</td>
<td>0.000*</td>
</tr>
<tr>
<td>Overlapping (O)</td>
<td>0.000*</td>
</tr>
<tr>
<td>Data set (D)</td>
<td>0.000*</td>
</tr>
<tr>
<td>S × R</td>
<td>0.000*</td>
</tr>
<tr>
<td>S × A</td>
<td>0.336</td>
</tr>
<tr>
<td>S × O</td>
<td>0.344</td>
</tr>
<tr>
<td>R × A</td>
<td>0.939</td>
</tr>
<tr>
<td>R × O</td>
<td>0.021*</td>
</tr>
<tr>
<td>A × O</td>
<td>0.007*</td>
</tr>
<tr>
<td>S × R × A</td>
<td>0.755</td>
</tr>
<tr>
<td>S × R × O</td>
<td>0.682</td>
</tr>
<tr>
<td>S × A × O</td>
<td>0.349</td>
</tr>
<tr>
<td>R × A × O</td>
<td>0.906</td>
</tr>
<tr>
<td>S × R × A × O</td>
<td>0.423</td>
</tr>
</tbody>
</table>
TABLE 7
MAIN EFFECT RESULTS

<table>
<thead>
<tr>
<th>Main Effect</th>
<th>Level</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scheduling Rule</td>
<td>SR</td>
<td>38.351</td>
</tr>
<tr>
<td></td>
<td>SD</td>
<td>36.680*</td>
</tr>
<tr>
<td>Priority rule</td>
<td>ERT</td>
<td>38.269</td>
</tr>
<tr>
<td></td>
<td>EDT</td>
<td>36.762*</td>
</tr>
<tr>
<td>Allocating method</td>
<td>Method1</td>
<td>38.058</td>
</tr>
<tr>
<td></td>
<td>Method2</td>
<td>36.973*</td>
</tr>
<tr>
<td>Overlapping</td>
<td>Non-overlapping</td>
<td>40.300</td>
</tr>
<tr>
<td></td>
<td>Overlapping</td>
<td>34.731*</td>
</tr>
</tbody>
</table>

FIGURE 9
INTERACTION BETWEEN SCHEDULING RULE AND PRIORITY RULE ON PENALTY

ACKNOWLEDGEMENTS
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REFERENCES


STUDY OF PRODUCTION SEAT BOOKING SYSTEM FOR MAKE-TO-STOCK PRODUCTS

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and

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Faculty of System Design,
Tokyo Metropolitan University, Tokyo, Japan
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ABSTRACT

This study deals with a problem in the design of a production seat system assigning market demands to the production schedule for make-to-stock products as the production environment. Similar to an airline or train booking system, customer’s orders are assigned a production seat. Using the production seat system, inquiries about the delivery for individual orders can be assigned quickly. As there is production lead time for make-to-stock production environment, the inventory is used for the dispersion of the market demand. Unlike the production seat system which considered the delivery date, it is necessary to adopt the balance of product inventory and the productive capacity for the design of the production seat system. In this study, a design variable is set as policy in the model: the productive allowance parameter and the standard stock setting parameter are variable for setting the quantity of production seats. The unfilled rate with respect to the market demand for products and average inventory rate of warehouse are used as manufacturing performance criteria. We identified how we should have selected the balance of the productive capacity as product inventory to reduce useless inventory, and reduce the unfilled rate with respect to the market demand in SCM.

KEYWORDS
Make-to-Stock Products, Production Seat System, SCM

INTRODUCTION

Because make-to-stock production makes products for stocking and subsequent sales, the control system are one in which products are first put into stock and then controlled to meet demand. For this reason, in the era in which all produced products were sold and there was increase of stock because of lack of sales, this was not a problem. At present, however, the environment is one in which demand fluctuates suddenly and there is a tendency toward inflation. With basic assignment control of inventory, because the rate of demand differs with different products, it is not possible to use uniform inventory assignment control, leading to an increased risk of remaining inventory of products that do not sell. On the other hand, for products that sell, there is often a shortage in which there is no inventory. Production control in recent years, rather than making assignment from actually held inventory, has the advantage of making assignment from future inventory by calculating from the production plan. Given this, by adopting a control system that uses the production seat system even for make-to-stock production, a switch from a control method that uses inventory as a buffer to a control method that uses time as a buffer envisioned.

Like an airline or train booking system, customer’s orders are assigned a production seat. Using the production seat booking system, inquiries about the delivery for individual orders can be assigned quickly. The production seat system is a production/sale unification system. Also, because it is possible to shorten the period of time from order receipt to planning, this is a production system that is expected to enable fast delivery and low inventory levels.

Previous studies on the production seat system have been reported. Tamura and Fujita (1994, 1997) gave an outline and described the characteristics of the production seat system, and comparatively studied the conventional MRP system and the production seat system in a single-stage manufacturing process; Akusawa (1994), Kuga (1994), and
Ohba, Tsubone and Uetake (2000) provided examples of the application of the production seat system; Tamura, Fujita and Kuga (1997) comparatively studied the conventional MTO system and the production seat system in a multistage manufacturing process and demonstrated the efficacy of the production seat system. Other studies have dealt with basic information, described an efficient method of assigning production seats for a single-stage manufacturing process in a composite production environment for MTS and MTO products, (Kobayashi; 2001) and clarified the influences of methods of assigning production seats and assigning MTO products on the manufacturing performance in a multistage manufacturing process including a bottleneck process (Kobayashi; 2002). Ohba et all constructed a practical model of the production seat system with flexibility in a composite production environment for MTS and MTO, based on an investigation of the actual conditions of the film manufacturing process. We clarify the degree to which the manufacturing performance can be enhanced by introducing the types of flexibility individually and then simultaneously. Also, from the production control conceptual model, Kodama [10] defined the intrinsic meaning of production seat assignment as indicating the assignment relationship between orders and a production plan.

In this study, a production seat system model is developed that introduces the idea of assigning demand to a production plan in a make-to-stock production environment. In a production seat system, in addition to the method of setting the production seat, which has been an issue in the past, factors such as the criteria for selection of the assignment method and the and how temporary demand orders are to be assigned can be envisioned. However, because in make-to-stock production fluctuation in demand is accommodated by product inventory, in contrast to a production seat system for products that considers delivery, it is necessary to introduce a balance between warehouse inventory and production capacity into the design of the production seat system. Given this, the model incorporates product inventory as well into the system.

The purpose of this study is to clarify the influence of two policy variables in setting the product seat. And this proves helpful in constructing a production seat system which is effective in practical operation.

**PRODUCTION MODEL**

Outline of the model is shown in Fig. 1.

**FIGURE 1**
**OUTLINE OF MODEL**

Plan by demand forecasting

⇒Production by real demand

Materials 1

| 1 line process |
| Bottle neck process = Setting production seat |
| Productive allowance parameter ε |
| Standard stock setting parameter Φ |

Warehouse

Retailing 1

Retailing 2

... 

Retailing l
**Market demand**

1) The make-to-stock products consist of \( n \) expected types (where \( n \geq 1 \)).
2) The product demand (for make-to-stock products) is reached at the end of each day.
3) The amount of demand for each product exhibits probability variations and is independent for each day.

**Manufacturing processes and Warehouse of products**

1) The manufacturing process consists of flow shop time assembly processes, and is a multistage process with \( m \) process steps. A bottleneck process exists among those processes, and the product seat is set for that bottleneck process.
2) The production lead time for the products is 1 period (\( L \) days).
3) After processing, a product is delivered to the warehouse, and shipment is made from the warehouse of an amount to accommodate the demand in the same period.

**Production Schedule**

The production seat booking system is, in a hierarchical fashion, composed of master scheduling, setting the total number of production seats, assigning MTS products to the production seat, and order release into production process. With each term of the production plan being the \( T\)-th term, and the planned terms (unit time periods) for setting production seats being the last day of each period, the procedure is as follows.

1) Planning master schedule: Total production capacity in term is determined on the basis of forecasting the demand for MTS at the end of term \((T-2)\).
2) Setting production seats: The production seat at bottleneck process for MTS in term is set based on master schedule.
3) Assigning orders to the production seat: Incoming orders is assigned the setting production seat available.
4) In issuing production instructions, after assignment of the production seat for an MTS product on the following day, a production order is issued based on the established production seat.

**Master production schedule**

In the master production scheduling, the production capacities of MTS products at bottleneck process in the term \( T \) is determined at the end of term \((T-2)\). The overall utilizable time for a bottleneck process in the term \( T \) is determined by the required processing time based on the predicted demand for products and the required processing time for filling the warehouse with inventory, base on the standard inventory. Two design variable are set as policy in the model: the productive allowance parameter \( c \) to express how much allowance productive capacity and the standard stock setting parameter \( \Phi \) to express how much set productive capacity as standard stock are variable for setting the production seats. The overall utilizable time is determined by the following equation.

\[
\bar{X}_{iT} = m_{ib} \cdot \left(1 + \varepsilon \right) \cdot \left( \sum \bar{d}_{iT} - \sum \bar{l}_{iT-1} + \sum \bar{l}_{iT} \right) \tag{1}
\]

\[
\bar{l}_{iT-1} = \bar{l}_{iT-2} + \bar{p}_{iT-1} - \bar{d}_{iT-1} \tag{2}
\]

\[
\bar{l}_{iT} = \bar{d}_{iT} \cdot \Phi \tag{3}
\]

- \( n \) : The number of product types, number of products
- \( \bar{X}_{iT} \) : The utilizable time for a bottleneck process in term \( T \)
- \( \bar{l}_{iT-2} \) : the estimated amount of inventory of a product at the end of the \((T-1)\)th term
- \( \bar{l}_{iT-2} \) : the true amount of inventory of a product at the end of the \((T-2)\)th term
- \( \bar{d}_{iT} \) : the predicted amount of demand for an MTS product in term \( T \)
- \( \bar{l}_{iT} \) : the standard amount of inventory of a product
- \( m_{ib} \) : The processing time for an MTS product in a bottleneck process
- \( \varepsilon \) : productive allowance parameter
- \( \Phi \) : standard stock setting parameter
- \( \bar{p}_{iT-1} \) : The planned production quantity of a product in the term \( T \)
- \( \bar{d}_{iT} \) : The expectation amount of demand for an MTS product
Setting production seats

At the end of term (T−2), the production seat for the term T is determined, based on the standard production plan. The production seat for each day of term T are set by the following equation, by distributing the utilizable operating time determined by the standard production plan evenly over each of the days of term T. Using the parameter , the daily production seat for MTS products in every process at the term index is set as follows:

\[ SE_{j} = \frac{X_{it}}{L} \]

\[ (j=t+1,t+2,\ldots,t+L) \]

\[ SE_{j} \]: the production seat for the j-th day

\[ L \]: the number of operating days in one term

Assigning orders to the production seat

In this study, a forward method of assignment is performed. Assignment is successive done of orders, from the remaining product seats received at the end of each day. Ones that cannot be assigned a production seat are extended to the next term. In addition, we divide the ratio and assign each product by indispensability quantity to calculate from true stock quantities and the standard stock quantities of the day before, when there are not able to assign to production seats on the day.

Production instructions

A production instruction is issued at the end of the j-th day upon establishment of assignment to the production seat for the (j+1)th day.

Manufacturing performance criteria

The unfilled order rate \( \alpha \), the average inventory quantity \( \beta \) are used as manufacturing performance criteria.

1) Unfilled rate of market demand for products \( \alpha \)

\[ \alpha = \frac{\sum U_j}{\sum d_j} \]

\[ \sum U_j \]: The number of the article numbers of j day out of stock

\[ \sum d_j \]: The number of all supplement article numbers of j day

2) Average inventory quantities of warehouse \( \beta \)

\[ \beta = \frac{\sum_{j=1}^{n} I_{jj}}{AD \times (n - DIS - 1)} \]

\[ \sum_{j=1}^{n} I_{jj} \]: The total of true stock quantities on j day

\[ DIS \]: The evaluation exclusion days

\[ AD \]: The expectation of the demand per one day
NUMERICAL EXPERIMENTS

Purpose of the experiment

We clarified how we should have selected the balance of the productive capacity.

Experimental conditions

1) With a term defined as 1 week, the number of operating days therein was taken as 5 days, so that \( L=5 \).
2) Fluctuations in market demand for MTS products are given by a normally distributed random variable with a mean of \( \mu \) (unit/day) and a coefficient of variance \( CV \).
3) The unit processing time at bottleneck process for MTS products is determined using an Erlang distribution with a mean of 1 and phase of \( k \).
4) The expected value of the overall production time for one term for all processes is taken as being \( 1000 \).
5) Numerical experiments are conducted as case studies based on actual data. The simulation period is 600 days for each parameter. The first 100 days are discarded, as they considered to be affected by the initial values, and results are evaluated using the data obtained in the latter 500 days.

Experimental results

Fig. 2 shows the relationship between the unfilled rate \( \alpha \) and the productive allowance parameter \( \varepsilon \) and standard stock setting parameter \( \Phi \). If the \( \varepsilon \) is made large and the proportion that the product seat is caused to track the predicted demand is made decrease the gap with respect to the actual demand becomes large and a large amount of unfilled product occurs. In addition, the absence of goods rate falls when I make \( \Phi \) big.

Fig. 3 shows the relationship between the average inventory rate \( \beta \) and the productive allowance parameter \( \varepsilon \) and standard stock setting parameter \( \Phi \). If the \( \varepsilon \) is made large and the proportion that the product seat is caused to track the predicted demand is made increase the gap with respect to the actual demand becomes large and a large amount of average inventory rate of warehouse \( \beta \) occurs. In addition, Average inventory rate \( \beta \) becomes large when I make \( \Phi \) big.

Fig. 4 shows relations of \( \varepsilon \) and \( \Phi \) that it is necessary to do below the unfilled rate \( \alpha \) to aim for 0.5%, when we changed the condition of the phase of the Erlang distribution to express the dispersion of the market demand for product. We can do below \( \alpha \) 0.5%, if we make \( \Phi \) big even if \( \varepsilon \) is small. On the contrary, we can do below \( \alpha \) 0.5% if we make \( \Phi \) big even if \( \varepsilon \) is small.
CONCLUSION

This study was directed at bottleneck processes in a flow-shop in an MTS production environment having a lead time, and established a production seat system that incorporates product inventory, clearly identifying the influence of the productive allowance parameter \( \varepsilon \) and standard stock setting parameter \( \Phi \) on the production performance. This model is an aid in effectively determining the productive allowance and standard stock setting. Also, in the operation of a production seat system for MTS products, if the lead time is considered, the production performance is improved with operation in which the capacity allowance is determined as a constant.

As a direction for the future, the introduction of a production seat system into the MTS production environment to reduce the average product inventory, in addition to imparted a margin with respect to product display space, is expected to have the effect of increasing the selection of productions, including newly introduced products.

Also, a new assignment system that utilizes real-time demand operation control system methodology is being considered that utilizes seat assignment, this being made possible in a production control and cloud processor
environment by disclosure of an open seat system, which will be linked to demand sped that reflects detailed demand per unit time for MTS products.

We concluded that the following hypothesis 1 seems to be supported by followings.

REFERENCES


Risk, Financial, and Strategic Management
SUPPLY CHAIN RISK MANAGEMENT IN AUTOMOTIVE INDUSTRY: A LITERATURE REVIEW

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ABSTRACT

Risk is defined as the chance of something happening that will have an impact on the achievement of objectives, and measured in terms of consequences and likelihood. Risks can come from uncertainty in financial markets, project failures, legal liabilities, credit risk, accidents, natural causes and disasters as well as deliberate attacks from an adversary. Risk Assessment is the overall process of risk analysis and evaluation; but risk management is the identification, assessment, and prioritization of risks followed by coordinated and economical application of resources to minimize, monitor, and control the probability and/or impact of unfortunate events. Therefore, risk arises as much from missed opportunities as it does from possible threats. The purpose of risk analysis and management is to help stakeholders avoid these failures. Risk analysis helps in estimating potential impacts of risk and in making decisions regarding which risks to retain and which risks transferring to other parties. Both quantitative and qualitative techniques are available for risk analysis. For automotive industry, risk is generally perceived as events that influence automotive company’s objectives of quality, cost, delivery; and service. Some of the risks associated with the production process are fairly predictable or readily identifiable; others may be totally unforeseen. This paper reviews the literature detailing risk determination, risk mitigation measures, and risk management practices in automotive supply chain.

KEYWORDS
Supply Chain, Risk Management, Automotive Industry

INTRODUCTION

Risk is defined as the chance of something happening that will have an impact on the achievement of objectives, and measured in terms of consequences and likelihood. Risks can come from uncertainty in financial markets, project failures, legal liabilities, credit risk, accidents, natural causes and disasters as well as deliberate attacks from an adversary. Therefore, risk arises as much from missed opportunities as it does from possible threats. Risk assessment is the overall process of risk analysis and evaluation; it is a step in a risk management procedure. Risk assessment is the determination of quantitative or qualitative value of risk related to a concrete situation and a recognized threat (also called hazard). In all types of engineering of complex systems sophisticated risk assessments are often made within Safety engineering and Reliability engineering when it concerns threats to life, environment or machine functioning (Wikipedia, 2011). Risk can be divided into two categories: 1) an operational risk is, as the name suggests, a risk arising from execution of a company's business functions. It is a very broad concept which focuses on the risks arising from the people, systems and processes through which a company operates. It also includes other categories such as fraud risks, legal risks, physical or environmental risks. 2) In finance, risk is the probability that an investment's actual return will be different than expected. This includes the possibility of losing some or all of the original investment. In a view advocated by Damodaran (2003), risk includes not only "downside risk" but also "upside risk" (returns that exceed expectations). Some regard a calculation of the standard deviation of the historical returns or average returns of a specific investment as providing some historical
measure of risk; see modern portfolio theory. Financial risk may be market-dependent, determined by numerous market factors, or operational, resulting from fraudulent behavior. Recent studies suggest that testosterone level plays a major role in risk taking during financial decisions.

In order to managing risk effectively, the identification, assessment, and prioritization of risks should be accomplished that are followed by coordinated and economical application of resources to minimize, monitor, and control the probability and/or impact of unfortunate events or to maximize the realization of opportunities. Methods, definitions and goals vary widely according to whether the risk management method is in the context of project management, security, engineering, industrial processes, financial portfolios, actuarial assessments, or public health and safety. The strategies to manage risk typically include transferring the risk to another party, avoiding the risk, reducing the negative effect or probability of the risk, or even accepting some or all of the potential or actual consequences of a particular risk. Certain aspects of many of the risk management standards have come under criticism for having no measurable improvement on risk, whether the confidence in estimates and decisions seem to increase. Furthermore, the purpose of risk analysis and management is to help stakeholders avoid these failures. Risk analysis helps in estimating potential impacts of risk and in making decisions regarding which risks to retain and which risks transferring to other parties. Both quantitative and qualitative techniques are available for risk analysis.

For automotive industry, risk is generally perceived as events that influence automotive company’s objectives of quality, cost, delivery; and service. Some of the risks associated with the production process are fairly predictable or readily identifiable; others may be totally unforeseen. The automotive supply chain is as complex as it gets. There are approximately 20,000 parts in a car, and if only one of those parts is unavailable, then the finished product cannot be shipped. At the top of the pyramid are Tier 1 suppliers that furnish major components, such as engines, that go into a vehicle platform. The Tier 2 suppliers furnish the parts that the Tier 1 suppliers require, such as the piston rod assembly that is part of the engine. As shown in the following schematic, there are typically 3-5 levels in the automotive supply chain, which is comprised by 1,000s of suppliers: raw material manufacturer, tier 3/4/5, tier 2, tier 1, car manufacturer, national distributor, dealer, and finally consumer. Clearly, automotive industry must rethink risk mitigation strategies to deal with large scale disruptions of their supply chains. This paper reviews the literature detailing risk determination, risk mitigation measures, and risk management practices in automotive supply chain.

WHAT IS RISK?

Definitions

Risk is the potential that a chosen action or activity (including the choice of inaction) will lead to a loss (an undesirable outcome) (Wikipedia, 2011). The notion implies that a choice having an influence on the outcome exists (or existed). Potential losses themselves may also be called "risks". Almost any human endeavour carries some risk, but some are much more risky than others.

1) Operational Risk

An operational risk is, as the name suggests, a risk arising from execution of a company's business functions. It is a very broad concept which focuses on the risks arising from the people, systems and processes through which a company operates. It also includes other categories such as fraud risks, legal risks, physical or environmental risks. Whereas, operational risk is the risk of loss resulting from inadequate or failed internal processes, people and systems, or from external events (Wikipedia, 2011).

2) Financial Risk

Financial risk an umbrella term for multiple types of risk associated with financing, including financial transactions that include company loans in risk of default. Risk is a term often used to imply downside risk, meaning the uncertainty of a return and the potential for financial loss (Wikipedia, 2011).

Previous Research on Risk

Walters and Halliday (2005) stated that economic value added (EVA) which subtracts the cost of capital from the after-tax operating profit for the period (cost of capital being calculated by multiplying capital employed by a relevant weighted cost of capital usually adjusted for industry sector risk). A positive value indicates value has been added during the period. EVA is more orientated toward the current period or recent past. It is not only the profitability of a company that matters, but also the capital needed to obtain that profitability, and its cost. Thus, obtaining a good Profit & Loss
result is not good enough. The capital necessary to achieve these results needs also to be measured. Implicit is the need to monitor the cost of capital and assess performance versus that cost. EVA is thus an objective measure that has a start point from which to make a comparison of performance within a relevant financial period (the current position). Because inventory in most organisations forms a significant portion of total asset value, EVA can be considered a good indicator when evaluating 4PL contribution to an organisation. On the other hand, Wonginta and Sirisoponsilp (2010) used one available method, named “Value at Risk (VaR),” widely applied in financial engineering, to determine full truckload pricing under demand, waiting time, uploading, and unloading time uncertainty. In our study, VaR was applied to minimize the service prices to new customers while maintaining the probability of loss within a specified tolerance level to enable more flexible full truckload pricing. A simulation model is developed to capture the stochastic patterns inherent in the operation of a full truckload network.

Pitinanondha and Akpolat (2007) introduced a conceptual framework for managing operational risk based on commonly used management systems. The authors mentioned that a literature review carried out in this field revealed that organisations make use of various frameworks and models to deal with risks in their operations. Although these frameworks differ in some aspects, there is strong evidence, however, that organisations seem to favour an Operational Risk Management (ORM) framework that is based on commonly used management systems including the Quality Management System (QMS), Environmental Management System (EMS), and Occupational Health and Safety Management System (OHSMS). In 2009, Akpolat analysed the operational risk management (ORM) practices in Australia. It provides a new perspective on how to use national and international operational management system standards as basis for systematic management of operational risks. It proposes a framework and identifies the critical factors for effective use of an ORM system. The proposed framework could also be used as a model to research ORM system applications in other countries.

**RISK ASSESSMENT/RISK MANAGEMENT**

**Definitions**

Risk assessment is a step in a risk management procedure. Risk assessment is the determination of quantitative or qualitative value of risk related to a concrete situation and a recognized threat (also called hazard). Quantitative risk assessment requires calculations of two components of risk: R, the magnitude of the potential loss L, and the probability p, that the loss will occur. In all types of engineering of complex systems sophisticated risk assessments are often made within Safety engineering and Reliability engineering when it concerns threats to life, environment or machine functioning. The nuclear, aerospace, oil, rail and military industries have a long history of dealing with risk assessment. Also, medical, hospital, and food industries control risks and perform risk assessments on a continual basis. Methods for assessment of risk may differ between industries and whether it pertains to general financial decisions or environmental, ecological, or public health risk assessment (Wikipedia, 2011).

However, risk management is the process of identification, analysis and either acceptance or mitigation of uncertainty in investment decision-making. Essentially, risk management occurs anytime an investor or fund manager analyzes and attempts to quantify the potential for losses in an investment and then takes the appropriate action (or inaction) given their investment objectives and risk tolerance. Inadequate risk management can result in severe consequences for companies as well as individuals. Management of risk aims to facilitate the exchange of information and expertise across countries and across disciplines. Its purpose is to generate ideas and promote good practice for those involved in the business of managing risk. All too often assessments of risk are crudely made and the consequences of getting things wrong can be serious, including lost opportunities, loss of business, loss of reputation and even life. This journal examines both the problems and potential solutions.

**Previous Research on Risk Assessment/Risk Management**

Pujawan and Geraldin (2007) presented a model for risk assessment and mitigation. We modified the well known FMEA model for risk assessment and adapt the House of Quality model for determining which risk agents are to be prioritized and then for selecting a set of cost-effective mitigation actions. In the model, each risk event is associated with a value of severity and each risk agent will have a probability of occurrence. The correlation of each risk agent and each risk event is determined. We defined aggregate risk potential for each risk agent as a measure of risks caused by a risk agent. The model is applied to a large fertilizer company in East Java, Indonesia. Whereas, Cowherd and Manson (2003) proposed enterprise risk management (ERM) is a relatively new discipline that focuses on identifying, analyzing, monitoring, and controlling all major risk classes (e.g., credit, market, liquidity, operational risk classes). Operational risk management (ORM) is a subset of ERM that focuses on identifying, analyzing, monitoring, and controlling operational risk. The purpose of this paper is to explain what enterprise risk management is and how operational risk management...
fits into the ERM framework. Nevertheless, Peter and Peter (2006) conducted the research study of the rapid rate of change in housing ownership in Australia calls for a need to develop a risk management model. Policy makers, at all levels are faced with new challenges of promoting maximum homeownership with minimum credit risk. The state housing authorities in Australia that provide loans to low-income households are concerned about defaults in the future. Estimating the risk of default is important so that homeownerships are fostered with minimum risk. This paper identifies income, financial, demographic characteristics, and locational factors as critical determinants of future risk. A risk management model has been developed and tested to serve as a useful tool for policy makers, government and private lenders to assess the risk of default and develop appropriate financial management strategies to minimise risk.

Bicimseven (2010) provided customs practitioners around the world with a framework ready to adapt to establish their own “strategic CRM agenda.”. Furthermore, the findings of this study contribute to ease the design/application of ERM solutions in public sector. Applying the well established ERM approach on customs administrations to analyze the risk management maturity level opens a new research avenue and practical implication to further develop and improve customs procedures and operations.

SUPPLY CHAIN MANAGEMENT

Definitions

Supply chain is a set of organizations directly linked by one or more of the upstream and downstream flows of products, services, finances, and information from a source to a customer. Managing a supply chain is ‘supply chain management’ (Mentzer et al., 2001). Management of supply chain is the systematic, strategic coordination of the traditional business functions and the tactics across these business functions within a particular company and across businesses within the supply chain, for the purposes of improving the long-term performance of the individual companies and the supply chain as a whole (Mentzer et al., 2001). Hines (2004) stated that “supply chain strategies require a total systems view of the linkages in the chain that work together efficiently to create customer satisfaction at the end point of delivery to the consumer. As a consequence costs must be lowered throughout the chain by driving out unnecessary costs and focusing attention on adding value. Throughout efficiency must be increased, bottlenecks removed and performance measurement must focus on total systems efficiency and equitable reward distribution to those in the supply chain adding value. The supply chain system must be responsive to customer requirements.” Supply chain management also encompasses the planning and management of all activities involved in sourcing, procurement, conversion, and logistics management. It also includes the crucial components of coordination and collaboration with channel partners, which can be suppliers, intermediaries, third-party service providers, and customers. In essence, supply chain management integrates supply and demand management within and across companies (CSCMP, 2011).

Previous Research on Supply Chain Management

According to supply chain management practices, Hasan (2009) conducted a study on sustainable supply chain management practices and operational performance. Practically, sustainable supply chain management has emerged as a key approach for enterprises aiming to become environmentally sustainable. The study will investigate the kinds of environmental management practices that are undertaken by companies in greening the supply chain and how these practices affect the environmental and operational performance of the companies. The study provides additional insight into the growing field of literature examining the relationships between environmental policies and operational performance. While, Basheka et al. (2010) examined the supply chain management trends and developments in Uganda. A total of 101 respondents from different organizations filled in a questionnaire that measured 41 key supply chain management trends and developments today and in the next five years using a scale ranging from (1) irrelevant to (5) most critical. We first examined the reliability of the survey instrument using Cronbach’ alpha which was found to with a co-efficient (r=0.96). We then conducted an exploratory factor analysis to identify the most important SCM trends and developments today and in the next five years. Our study found that in Uganda’s context, the most important SCM trends in the next five years will be an emphasis on (1) Product quality, safety, and supply chain delivery and security, (2) Managing fuel and transportation costs, (3) Development of new technologies that impact supply chain efficiency, (4) Managing supplier diversity, and (5) Supply chain flexibility which is seen as the major driver of supply chain strategy. We develop a framework of the most important SCM trends today and in the next five years. Childerhouse (2010) mentioned that the concept of supply chain management has evolved from focusing initially on functional co-ordination within an organisation, then to external dyadic integration with suppliers and customers and more recently towards a holistic network perspective. A triad is the simplest meaningful sub-element of a network, and as such will be used as the unit of analysis for this research into relationship continuity and information connectivity of triadic parties. The type of interdependence between network players dictates the type of coordination required. Most organisations operate in supply chains with sequential or reciprocal interdependence, both of which require advanced forms of information
systems enabled coordination. Networks are dynamic, the connections, working relationships and interdependency evolve over time. Thus any information system solution needs to be reasonably robust to alternative network dynamics. In this paper, we match information systems to supply chain triadic scenarios in an attempt to ensure appropriate connectively.

Abdullah (2010) stated that supply chain management (SCM) is viewed as a vital strategic tool for corporate competitiveness since it can improve efficiency and productivity while reducing the overall operating costs, as observed in various manufacturing sectors. Malaysia, wanting to improve this situation, has followed suit by introducing the Construction Industry Masterplan (2006-2015) through the Construction Industry Development Board (CIDB), with emphasis on enhancing the value chain that has lead to research initiatives by the government to investigate the applicability of Construction Supply Chain Management (CSCM). This paper presents the findings of a research effort in exploring this issue. The study employed a mixed-mode approach, implemented through both interviews and questionnaire surveys, to explore the internal (internal supply chain – information dissemination, management leadership, relationship development) and external (external supply chain – customer and supplier relationship management) parts of the construction supply chain. The Rasch Measurement Model was used to interpret and support the findings, which was further furnished with the themes uncovered during the interview sessions. The findings revealed that the construction industry players were currently moderate level implementers of the CSCM practices, and the players viewed CSCM as a viable approach of improving the Malaysian Construction industry.

**SUPPLY CHAIN RISK MANAGEMENT**

Supply chain risk management (SCRM) is a discipline of risk management which attempts to identify potential disruptions to continued manufacturing production and thereby commercial financial exposure. SCRM attempts to reduce supply chain vulnerability via a coordinated holistic approach, involving all supply chain stakeholders, which identifies and analyses the risk of failure points within the supply chain. Mitigation plans to manage these risks can involve logistics, finance and risk management disciplines; the ultimate goal being to ensure supply chain continuity in the event of a scenario which otherwise have interrupted normal business and thereby profitability. Sometimes, it's possible for supply chain logistics techniques such as supply chain optimization to prejudice contingency planning which would otherwise reduce the overall risk level for that particular supply chain (Wikipedia, 2011).

**Previous Research on Supply Chain Risk Management**

Vanany et al. (2007a) conducted an exploratory study to explore the phase of initiation in Indonesian manufacturing companies context. There are three main objectives of this paper. Firstly, is to confirm the urgency of needs of SCRM in the Indonesian manufacturing companies. Secondly, is to identify the practices of SCRM. Finally, it is to explore the source of supply chain risk. These three objectives were achieved through survey methods and interview semi-structured done with several operation managers. Findings from this research, indicate that most of questionnaires and interviewed managers believe that the implementation of SCRM is important to be implemented as it can reduce cost, reduce the lost of profit, and obtained fulfill order/ demand within unpredictable condition after disruption. They also claimed that the information sharing, collaborative relationship and corporate social responsibility are the significant practices for SCRM implementation. Lastly, they stressed that the inbound and outbound sources of the risks need to be studied seriously as they can disrupt the operations. In another research paper, Vanany et al. (2007b) stated that supply Chain Risk Management has increasingly becoming a more popular research area recently. Various papers, with different focus and approaches, have been published. This paper aims to survey supply chain risk management (SCRM) literature. Paper published in relevant journals from 2000 to 2006 will be analyzed and classified into five categories: conceptual, descriptive, empirical, exploratory cross-sectional, and exploratory longitudinal. The literature review will provide the basis for outlining future research opportunities in this field.

Whereas, Liu et al. (2008) proposed the relative risk scale of supply chain fourth party logistics are extended nowadays, and lots of uncertain factors affect the evaluation process. In order to solve these problems, an analytical network process (ANP) was used to estimate the risk possibility. A risk factors index system of fourth party logistics was built first. The ANP considered all kinds of risk factors as well as influence among them. The feedback relation between each two factors was described and calculated. Finally all of the risk factors were sorted synthetically. The example shows that ANP is a suitable method. In 2009, Zailani et al. (2009) again proposed supply chain risk management has increasingly becoming a more popular research area recently. Various papers, with different focus and approaches, have been published since a few years ago. This paper aims to survey supply chain risk management (SCRM) literature. Paper published in relevant journals from 2000 to 2007 are analysed and classified into five categories: conceptual, descriptive, empirical, exploratory cross-sectional, and exploratory longitudinal. We also looked at the papers in terms of the types of
risks, the unit of analysis, the industry sectors, and the risk management process or strategies addressed. The literature review will provide the basis for outlining future research opportunities in this field. In the mean time, Zailani et al. (2009) highlighted steps to be taken by business organizations through supply chain risks management (SCRM) to make sustainable development a reality. This paper is based on the conceptual perspectives on the effect of risks sources to the implementation of supply chain risks management. Generally, supply chain risk is defined by the distribution of the loss resulting from the variation in possible supply chain outcomes, their likelihood, and their subjective values. Supply chain risks comprise risks due to variations in information, material, and product flows, which originate when dealing with global supply chain. Thus, supply chain risks refer to the possibility and effect of a mismatch between supply and demand. When supply chain risks occur, a quick response can help minimize the consequences. This requires companies to have strategies in place before the disruption occurs; however, risk strategy is associated with specific supply chain sources. Therefore, this paper presents a detailed review of work reported in the literature on supply chain sources and SCRM. SCRM can play significant role in achieving the “triple bottom line” of social, environmental, and economic benefits and, therefore, contributing to sustainable development of the society.

According to risk management in logistics service providers, Liao (2009) identified the prospect and current problems of the Third Party Logistics (3PL) about finance service. The primary problem was to get a reliable risk control. 3PL may meet eight kinds of the risks: interior management risk, operation risk, technical risk, market risk, security risk, environment risk, law risk and credit risk. This paper proposed seven countermeasures in the management and the risk controls of the 3PL. One is to manage well customer so as to develop the cooperative relation between the bank and the customer in risk management. Two is to enhance the credit management to the customer, and to develop the enquiry information platform of the business for effective process supervision to the risks. Third is to establish the nimble and fast system about market information collection and feedback. Four is to improve the management the business operation and the interior norm. Five is to pay attention to the national policy and laws that will affect the logistics financial development. Six is to establish the management mode of the logistics business and create the proper new logistics risk by the market capital operation. Seven is to synthetically analyze the financial service ability to optimize the service methods. Finally, one successful case of China Nationals Materials Storage and Transportation Corporation (CMST) was used to verify my proposal basically. However, Rojamornkul et al. (2009) mentioned that the logistics industry is changing rapidly due to the combination of a de-regulated transportation environment, together with 3PLs embracing the internet, e-commerce and other electronic means to provide their logistics services. Recently, there have been many discussions with respect to the most notable inclusion of a 4PL or 4th Party Logistics. A 4PL is best described as an entity that positions itself between the manufacturer and the 3PL. Therefore, concepts related to risks management of 4PL must be defined first. This research study will propose a factor-based evaluation model, which combines analytic hierarchy process and risk matrix to evaluate the risks. The main objectives of the study are: 1) identify, characterize, and assess threats, 2) assess the vulnerability of critical assets to specific threats, 3) determine the risk (i.e. the expected consequences of specific types of attacks on specific assets), 4) identify ways to reduce those risks, and 5) prioritize risk reduction measures based on a strategy of Fourth-Party Logistics Supply Chain. Risk Management Process comprising of hazard identification, risk assessment, and risk control will be investigated.

Kuhn (2010) found that many 3PL companies are seeking to get to the next level of service providers (4PL). For achieving this target on of the major elements is the integration of risk management to manage especially worldwide supply chains. By introducing the risk factor, it linked to lead time deviations – analysed and evaluated by 6Sigma quality tools – a first step is taken to capture risk in a measureable KPI. Further empirical research is required not only to apply this risk assessment in automotive supply chains but also in other industry sectors’ logistical pipelines. Also a field of interest is given by developing quality as a second KPI for risk assessment along the supply chain. With joining time and quality into one tool a holistic approach crystallizes out to assess risk. But one of the hurdles to achieve this assessment level is the still existing predominant 3PL architecture of external service providers: Only after stepping up to 4PL structures the road ahead is free for external service provider for an integrated risk evaluation on worldwide supply chains. While, Rojamornkul et al. (2010) commented on the proposed model with theoretical review and introduced risk management methodologies and measurement by using the proxy, analog or surrogate method, the earnings volatility method, and the direct estimation method. The 4PL’s risk management model has been rarely identified and developed, compared to the popular 3PL model. Thereby, considering this model needs a comprehension of both 3PL and 4PL, or other categories of logistics providers (i.e., 1PL or 2PL). The theory and measurement presented here is expected to offer an overview of risk management enabling 4PL organizations to appropriate and effective review and reporting arrangements that reinforce and support risk management activities. This will allow up-to-date and accurate performance information leading to the ongoing identification and monitoring of risks by developing an annual assessment of the effectiveness of the process based on the above methods of measuring an enterprise's operational and business risk.

More literature review on a classification of the supply chain risk management can be found in Appendix conducted by Vanany et al. (2007b).
RISK MANAGEMENT IN AUTOMOTIVE SUPPLY CHAIN

Vehicle manufacturers and suppliers cope with raw material risk and the growing need to proactively manage purchasing, demand/supply balancing and risk management of raw materials and financial derivatives. Managing risk in the automotive supply chain should also be looking at logistics, accounting and decision support tools to create a complete commodity management platform that will help to preserve profit margins in the face of today's unprecedented commodity volatility. The vehicles that roll off today's assembly lines contain several raw materials, as do the machines that make them. Vehicle manufacturers would have some of the most diverse and complex procurement portfolios, which represent equally complex supply networks and a broad series of commodities markets. Therefore, this can experience severe volatility at any given moment. Volatility is a source of risk, especially for organisations not used to running their day-to-day operations amid such rapid fluctuations in prices. But it is important to remember that volatility also brings opportunity. Those that put the processes and systems in place to better manage volatility and risk will do better than competitors (Schwartz, 2011).

Previous Research on Risk Management in Automotive Supply Chain

Patterson (2002) mentioned that in today's competitive environment, there is a continual need for organisations to invest substantial amounts of resource into the development and manufacture of products and processes, and Automotive Manufacturing Organisations are no exception to this. However, if the success rate of the projects undertaken by these organisations could be increased, then the level of resources invested in these projects could potentially be reduced. The management of risk offers a method through which the success rate of projects can be increased. However, as yet, many organisations within the Automotive Manufacturing Sector have not undertaken to integrate a rigorous method of managing the risks to their projects. This work focuses on the development and implementation of a project Risk Management Methodology into the Automotive Manufacturing Industry.

Thun and Hoenig (2009) conducted a study of “Supply Chain Risk Management in the German Automotive Industry.” Their goal was twofold: a) to identify supply chain risks and risk drivers, b) investigate measures for dealing with SC risks and their impact on SC performance. Based on the results of the survey the following hypotheses could not be rejected and therefore can be seen as validated: 1) supply chains are susceptible to supply chain risks Complexity (eg. globalization) and efficiency (eg. outsourcing) of the supply chain are key drivers for supply chain risks; 2) internal supply chain risks have a higher likelihood to occur than external risks; 3) companies with a high degree of supply chain risk management show a higher performance than companies with a low degree; and 4) there is a difference between companies using preventive risk mitigation instruments contrary to those using reactive instruments in terms of supply chain performance. Whereas, Mojonnier (2011) indicated the problems in the automotive supply chain are greater than originally portrayed by the automotive manufacturers. It was also reported that Nissan is considering shipping engines from its Tennessee plant to Japan. This is crisis management, reacting to events as they occur. The automakers should develop a risk management plan, prior to the occurrence of a disaster. Such a plan would benefit everyone involved, and be a less costly experience for the OEMs.

TABLE 1
SUMMARY OF RESEARCH PAPERS ON THE SUPPLY CHAIN RISK MANAGEMENT IN AUTOMOTIVE INDUSTRY

<table>
<thead>
<tr>
<th>Researcher</th>
<th>Theme and Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cowherd and Manson (2003)</td>
<td>Enterprise risk management (ERM)</td>
</tr>
<tr>
<td>Walters and Halliday (2005)</td>
<td>Economic value added in 4PL</td>
</tr>
<tr>
<td>Peter and Peter (2006)</td>
<td>Risk management model</td>
</tr>
<tr>
<td>Vanany, Zailani, and Pujawan (2007)</td>
<td>Supply chain risk management (SCRM) literature</td>
</tr>
<tr>
<td>Pujawan and Geraldin (2007)</td>
<td>Model for risk assessment and mitigation</td>
</tr>
<tr>
<td>Pitinanondha and Akpolat (2007)</td>
<td>Managing operational risk based on commonly used management systems</td>
</tr>
<tr>
<td>Liu et al. (2008)</td>
<td>Risk scale of supply chain fourth party logistics</td>
</tr>
<tr>
<td>Hasan Akpolat (2009)</td>
<td>Operational risk management (ORM)</td>
</tr>
<tr>
<td>Zailani, Vanany, and Pujawan (2009)</td>
<td>Supply chain risk management (SCRM) literature</td>
</tr>
<tr>
<td>Zailani, Vanany, and Pujawan (2009)</td>
<td>Supply chain risks management (SCRM)</td>
</tr>
<tr>
<td>Rojamornkul, Laptaned, and Baramichai (2009)</td>
<td>Risk management in 4PL</td>
</tr>
<tr>
<td>Bicimseven (2010)</td>
<td>Risk management with ERM approach</td>
</tr>
</tbody>
</table>
CONCLUSION AND ANTICIPATED RESULTS

The formal risk analysis and management techniques are rarely used by the Thailand Automotive industry due to the lack of knowledge and expertise. The industry is also skeptical about the suitability of these techniques to Automotive. In most situations, the contractors and consultants perceive risk based on their experience and judgment. The risk elimination and risk transfer to a specialty sub-contractor were found to be the most favored method of risk management in Automotive. However, it was suggested by the respondents that these practices lead to low productivity, poor quality and Delivery delays. It is suggested that most prime contractors and construction managers in the Automotive Part industry (200 Companies) do not know much about the formal risk management techniques. So it would be appropriate to develop some sort of formal and/or informal education and training modules. Formal education could be graduate studies in construction project management. Informal education and training could take the form of career development programs (like risk management awareness program) organized by academic institutions or professional organizations such as the American Society of Civil.

REFERENCES


Schwartz, M. (2011). The Race to Manage Risk in the Automotive Supply Chain, Triple Point Technology, Friday, February 18, 2011,


## APPENDIX
### CLASSIFICATION OF THE SUPPLY CHAIN RISK MANAGEMENT ARTICLES

<table>
<thead>
<tr>
<th>No</th>
<th>Author(s)</th>
<th>Purpose of study</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Ritchie and Brindley (2000)</td>
<td>Premises that the extant linear supply chain relationship model that dominates most sectors will rapidly be replaced by a more amorphous supply chain relationship model.</td>
</tr>
<tr>
<td>2</td>
<td>Zsidisin and Panelli (2000)</td>
<td>Understands how purchasing organizations assess supply risk and the action the organizations respond to the risk.</td>
</tr>
<tr>
<td>3</td>
<td>Johnson (2001)</td>
<td>Describes supply chain lessons focused on reducing risk by actively managing both demand and supply variability.</td>
</tr>
<tr>
<td>6</td>
<td>Juttner, Peck et al (2003)</td>
<td>Seeks to identify an agenda for future research and to clarify the concept of supply chain risk management.</td>
</tr>
<tr>
<td>8</td>
<td>Zsidisin (2003)</td>
<td>Describes characteristics of inbound supply that affect managerial perceptions of supply risk.</td>
</tr>
<tr>
<td>13</td>
<td>Barry (2004)</td>
<td>Raises some essential supply chain questions as well as some that have impact on the field from outside of it.</td>
</tr>
<tr>
<td>15</td>
<td>Chopra and Sodhi (2004)</td>
<td>Describes sources of supply chain risk and how the company managing risk to avoid disruptions.</td>
</tr>
<tr>
<td>16</td>
<td>Christopher and Lee (2004)</td>
<td>Suggests that one key element in any strategy designed to mitigate supply chain risk is improved “end-to-end” visibility.</td>
</tr>
<tr>
<td>18</td>
<td>Finch (2004)</td>
<td>Presents a secondary analysis of the literature, supplemented by case studies to determine if large companies increase their exposure to risk by having SMEs.</td>
</tr>
<tr>
<td>20</td>
<td>Giunipero and Eltantawy (2004)</td>
<td>Proposes that situational factors-degree of product technology, security needs, the relative importance of the supplier, and the purchasers.</td>
</tr>
<tr>
<td>26</td>
<td>Spekman and Davis (2004)</td>
<td>Discusses these risks at length, shows how they are endemic to the extended enterprise, and attempts to develop a typology for categorizing them in six areas of supply chain-related risks.</td>
</tr>
<tr>
<td>29</td>
<td>Watson (2004)</td>
<td>Shows that relationship and contracts in the industry are structured to reflect the dominance of key players</td>
</tr>
<tr>
<td>31</td>
<td>Appelqvist and Gubi (2005)</td>
<td>Seeks to reduce risk and inventories while still providing high product variety and acceptable response time</td>
</tr>
<tr>
<td>32</td>
<td>Guillen, Mele et al (2005)</td>
<td>Designs and retrofits problem of a supply chain (SC) consisting of several production plants, warehouses and markets, and the associated distribution systems, is considered</td>
</tr>
<tr>
<td>33</td>
<td>Hallikas, Puimalainen et al (2005)</td>
<td>Provides a theoretical review of supplier relationships and risk management, as well as a survey-based empirical study conducted</td>
</tr>
<tr>
<td>34</td>
<td>Hendricks and Singhal (2005)</td>
<td>Investigates the long-term stock price effects and equity risk effects of supply chain disruptions</td>
</tr>
<tr>
<td>35</td>
<td>Juttner (2005)</td>
<td>Examines the business requirements for supply chain risk management (SCRM)</td>
</tr>
<tr>
<td>37</td>
<td>Nagurney, Cruz et al (2005)</td>
<td>Develops a supply chain network model in which both physical and electronic transactions</td>
</tr>
<tr>
<td>39</td>
<td>Peck (2005)</td>
<td>Reports on findings of a cross-sector empirical study of the sources and drivers of supply chain vulnerability</td>
</tr>
<tr>
<td>40</td>
<td>Sheffi and Rice (2005)</td>
<td>Provides the building of resilient enterprise should be a strategic initiative that changes the way a company operates and increases its competitiveness.</td>
</tr>
<tr>
<td>41</td>
<td>Sodhi (2005)</td>
<td>Provides two risk measures (demand and inventory risk) and two linear programming models to help manage demand uncertainty</td>
</tr>
<tr>
<td>42</td>
<td>Towill (2005)</td>
<td>Minimizes business risk of incurring increased marketability and acquisition costs due to volatile demand exacerbated by the bullwhip phenomenon</td>
</tr>
<tr>
<td>43</td>
<td>Zsidisin, Melnyk et al (2005)</td>
<td>Presents case study research findings examining how and why firms create business continuity plans to manage this risk</td>
</tr>
<tr>
<td>44</td>
<td>Zsidisin, Ragatz et al (2005)</td>
<td>Explores that concept, drawing on the findings of a recently completed field study</td>
</tr>
<tr>
<td>45</td>
<td>Zsidisin and Smith (2005)</td>
<td>Extends a recent stream of research indicating that ESI may be as useful tool for managing supply risk</td>
</tr>
<tr>
<td>47</td>
<td>Beasley (2006)</td>
<td>Describes the balanced scorecard into enterprise risk management actually strengthens the scope of management’s focus on broader sets of risks.</td>
</tr>
<tr>
<td>48</td>
<td>Brun, Caridi et al (2006)</td>
<td>Develops and tests new methodology is based on the consideration that activities whose execution can be supported by advanced planning and scheduling an supply chain management solutions</td>
</tr>
<tr>
<td>49</td>
<td>Chen, Chen et al (2006)</td>
<td>Proposes a risk sharing contract that requests the retailer to partially compensate for the manufacturer’s loss</td>
</tr>
<tr>
<td>50</td>
<td>Chen and Seshadri (2006)</td>
<td>Reconstructs supply chain structure used optimal control theory to solve single risk neutral distributor supplies</td>
</tr>
<tr>
<td>51</td>
<td>Choi and Krause (2006)</td>
<td>Formulates in terms of four major areas of research within supply chain management</td>
</tr>
<tr>
<td>52</td>
<td>Cucchiella and Gastaldi (2006)</td>
<td>Develops a framework for the management of uncertainty in supply chain finalized to reduce the firm risks</td>
</tr>
<tr>
<td>54</td>
<td>Faisal, Banwet et al (2006)</td>
<td>Presents an approach to effective supply chain risk mitigation by understanding the dynamics between various enablers</td>
</tr>
<tr>
<td>55</td>
<td>Gaudenzi and Borghesi (2006)</td>
<td>Provides a method to evaluate supply chain risks that stand in the way of the supply chain objectives using AHP method</td>
</tr>
<tr>
<td>56</td>
<td>Giunipero,L, Hanfield, et al (2006)</td>
<td>See to examine the key skills and knowledge necessary for firms to improve in order to maximize the purchasing function's contribution to the organization</td>
</tr>
<tr>
<td>No</td>
<td>Author(s)</td>
<td>Purpose of study</td>
</tr>
<tr>
<td>----</td>
<td>-----------</td>
<td>------------------</td>
</tr>
<tr>
<td>58</td>
<td>Papadakis (2006)</td>
<td>Aims to shed light on the financial implications of supply chain design and in particular on the differences between pull- and push-type designs and exposure to difficult to foresee supply disruptions</td>
</tr>
<tr>
<td>59</td>
<td>Peck (2006)</td>
<td>Aims to foster a more explicit understanding of the relationships between supply chain vulnerability, risk, and supply chain management</td>
</tr>
<tr>
<td>60</td>
<td>Sutton (2006)</td>
<td>Aims to focus on raising awareness of the limitations of traditional &quot;enterprise-centric&quot; views of enterprise risk management</td>
</tr>
<tr>
<td>62</td>
<td>Wilding and Humphries (2006)</td>
<td>Tests the well-accepted Williamson's economic organizations failure framework as a theoretical model through long term collaborative relationships</td>
</tr>
<tr>
<td>63</td>
<td>Wilson (2006)</td>
<td>Investigates the effect of a transportation disruption on supply chain performance using system dynamics comparing a traditional supply chain and a vendor managed inventory system (VMI)</td>
</tr>
<tr>
<td>64</td>
<td>Wu, blackhurst et al (2006)</td>
<td>Reinforces inbound supply chain risk management by proposing an integrated methodology</td>
</tr>
</tbody>
</table>

Source: Vanany et al. (2007b)
HOW TO CREATE AND PERFORM INTERNATIONAL BUSINESS OPPORTUNITY: AFRICA, ASIA AND EUROPE?

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HOW TO CREATE AND PERFORM INTERNATIONAL BUSINESS OPPORTUNITY: AFRICA, ASIA AND EUROPE?

by

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ABSTRACT

As an initial stage is how to elaborate the ownership matter, business administration, and productivity approach, especially in Indonesia. By using specific treatment procedure and analysis will employ “openness indicator”, also. Various variables to be utilized; entry level to a new business, starting a business, dealing with licenses, registering property, getting credit, protecting investors, paying taxes, trading across borders, enforcing contracts, and exit level from a business. Simple regression and mapping problem solution will be much understandable in this article, its possible for getting the simple sign or indicator in earlier stage. Indonesian manufacturing industries development is one of indicator on this article. The aim of this article is also to get better understanding; how to execute and to develop the business in better ways via comprehensive learning by doing partnership and framework of business itself. For instance: Making performance identification and notification for certain issues correlated with the subject and target agenda. In example, exploring & identifying: Understanding Regulation, reducing obstacles to growth: Jobs creation, How to Reform, business activity, business reform, creating Difference ideas for Entrepreneurs. The writer has been rethinking how to elaborate the possibility of business alternative and/or business opportunity on wider perspective and framework. Finally, in this article can be as representation which countries, region, cities and geographic area analysis will be appears for business perspective in near future. It will be much easier to overcome the best solution with update issues and international perspectives, especially international business opportunity: Africa, Asia and Europe. The point of view is how Indonesia is a key country sample will stimulate itself and network areas as developing countries, successfully.

KEYWORDS
Ownership, Business Administration, Productivity Approach, Simple Regression Analysis Approach and Mapping Problem-Solution, and Business Reform

THE OWNERSHIP MATTER, BUSINESS ADMINISTRATION, AND PRODUCTIVITY

The windfalls of oil boom stimulated industrial development in Indonesia, but the key importance was in the involvement of the foreign company in manufacturing industry. Foreign investments have encouraged for Indonesian manufacturing firm in many ways. In term of industrial sector, the government policy under Suharto era, tried to attract more foreign investment to promote Manufacturing sector.

In Indonesia’s manufacturing experience, import-substituting industrialization in Indonesia in the 1970s was much influenced by a wide array of protectionist barriers, including the highest nominal and effective rates of protection for consumer goods in ASEAN countries.

The bulk of the oil windfall was invested in infrastructure, education, and labor-intensive projects. During the collapse of the oil prices in the 80’s, spending on prestigious projects and subsidies for energy and food was cut, although development spending was maintained, the currency was devalued and a round of economic liberalization was launched to stimulate fresh growth.
National industrial capacity is based on major resource projects in steel, natural gas, oil refining, and aluminum, and import substitution. The industrial growth has slowed down considerably in the world oil market. Indonesia, forced to develop a more sustainable source of non-oil exports, particularly manufactured exports, and was forced to undertake a thorough reappraisal of its industrial strategy. As a result, the efficiency of the manufacturing sector and its general ability to achieve international competitiveness would have been necessary if the manufacturing sector were to replace the oil sector as the engine of Indonesia’s economic growth and as the major source of foreign exchange earnings. The government has tried to invite foreign capital entry, adoption of free market, open door policies and the restructuring of the Indonesian Economy. At that time, government tried introducing export-oriented industrialization.

The idea to move upstream in the growth momentum of the manufacturing sector as well as Indonesia’s industrial structure which have weak backward and forward linkages. From this view it was possible to make strengthen the manufacturing sector and manufactured export can grow, but imports will also grow usually. However, the efficient use of resources becomes the key success factor determining long run comparative advantage, particularly to achieve gains from the trade liberalization.

The problem in development is the coordination of the economy. This is difficult to achieve without the “success indicator” of benefit or profit. Planning is complex and difficult means of running an industrial society. However, mismanagement in many countries has reflected in many sectors and inefficiency is obstacle for resource allocation and the steady growth of aggregate output overtime. The coordination and integration of plan is tremendously complicated task.

Reformation and reconstruction for national institution, popular attitudes, and social structure in community as a multidimensional process, those are not easy to reduce of inequality during the process of economic growth. In the real fact of Indonesian manufacturing condition the import of raw material still high. The strong views of the major policy decision maker of industrial policy reflected in the extension of protection against imported intermediate and capital goods. Canonical Correlation is an additional procedure for assessing the relationship between variables. Specifically, this analysis allows us to investigate the relationship between two sets of variables. To the best illustration has been noted here using simple Cobb-Douglas production function, the writer has tried to specify an industrial production function for Indonesia in the following way.

Output manufacturing as a function of capital, openness level, total worker,

Definition: Manufacturing Output, CAP; machinery and building include equipment openness level as total import manufacturing/Total Import Manufacturing + Total Output, TW: Total worker by sector in Manufacturing Industries. It can be formulated as follow:

\[
Y' = A + B_1X_1 + B_2X_2 + B_3X_3
\]

\[
F = \frac{R^2_{Y,12,k}}{k} \left(1 - \frac{R^2_{Y,12,k}}{(N - k - 1)}\right), df = k, N - k - 1.
\]

\[
Z_Y = \beta_1Z_1 + \beta_2Z_2 + \beta_3Z_3.
\]

\[
F = \frac{(R^2_{Y,AB} - R^2_{Y,A})/k_B}{(1 - R^2_{Y,AB})/(N - k_A - k_B - 1)}, df = k_B, N - k_A - k_B - 1.
\]

The purpose of using openness, as input variable to better understand how much openness give impact to the output mainly for the domestic output. In the openness factor is contain the import variable. Because the import is important issue in Indonesia, most of manufacturing industries are really depend on the raw material import or intermediate goods.

According the Government issues that, as much as possible the manufacturing sector should not really depend on the material import. The depending itself becomes obstacles for manufacture development. With assumption that only for specific industry which is with import, the production become efficient or can produce output in optimum. Furthermore, on specific ways;

---

1 http://www.statsoft.com/textbook/canonical-analysis/
2 Introduction to Multiple Regression, Dale E. Berger, Claremont Graduate University
\[
P(R = r | e) = \frac{P(e | R = r) P(R = r)}{P(e)}
\]

\[
P(D = \text{true} | T = \text{true}) = \frac{P(T = \text{true} | D = \text{true}) \cdot P(D = \text{true})}{P(T = \text{true} | D = \text{false}) \cdot P(D = \text{false})}
\]

Regression 3:

\[
y \sim N(X\beta, \sigma^2 I) \text{ or } p(y | X, \beta, \sigma^2) \propto (\sigma^2)^{-n/2} \exp\left(-\frac{1}{2\sigma^2} (y - X\beta)'(y - X\beta)\right). \text{ note that } (y - X\beta)'(y - X\beta) \text{ written as }
\]

\[
(y - Xb)'(y - Xb) + (\bar{b} - b)'X'X(\bar{b} - b), \text{ where } b \text{ is the OLS } (X'X)^{-1}X'y, \text{ and the likelihood as follow: }
\]

\[
p(y | X, \beta, \sigma^2) \propto (\sigma^2)^{-(n-k)/2} \exp\left(-\frac{1}{2\sigma^2} (n - k)s^2 \right) \times (\sigma^2)^{-k/2} \exp\left(-\frac{1}{2\sigma^2} (\beta - b)'X'X(\beta - b)\right)
\]

\[
p(\theta) \propto \theta^{-(\alpha+1)} \exp\left(-\gamma / \theta\right), \text{ so, } \theta^2. \text{ The natural conjugate with likelihood, thus: }
\]

\[
p(\sigma^2) \propto (\sigma^2)^{-(\nu_0 / 2)+1} \exp\left(-\nu_0s_0^2 / 2\sigma^2\right),
\]

\[
p(\beta | \sigma^2) \propto (\sigma^2)^{-k/2} \exp\left(-\frac{1}{2\sigma^2} (\beta - \bar{\beta})'U'U(\beta - \bar{\beta})\right).
\]

\(\sigma^2\) has a normal prior with a prior mean \(\bar{\beta}\) and matrix \(\sigma^2(U'U)^{-1}\). The variance \(\sigma^2\) has in prior as y with degrees of freedom \(\nu_0\) and mean \(s_0^2\).

The posterior is:

\[
p(\theta, \sigma^2, y, X) = N((X'X+U'U)^{-1}(X'Xb+U'U \bar{\beta}), \sigma^2(X'X+U'U)^{-1}). \quad \text{That is, } \theta \text{ is a weighted average of the OLS estimator } b \text{ and the prior } \bar{\beta}, \text{ with weights reflecting the variability of data } X \text{ relative to the implicit data } U.
\]

The innovation is in the posterior distribution, even if we cannot identify a classic distribution for its shape.

The data are available for estimation in this paper. Food and beverages product, Garment and textiles product, Paper and paper products, other chemical products, Non-metallic, mineral products, Basic metallic products and other Machinery except electrical, machinery apparatus, Transport equipment product, other industrial products. Garment and textiles product significant, paper and paper products not. Other chemical products the capital and openness significantly to contributed to the output.

Non metallic mineral product, the openness, and labor significantly contributed to the output basic metallic products and other, capital and labor significantly contributed basic and metallic output. Machinery except electrical product, capital and labor were significant electrical machinery apparatus, capital and labor significantly contributed to the output but openness transport equipment product, labor was significant other industrial products, labor and openness contributed significantly to the output in other industrial sector.

---

As the estimation result shows, that openness gives positive impact to the output in most of the sectors. The capital does not give much effect to the output. The very significant impact is given by labor. This is reflects the real condition that in Indonesia many sectors are labor intensive than capital intensive and therefore the output is much dependent on labor.

**MANUFACTURING SECTOR PERFORMANCE**

<table>
<thead>
<tr>
<th>Manufacturing Sector-Description</th>
<th>75-81</th>
<th>82-84</th>
<th>85-89</th>
<th>90-95</th>
<th>95-'00</th>
<th>'00-05</th>
<th>'05-10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manufacturing value added</td>
<td>8</td>
<td>5</td>
<td>13</td>
<td>13,7</td>
<td>16,2</td>
<td>18,7</td>
<td>21,2</td>
</tr>
<tr>
<td>Manufactured export (SIT categories 5-8)</td>
<td>34</td>
<td>29</td>
<td>27</td>
<td>23,0</td>
<td>19,5</td>
<td>16,0</td>
<td>12,5</td>
</tr>
<tr>
<td>Manufacturing value-added in GDP</td>
<td>8</td>
<td>11</td>
<td>14</td>
<td>17,0</td>
<td>20,0</td>
<td>23,0</td>
<td>26,0</td>
</tr>
<tr>
<td>Manufactures in total exports</td>
<td>4</td>
<td>11</td>
<td>31</td>
<td>42,3</td>
<td>55,8</td>
<td>69,3</td>
<td>82,8</td>
</tr>
<tr>
<td>Exports</td>
<td>0.8</td>
<td>1.8</td>
<td>3.9</td>
<td>0.9</td>
<td>1.9</td>
<td>3.10</td>
<td>0.10</td>
</tr>
<tr>
<td>Imports</td>
<td>6.3</td>
<td>10.3</td>
<td>8.8</td>
<td>6.4</td>
<td>10.4</td>
<td>8.9</td>
<td>6.5</td>
</tr>
</tbody>
</table>

* Source raw data: BPS. Estimated by writer, (SAS procedure & method)

Firm Entries and Firm Exit in Case of Indonesia

Discussing the case of firm entries and firm exits are interesting because it will bring us for more clear understanding about the behaviors of the dominant firm. Furthermore, the developments of industry have seen from the increasing of number of firm. at least for Indonesian manufacturing industry we can see the changing of number of firm. Indonesian firms in category large industry own by conglomerate. There are many firms in medium size also own by conglomerate, but in case of small industries are owned by individual or local people those are have limitation to develop because the market size for them relatively small rather than medium and large size firm.

Many industries supplied by a large firm and fringe of smaller rivals and each firm who dominate will become a winner and the loser will exit from the competition, or the dominant firm becomes predator for other firm. In case of Indonesia, which mentioned above the conglomerates that own the big firm or plant are very dominant and have closed relationship with the government. The new firm will entry to the market, if they will get profit from the market, and exit if they loss or no profit.

This condition influence by the role of government under “orde baru” which foreign firm allowed built new firm in Indonesia. The number exits in each period number of exits are increasing, from this condition; we can learn that in small manufacturing industries the consistency of establishment changing very easily. Since almost all of them, the competition very high and producing almost in the same output or product then market oriented for domestic market only.
ENTRY EXIT MATTER

The Number of Entries and Number of Exits by Size of Firm

<table>
<thead>
<tr>
<th>Size of Firm By Number of Workers</th>
<th>Numbers of Entry</th>
<th>Numbers of Exits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small</td>
<td>5993</td>
<td>5088</td>
</tr>
<tr>
<td>Medium 1</td>
<td>982</td>
<td>1104</td>
</tr>
<tr>
<td>Medium 2</td>
<td>722</td>
<td>1218</td>
</tr>
<tr>
<td>Large</td>
<td>106</td>
<td>186</td>
</tr>
<tr>
<td>Very Large</td>
<td>45</td>
<td>75</td>
</tr>
</tbody>
</table>

Source raw data: BPS. Estimated by writer, (SAS procedure & method). Note: Accumulation

If we pay attention carefully from table above is small firm then medium gradually until very large firm. The barrier entry became larger significantly with size of firm in other word if size firm become larger for the new entries become difficult although the new entries larger than number of exits in each period. Also the tendency have shown in table 2.3 which is the size of firm become larger the number of new entries became smaller, this tendency happen also in number of exits if the size of firm became larger the number of exits became smaller too.

The Average Number of Exit and Entry 1975-2010

<table>
<thead>
<tr>
<th>Period</th>
<th>Avg. Numb. of Exits</th>
<th>Avg. Numb. of Entries</th>
</tr>
</thead>
<tbody>
<tr>
<td>1975-80</td>
<td>819</td>
<td>380</td>
</tr>
<tr>
<td>1981-85</td>
<td>1538</td>
<td>614</td>
</tr>
<tr>
<td>1986-90</td>
<td>1432</td>
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</tr>
<tr>
<td>1991-1995</td>
<td>1481</td>
<td>1152</td>
</tr>
<tr>
<td>2000-2005</td>
<td>1787,5</td>
<td>1504</td>
</tr>
<tr>
<td>2005-2010</td>
<td>1975,5</td>
<td>1782,6</td>
</tr>
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</table>

Source raw data: BPS. Estimated by writer, (SAS procedure & method)

The Percentage of Exit by Size of Firm

<table>
<thead>
<tr>
<th>Size of Firm</th>
<th>The Percentage of Exit by Size of Firm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small (20-50)</td>
<td>32.78</td>
</tr>
<tr>
<td>Medium 1(51-100)</td>
<td>16.01</td>
</tr>
<tr>
<td>Medium 2(101-250)</td>
<td>10.61</td>
</tr>
<tr>
<td>Large (500-999)</td>
<td>2.35</td>
</tr>
<tr>
<td>Very Large (1000+)</td>
<td>4.19</td>
</tr>
</tbody>
</table>

Source raw data: BPS. Estimated by writer, (SAS procedure & method)
According to Table 2.6, the growth by size of workers who engaged in all categories slowed down compared to the period before 1985-1990. In period 1985-1990, the growth increased compared to the period of 1980-1985. The growth 9.67%, medium (101-250 workers) and small industries (20-50 workers) accounted 11.63% the growth for that sector was not so different around 11% in period 1990-1995.

ROLE OF FDI-THEORETICAL CONSIDERATION

However, the coefficient of foreign investment became negative when the interaction term is introduced, implying that much foreign knowledge influence the way of thinking through the local of people. The concept FDI can be defined as an investment made to acquire management interest in an enterprise operating in an economy other than that of the investor. FDI flows therefore represent the expansion of the international activities of multinational companies.

Dunning (1993b), FDI takes place when three sets are known as the OLI (ownership, location and internalization) paradigm:
1) The specific ownership competitiveness will give advantage.
2) The location advantage in a host country implies that firms choose different locations.
3) The firm’s greater benefits in exploiting both ownership-specific and location advantages through internalization.

This set of determining factors must exist simultaneously for FDI to take place. However, from this set of determinants the location determinant is the only factor, which governments of host countries can influence directly. The general principle holds that host countries that offer what TNCs are seeking shall have a good chance of attracting FDI.

In general, three mainstream host country location-specific determinants can be distinguished; the national policy framework, business facilitation, and macroeconomic determinants (UNCTAD, 1998b, p.92). Lucas (1993b, p.402) indicated that “orde baru’s rule” in Indonesia; disturbances in the Philippines despite Marcos’ martial law and the Vietnamese threat to Thailand in the 1970s were all associated with declining FDI.

A stable political environment implies policy stability. FDI flows can be constrained by corruption, confiscation, or damage to property, excessive and discriminatory regulations, and heavy state intervention in the economy.

Business facilitation includes proactive measures to facilitate the business that foreign investors undertake in host economies. These include the promotion efforts and investment incentives of foreign direct investors, reducing corruption and improving administrative efficiency, after-investment services and the provision of social amenities that can contribute to the quality of life of personnel. Business-related FDI determinants are neither sufficient nor necessary for FDI to take place.

INTERNATIONAL FLOW OF FDI

Regional links are important for FDI from the source countries. This is evident in the fact that developed countries in the European Union direct their FDI flows mainly to Eastern Europe, although their involvement in Latin America should not be underestimated. FDI flows from the United States are mainly concentrated on Latin America, which is a reflection of physical proximity as a factor in determining the location of FDI flows in particular to the manufacturing sector. However, with the service sector becoming more important, regional preferences may decrease.

A new trend seems to be the emergence of TNCs in emerging economies. This is because improvements in developing countries’ economic policies have created a climate for strong international business to emerge. In this regard, Hong Kong, Singapore, Taiwan, Republic of Korea, and Malaysia are unusual among developing countries in the extent to which they are both recipients and sources of FDI among emerging economies (UNCTAD, 1998, p.370).

Most developing countries experience a shortage of capital. This reflected in their respective savings-investment and import-export gaps, which implies that developing countries have insufficient savings and/or foreign exchange to finance their investment needs. To bridge this gap they need an inflow of foreign capital.

FDI is an important source of capital for growth in developing countries, with assumption generally made that FDI can contribute to economic growth and restructuring in developing economies. However, there is increasing competition...
between developing and developed countries to attract FDI flows in order to either enter into, or consolidate their position
within, an increasingly integrated world production, trading and investment system.

**CAPITAL INVESTMENT IN MANUFACTURING INDUSTRIES**

It was interesting to break down the average capital investment from domestic’s loan and foreign loan to how much
the loan both from domestics and foreign loan have been influenced in manufacturing sector especially for standard
international code 3-digit Indonesian manufacturing industries. The basic food sector in average capital investment from
domestic loan and foreign loan indicated that the flow of foreign investment was lower than domestic. The domestic’s
investment is dominant in every sector means that domestic’s investment is very important things for industrial development.
But the question, where is the original loan was came into manufacturing industries mainly from domestics loan whether
domestics loan as “mediator” from foreign loan due to the restrictions of government rule. These questions will possibilities
to come up which is the potential “energy” of Indonesian manufacturing industry.

In electronic sector, which has high technology the foreign loan, was close to textile sector in term of foreign loan,
to argue that electronic industries could be a new leading of industrial sector, unfortunately the electronic sector did not
appear good performance as a new leading sector. Industry of electronic good, in developing country can absorb the labor
and the high technology but technological transfer does not work well. Most of electronic industries own by joint venture of
foreign ownership even though domestic firm has license from foreign firm to produce the electronic good, the quality, and
quantity still under international standard. If government can make good composition of foreign loan and domestic loan, the
allocation of loan can distribute as well as the planning. It is possible the industrial sector would have been in good prospect
in the future.

The Structure of Indonesian Manufacturing Ownership in 3-Digit Level

<table>
<thead>
<tr>
<th>Year</th>
<th>Foreign Ownership</th>
<th>Domestic Ownership</th>
<th>Local Government Ownership</th>
<th>Central Government Ownership</th>
</tr>
</thead>
<tbody>
<tr>
<td>1975</td>
<td>2.79</td>
<td>93.07</td>
<td>1.79</td>
<td>2.34</td>
</tr>
<tr>
<td>1976</td>
<td>3.12</td>
<td>92.72</td>
<td>1.76</td>
<td>2.40</td>
</tr>
<tr>
<td>1977</td>
<td>3.29</td>
<td>92.42</td>
<td>1.89</td>
<td>2.40</td>
</tr>
<tr>
<td>1978</td>
<td>2.97</td>
<td>92.85</td>
<td>1.83</td>
<td>2.34</td>
</tr>
<tr>
<td>1979</td>
<td>2.89</td>
<td>93.22</td>
<td>1.62</td>
<td>2.27</td>
</tr>
<tr>
<td>1980</td>
<td>2.80</td>
<td>92.97</td>
<td>1.72</td>
<td>2.51</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Year</th>
<th>Foreign Ownership</th>
<th>Domestic Ownership</th>
<th>Local Government Ownership</th>
<th>Central Government Ownership</th>
</tr>
</thead>
<tbody>
<tr>
<td>2005</td>
<td>2.62</td>
<td>93.36</td>
<td>1.58</td>
<td>2.43</td>
</tr>
<tr>
<td>2006</td>
<td>2.15</td>
<td>93.79</td>
<td>1.32</td>
<td>2.74</td>
</tr>
<tr>
<td>2007</td>
<td>2.80</td>
<td>93.08</td>
<td>1.79</td>
<td>2.34</td>
</tr>
<tr>
<td>2008</td>
<td>3.46</td>
<td>92.72</td>
<td>1.76</td>
<td>2.40</td>
</tr>
<tr>
<td>2009</td>
<td>3.63</td>
<td>92.42</td>
<td>1.89</td>
<td>2.40</td>
</tr>
<tr>
<td>2010</td>
<td>2.97</td>
<td>92.85</td>
<td>1.83</td>
<td>2.34</td>
</tr>
</tbody>
</table>

Source: Bureau of Statistics, Jakarta
COUNTRIES AT RISK FROM CLIMATE CHANGE EFFECTS

<table>
<thead>
<tr>
<th>Flood</th>
<th>Storm</th>
<th>Coastal Tm</th>
<th>Coastal Tm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bangladesh</td>
<td>Philippines</td>
<td>All low-lying Island States</td>
<td>All low-lying Island States</td>
</tr>
<tr>
<td>China</td>
<td>Bangladesh</td>
<td>Vietnam</td>
<td>Netherlands</td>
</tr>
<tr>
<td>India</td>
<td>Madagascar</td>
<td>Egypt</td>
<td>Japan</td>
</tr>
<tr>
<td>Cambodia</td>
<td>Vietnam</td>
<td>Tunisia</td>
<td>Bangladesh</td>
</tr>
<tr>
<td>Mozambique</td>
<td>Moldova</td>
<td>Indonesia</td>
<td>Philippines</td>
</tr>
<tr>
<td>Lao PDR</td>
<td>Mongolia</td>
<td>Mauritania</td>
<td>Egypt</td>
</tr>
<tr>
<td>Pakistan</td>
<td>Haiti</td>
<td>China</td>
<td>Brazil</td>
</tr>
<tr>
<td>Sri Lanka</td>
<td>Samoa</td>
<td>Mexico</td>
<td>Venezuela</td>
</tr>
<tr>
<td>Thailand</td>
<td>Tonga</td>
<td>Myanmar</td>
<td>Senegal</td>
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<tr>
<td>Vietnam</td>
<td>China</td>
<td>Bangladesh</td>
<td>Fiji</td>
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<tr>
<td>Benin</td>
<td>Honduras</td>
<td>Senegal</td>
<td>Vietnam</td>
</tr>
<tr>
<td>Rwanda</td>
<td>Fiji</td>
<td>Libya</td>
<td>Denmark</td>
</tr>
</tbody>
</table>

Source: World Bank staff
Note: Blue shade indicates countries in East Asia and Pacific

How to create and to execute the business:
Overall to create and execute the business, at least we must pay attention about:

The structure of ownership than can be distinguish by deep research and through data supporting in detail. Normally, can trace up to the name of entreprise and update activities. The process of administration, its means the procedure of bureaucracy standards is the most important things to all kind of business. It will give impact on taxing procedure, profit earning and future entreprise development.

Business Opportunity:

Source: database report on doing business
Dealing Business and closing Business:


Regulatory quality rating:
Denmark, Chile, Belgium, Greece, Botswana, Costarica, Thailand, Ecuador, Ukraine, Indonesia, Georgia, Bangladesh, Nigeria, Zimbabwe

- Update Issues, in real time.
- Local, National and within International Perspectives:

- **Growth in Broad based: Selected Countries**

<table>
<thead>
<tr>
<th></th>
<th>Estimate</th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
</tr>
</thead>
<tbody>
<tr>
<td>Developing East Asia</td>
<td>7.4</td>
<td>9.6</td>
<td>8.2</td>
<td>7.9</td>
</tr>
<tr>
<td>China</td>
<td>9.2</td>
<td>10.3</td>
<td>9.0</td>
<td>8.5</td>
</tr>
<tr>
<td>Indonesia</td>
<td>4.6</td>
<td>6.1</td>
<td>6.4</td>
<td>6.7</td>
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<tr>
<td>Malaysia</td>
<td>-1.7</td>
<td>7.2</td>
<td>4.8</td>
<td>5.7</td>
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<tr>
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<td>1.1</td>
<td>7.3</td>
<td>5.0</td>
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<td>-2.3</td>
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<td>3.7</td>
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<td>Vietnam</td>
<td>5.3</td>
<td>6.8</td>
<td>6.3</td>
<td>6.7</td>
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<tr>
<td>Cambodia</td>
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<td>6.5</td>
<td>6.5</td>
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<td>Fiji</td>
<td>-3.0</td>
<td>0.1</td>
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<tr>
<td>Lao PDR</td>
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<td>8.4</td>
<td>8.6</td>
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</tr>
<tr>
<td>Mongolia</td>
<td>-1.3</td>
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<td>10.3</td>
<td>7.8</td>
</tr>
<tr>
<td>Papua New Guinea</td>
<td>5.5</td>
<td>7.5</td>
<td>5.5</td>
<td>5.5</td>
</tr>
<tr>
<td>Developing East Asia excl China</td>
<td>1.2</td>
<td>6.9</td>
<td>5.3</td>
<td>5.7</td>
</tr>
<tr>
<td>High-income countries</td>
<td>-3.4</td>
<td>2.9</td>
<td>2.4</td>
<td>2.7</td>
</tr>
</tbody>
</table>

*Growth in 2010 was broad-based, calculated in percent change year-on-year*

*Sources: CEIC and World Bank staff projections*

- Business plan and evaluation
- How to know
  *Business intelligent not enough, to know more than customer need.*
- how to be
  *Ownership and strategic policy*
- how to make, by prudent decision,
• Conclusion, discussion, and remark

Evaluation and business estimation, intelligent and business challenging are should be run on long term mechanism and business behavior.

On the reality common countries are regulate in small portion. I could add here that the country like France especially in French civil Law tradition is very rich. On the other hand the country like Tunisia is least regulated but most efficient in contract enforcement. Uruguay face on worker policy is small regulated country in term of hiring and firing them. On the contrast Sierra Leone has a big regulated business country. According to system that is not efficient; India is a good example for this matter. (See, World Bank report 2004).

In all means the good regulation does not means undersized regulation. Commonly, many countries have special aspect on how to control the business and how to optimize the regulation in order to push up the business running well and in proper way. For instances can be explain here that in cases of tax, statistical purposes and or social security regulation must be on good function.

<table>
<thead>
<tr>
<th>Country</th>
<th>Starting a business</th>
<th>Dealing with licenses</th>
<th>Hiring and firing</th>
<th>Registering property</th>
<th>Getting credit</th>
<th>Protecting investors</th>
<th>Paying taxes</th>
<th>Trading across borders</th>
<th>Enforcing contracts</th>
<th>Closing a business</th>
</tr>
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<tbody>
<tr>
<td>Serbia and Montenegro</td>
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</tr>
</tbody>
</table>

Note: Countries are ranked on the number of reforms. When countries have the same number of reforms, they are ranked on the impact of the reforms on the Doing Business indicators. The larger the improvement in ranking on each set of indicators, the higher the country ranks as a reformer.

In best example for developing country Thailand has efficient property registration, registration is easy and faster. Compare to develop country so called Norway for best sample that the registrations just obtain from internet connection or the other media in trade and industries office, easily.

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http://www.statsoft.com/textbook/canonical-analysis/


Introduction to Multiple Regression, Dale E. Berger, Claremont Graduate University

The World Bank, various issues

International Finance Corporation, various issues
ANNEX

<table>
<thead>
<tr>
<th>Economy</th>
<th>Ease of Doing Business</th>
<th>Starting a Business</th>
<th>Dealing with Licenses</th>
<th>Registering Property</th>
<th>Protecting Investors</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Time (days)</td>
<td>Time (days)</td>
<td>licenses RANK</td>
<td>Time (days)</td>
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<td>6</td>
<td>67</td>
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<td>38</td>
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<td>Australia</td>
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<td>221</td>
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<td>Saudi Arabia</td>
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</table>

Source: The World Bank

<table>
<thead>
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Source: The World Bank
EXPLORING THE EXISTENCE OF RISK DISTRIBUTION IN THE SUPPLY CHAIN

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by

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ABSTRACT

Risk distribution in supply chains was initially explored by Yingvilasprasert and Banomyong (2010). However, its concept is still unclear and inadequate to figure out what exactly it is. The aim of this paper is to further explore whether the concept of risk distribution is valid and can be further applied to business practice. It is hoped that risk distribution will be alternative risk response strategy for supply chain risk management. E-mail survey was conducted to explore risk distribution perspective from researchers whose research area is supply chain risk management. The questions were asked to clarify for conceivable characteristics of risk distribution strategy and thus to distinguish with others, i.e. risk sharing, risk transfer, or risk diversification. The study infers that risk distribution is existed in supply chain research. The respondents provided precise explanation and presented clear examples of risk distribution against other strategies. The study conducted with academic researchers. However, it needs extension to business perspective. The valid concept of risk distribution can raise issues for future supply chain research. Risk distribution is revealed for alternative risk management strategies. Practitioners will get benefit especially when firm have limited resources or lack of risk control ability. Understanding the strategy will allow firm and its supply chain members prepare for distribution impacts.

KEYWORDS
Supply Chain Risk, Risk Distribution, Risk Management Strategy, Supply Chain Risk Management

INTRODUCTION

Risk has been widely accepted for its unpredictable impact and loss. Every organisation tries to set up risk management program but that not easy to prevent impacts from risk events. In fact, organisations prefer not to alter business practice. It might encompass unexpected spending when establishing some risk management programs. In prior study, risk distribution seems to be alternative strategy. Risk distribution is referred when risk originator (firm) decides to pass on their risk exposure to many capable receivers. Each receiver would get different type and amount of risks in accordance with their control ability.

Risk distribution was firstly discussed in Legal field by Steyer (1940) and it is widely accepted in many disciplines, i.e. Medical Science, Natural Science, and Finance (Caballero et al., 2007, Qian et al., 2009, Schwartz, 2007). The study of risk distribution trends to be increasing from year to year. Most studies have focused on distribution pattern, distribution impact, and contingency proposal.

In supply chain, four articles are presented related to risk distribution. Three articles discussed on the distribution of maritime and transport risks against legal issues while another one discussed on supply chain risk distribution simulation (Anonymous, 1964, Forte, 1987, Ji et al., 2009, Roberts, 1978). These four articles aimed to provide insights of risk distribution impacts but not defining characteristics of risk distribution in supply chains. In the light of this gap, Yingvilasprasert and Banomyong (2010) proposed a framework to describe risk distribution
phenomenon from a holistic view of other disciplines. However, the developed framework still presents ambiguous picture and cannot clearly state how risk distribution distinguishes from other strategies, i.e. risk sharing or risk transfer. The purpose of this manuscript is to take a step toward by exploring the valid concept of risk distribution strategy from academic perspective.

**RISK DISTRIBUTION STUDY: A BACKGROUND**

Supply chain risk management becomes critical attention in the recent year. It is an overlap concept between supply chain management and risk management (Brindley, 2004). There are three major activities: (1) risk identification, (2) risk assessment, and (3) risk response. Risk identification is a process to source and list all potential risk in a firm. Risk assessment is to assess the identified one against risk impact an risk probability. Risk response means any actions to mitigate risk exposure. Manuj & Mentzer (2008) focused supply chain risk management in a global scale based upon complexity and competitiveness in today’s business. Figure 1 illustrates the framework.

**FIGURE 1**

A GLOBAL SUPPLY CHAIN RISK MANAGEMENT FRAMEWORK

Risk distribution is one of famous risk response strategy in many disciplines, i.e. Medical Sciences, Law, and Finance. However, a review of supply chain risk management literature provides less attention to risk distribution strategy. Figure 1 is also figured out.

Accessing through Google Scholar database contained peer-review articles and grey literature. Grey literature is used for revealing unpublished information. This is very useful for new subject like risk distribution in supply chains. Google Scholar database is also up-to-date and freely access. However, the study additionally extracted commercial literature from ProQuest, Emerald, and ScienceDirect access. The papers are searched by two inclusive criteria: (1) the title of paper related to risk distribution and (2) written in English. The first criterion was applied for ensuring a core study of risk distribution strategy. Second criterion was set to reduce distortion of languages. Table 1 illustrates the paper access from the database by publication area.
TABLE 1
NUMBER OF PUBLICATIONS RELATED TO RISK DISTRIBUTION

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It is observed that risk distribution is not a new term for supply chain discipline. However, it rarely captures conceivable characteristics. In prior study, Yingvilasprasert and Banomyong (2010) tried to extract phenomenon of risk distribution from multi-disciplinary review as well as supply chain risk management concept. Figure 2 illustrates their proposed framework.

FIGURE 2
PROPOSED FRAMEWORK FOR RISK DISTRIBUTION STRATEGY

Source: Yingvilasprasert and Banomyong (2010)

From Figure 2, the framework presented three antecedents for risk distribution selection in order to mitigate risk in supply chains. First antecedent calls “risk selection”. Most firms always control high risk exposure to reduce huge impact. However, each risk characteristic can be managed by particular strategies. It is truth that risk distribution is only proper for risk that can distribute out.

Second antecedent is “lack of risk control ability”. It is focused based upon the importance for risk distribution process start-up. Risk distribution truly impacts others and that may consequent to relationship loss. Firm would transform some risk before sending out. Transforming helps firm absorb some risk portion they can. The rest risk portion will be the distributed amount. Risk distribution is then alternative strategy when firm lacks of risk control ability and needs immediate risk action.

“Member selection” is the last antecedent. From distribution process, it is not successful if no one accepts the distributed risk. Firm will choose only capable receivers in order to reduce relationship impact. Due to the fact that risk is negative thing, most firms always hand benefits together with risk, i.e. commit order, order opportunity, or premium rate. Capable risk receiver means any members firm guess on their capability to handle or manage risk being distributed. Their judgement bases on technical capability, reputation, and area of expert, for instance.

These three rationales allow firm choose risk distribution strategy for mitigating their risk out from firm. However, this framework still cannot interpret what exact risk distribution conceive for supply chains. This requires for further investigation.
**RISK DISTRIBUTION IN THE SUPPLY CHAIN**

The lack of references in supply chain literature presented a significant gap for risk distribution study. Although Yingvilasprasert and Banomyong (2010) tried to capture risk distribution concept and develop framework for supply chains, but these are not enough to clearly define what risk distribution is. The developed framework is illustrated by Figure 1. The manuscript is then step toward by investigating academic researchers who are in the following criteria: (1) researchers who interest in supply chain risk management area and (2) researchers who have ever published in peer-review journals in particular for supply chain risk management subject.

Due to the fact that supply chain risk management is infancy stage, researchers in this area is limit. Scoping respondent target in the first criterion would gain more reliable data. The targeted respondents could deliver solid idea and share information about risk management strategy. Additionally, the second criterion was set for peer-review focus. Peer-review process consists of many reviewers. The study believed that any researchers who published in peer-review journal could provide more consistent attitude than the others, especially in supply chain risk management subject.

Both inclusive criteria were favourable to ensure the conceivable characteristics of risk distribution. The manuscript applied these criteria to access researchers’ name and e-mail address through university website or academic papers where provide researchers’ information. The access revealed 88 academic researchers. However, only 74 researchers could be contacted. Most of them are in aboard, especially in USA and UK. E-mail survey was then used as a research strategy. The questions were simply designed to capture risk distribution as either similar to or different from others and to reflect what risk distribution exactly conceives.

Within a week, the study got feedbacks from 21 respondents (yielded 28.38% response rate). However, three of them were unusable response because the respondents could not provide any idea about risk distribution strategy. In addition to 18 usable responses, all of them were Professors and/or Lecturers in University. This supported the data to be more reliable. The manuscript presents the findings in the next sub-section.

**Results**

From 28.38% response rate, the study inferred that risk distribution is existed in supply chains. Risk distribution was found as a new terminology to describe a phenomenon of spreading the risk to others. Risk originators or focal firms distribute the risks when they do not have risk control ability at a certain time. Risks might be transformed before distributing out in order for firms absorb some risk portions which they can control. The rest portions are spread to many risk receivers. Each receiver is possible to get different types and amounts of risks in accordance with their control ability and expertise, for instance. Risk receivers are not limited to suppliers, customers, or transporters. Supply chain facilitators, i.e., maritime service or insurance company are also mentioned.

The aforementioned characteristics are simply illustrated by the following example. A focal firm gets urgent order from customer (demand risk). However, current production capacity can make 20% extra. The rest 80% order quantity a focal firm distributes to three suppliers: supplier A 30%, supplier B 40% and supplier C 10%. Each supplier can produce all distributed orders or further spread to the next.

Additionally, the findings demonstrated another four terminologies which are likely to risk distribution: (1) risk diversification, (2) risk transfer, (3) over-insuring, and (4) risk transfer. A literature review was used to verify such terminology and each presented as follows:

**Risk diversification:** This technique helps managerial level to control production and price risks by combining production, activities or enterprise portfolio in order to maintain a relative flow of income and suit to the economic situation from the predictable and unpredictable fluctuation (Featherstone & Moss, 1990).

**Risk transfer:** The strategy suggests firm to push their risk to another member. Risk transfer concept can be categorised into two conditions: (1) transferring to whom able to minimise risks or manage risks and (2) attention be paid to the cost of quantifying risk, which can outweigh the benefits of efficient allocation (Hall, Holt, & Graves, 2000).

**Over-insuring:** This strategy allows firm to pay extra for covering anything firm do not need (Stadtliaus, 1960). This also refers when giving tolerance for ex-act reproduction. Firm then has to pay in order to avoid unexpected and unpredictable risk.

**Risk sharing:** This strategy suggests firm to share risks among supply chain members (Juttner, 2005). However, firm has to decide which risks should be shared and then divided it to their supply chain members (Pratt & Zeckhauser, 1989).

It is found that only risk sharing and risk transfer are likely to risk distribution. From academic perspective, risk distribution is certainly inferred in different way.
Risk sharing mostly discusses on the sharing of business risks among partners/shareholders. The portion of the risks is divided by using share value or investment amount. Risk handling ability is not considered when sharing. Some partners might get loss if they do not have enough control ability. Relationship is a key element for risk sharing. It requires every partner keep talking and needs collaboration. A good relationship allows partners to perceive the same picture and thus help altogether minimise risk exposure.

In contrast, risk transfer is less collaborative. Risk transfer is referred when forwarding all portions of risk out to a facilitator such as insurance company. Without sharing characteristics, risk transfer hands the risk to the most able to handle. One respondent illustrated by using a case of manufacturer where has production problem (production risk). 10% of production line is shutdown from a broken machine. A manager informs this concern to the middle man. If the middle man does not further communicate, this production risk will be transferred to end customers.

Risk distribution thus goes beyond risk sharing and risk transfer. The distributed risk is not ended at the next tier. It will roll to the next until all of the risks are mitigated from supply chain. This means that all members absorb risk due to their capability. In addition, the distribution of risk does not have a fix pattern. Risk is able to be distributed by passing over some members or some tiers. For example, focal firm can directly distribute risks to 2nd tier members. In practice, risk distribution could enhance firm performance and assure competitive advantage in a long run. Risk distribution dissolves for one who carries too heavy risk by spreading to other capable risk receivers. Higher capability receivers would gain higher risk portions. Hence, risk distribution is existed as the essence of supply chain management and further provides many areas of research opportunities.

CONCLUSION

Risk distribution was a lack of studying in prior supply chain research. The light of this gap introduced Yingvilasprasert and Banomyong (2010) propose a framework to explain risk distribution phenomenon. However, this developed framework is still ambiguous. The manuscript aims to further investigate on a valid concept of risk distribution in supply chains. Academic researchers in supply chain risk management area were target respondents. From findings, risk distribution was inferred as a new terminology. Focal firm applied risk distribution with the concept of spreading risk/loss to several targets. In addition, risk distribution is definitely different from current strategies, i.e. risk sharing and risk transfer. The study was limited to academic perspective. It still needs further investigation with business one. Research opportunities are presented based on the valid concept of risk distribution. Business practitioners can apply the strategy when their organisations do not have enough risk control ability at a certain time. Risk distribution would make supply chain members understand when and how to play in a role of risk originators and risk receivers.

REFERENCES


IDENTIFICATION OF ENVIRONMENTAL SUSTAINABILITY STRATEGY PATTERNS IN AGRIFOOD SUPPLY CHAIN OPERATIONS

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IDENTIFICATION OF ENVIRONMENTAL SUSTAINABILITY STRATEGY PATTERNS IN AGRIFOOD SUPPLY CHAIN OPERATIONS

by

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ABSTRACT

The current economic climate has resulted in companies taking more decisive action in addressing their business performance and identifying sources of waste. In Europe, companies revise their strategies/policies to address potential economic problems as well as changes in national and EU environmental policies. As most organisations rely on some form of supply chain for provision of their goods and services, the sustainability dimensions is one area that needs to be addressed. This is apparent in the case of the Agrifood Sector, responsible for a large environmental impact which extends from credence attributes – physical and process related, as well as transportation and distribution channels. Some measures and initiatives introduced in the sector include investing in sustainable technologies, improving partnerships that help deliver better services and more efficient SC operations, engage employees with improved information, communication and transportation systems. The aim of this preliminary study is to identify a wide range of environmentally sustainable strategy patterns in food company supply chain operations and activities.

KEYWORDS
Transport Operations, Sustainability, Corporate Social Responsibility, Transportation Systems

INTRODUCTION

The agrifood chain sector is responsible for a large environmental impact (Dutaur and Verchot, 2007; Prather et al., 2001; Reicosky et al., 1999). It is currently heavily dependent on non-renewable energy resources and on the use of chemicals for profitable production (West and Marland, 2002). In this situation, a new and more sustainable approach to food production has been developing supported by integrated and efficient production systems, allowing the transformation of agricultural products and delivery to final consumers with a lower use of natural resources, and with lower pollution levels (Mosier et al., 2006). In Europe, the agrifood sector is responsible for about 30% of all carbon emissions from economic activities (UNEP-DTIE, 2011). Within this sector, it has been estimated that agriculture contributes about 49% of the GHG emissions from the food supply chains of the EU, consumer preparation and food consumption accounts for 18% and manufacturing for 11% of emissions. Reducing emissions from food transport has been a significant trend among retailers through using logistical arrangements such as backhauling and pooling to improve efficiency (Garnett, 2003). A generic input/output model summarising the environmental impact of Agrifood supply chains is introduced in Figure 1.
FIGURE 1
AN INPUT/OUTPUT MODEL FOR THE ENVIRONMENTAL IMPACT OF AGRIFOOD SUPPLY CHAINS
(SOURCE: AUTHORS)

REVIEW OF LITERATURE

Growing environmental, social and ethical concerns as well as increased awareness of effects of food production and consumption on the natural environment have led to increased pressure from consumer organisations, environmental advocacy groups, and policy makers to agrifood companies to deal with social and environmental issues related to their supply chains within product lifecycles, from ‘farm to fork’ (Vachon and Klassen 2006; Welford and Frost 2006; Courville 2003; Weatherell et al. 2003; Ilbery and Maye 2005; Maloni and Brown, 2006; Matos and Hall 2007). Stakeholders demand corporate responsibility to go beyond product quality and extend to areas of labour standards, health and safety, environmental sustainability, non-financial accounting and reporting, procurement, supplier relations, product lifecycles and environmental practices (Bakker and Nijhof, 2002; Waddock and Bodwell 2004; Teuscher et al. 2006). Sustainable supply chain management expands the concept of sustainability from a company to the supply chain level (Carter and Rogers, 2008) and should provide companies with tools for improving their own and the sector’s competitiveness, sustainability and responsibility towards stakeholder expectations (Fritz and Schiefer, 2008). Principles of accountability, transparency and stakeholder engagement are highly relevant to sustainable supply chain management (Waddock and Bodwell 2004; Teuscher et al. 2006; Carter and Rogers 2008). The impact of consumer demand to the environmental efficiency of the agrifood sector is given in Figure 2. In response to stakeholder pressures for transparency and accountability, agrifood companies need to measure, benchmark, and report sustainability performance of their supply chains, whilst policy makers need to measure the performance of sectors within the supply chain context for effective target setting and decision-making.
Although sustainability assessments have traditionally focused on agriculture (McNeeley and Scherr 2003; Filson 2004), recently researchers and policy makers have made attempts to develop more holistic approaches by incorporating stages of food processing, food retailing and specifically transportation in the assessment frameworks of food supply chains (Heller and Keoleian 2003; Green and Foster, 2005). Various approaches have been developed to measure sustainability of the food supply chains that identify effects at regional, industrial, and firm levels. Some specific sustainability assessment frameworks developed for the food sector include: farm economic costing (Pretty et al. 2005); lifecycle approach to sustainability impacts (Roy et al, 2009; Blengini et al, 2009; Heller and Keoleian 2003); food miles (Kemp et al, 2010; Coley et al, 2009; Garnett 2003); energy accounting in product lifecycle (Carlsson-Kanayama et al. 2003); mass balance of food sectors (Lopez et al, 2008; Risku-Norja et al, 2008; Ortiz, 2008); ecological footprint (Mena et al, 2010; Gerbens-Leenes et al. 2002; Burton et al, 2009; Ridoutt et al, 2010; Collins and Fairchild 2007); and farm sustainability indicators (Meul et al, 2009; Rodrigues et al, 2010; Gómez-Limón et al, 2010, Nickell et al, 2009; Fernandes et al, 2008). Some concepts related to sustainable approaches for managing the supply chain have been questioned; as an example, there are arguments against the concept of food miles as a driving force that may change purchasing behaviour of EU consumers (Coley et al, 2011).

AIMS AND OBJECTIVES

In order to evaluate patterns of implementation of sustainability strategies in the Agrifood supply chain, an empirical research was initiated. In this paper, we present the outcomes of the preliminary phase of this research. The aim of this pilot study was to collect qualitative data through a short questionnaire, using structured questions (Aaker et al., 1995). The main objectives are to identify current implementation and future trends in sustainable practices implementation that may constitute individual elements of an overall sustainability strategy, to evaluate the factors affecting the implementation of sustainability, and assess the benefits that an agrifood company may anticipate from these practices.
METHODOLOGY

Data for this pilot study were collected through a questionnaire survey. The questionnaire consisted of nine questions. The survey was distributed through email, both as an online link as well as an electronic document that could be returned via email or in hardcopy. A total of 214 UK-based companies involved in the Agrifood products distribution sector were contacted. E-mail contacts were obtained through websites of governmental agencies, sectoral and product specific associations. In total, 36 completed questionnaires were received, representing an initial response rate of 16.8%. It usually takes no more than 12-25 cases to reveal the major difficulties and weaknesses in a pretest questionnaire (Rossi et al., 1983, 226). These researchers also state “A pilot test of 20-50 cases is usually sufficient to discover any major flaws in a questionnaire before they damage the main study” (p. 181). However, because of a number of returned emails, perhaps due to recent company closures, the valid data set used for extracting results for this paper features a valid response rate of 23%. Considering the typical difficulties of corresponding with SMEs when lacking a personal contact the number of responses is considered fair. The questionnaire was structured as presented in Table 1.

<table>
<thead>
<tr>
<th>Table 1: Structure of Questionnaire and Variables</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Questionnaire context</strong></td>
</tr>
<tr>
<td>Q1. Size of the company</td>
</tr>
<tr>
<td>Q2. Identification of the sub-sector where the company operates</td>
</tr>
<tr>
<td>Q3. Existence of a CSR policy and implementation team</td>
</tr>
<tr>
<td>Q4. How the company conceives the sustainability concept</td>
</tr>
<tr>
<td>Q5.6. What sustainable practices the company is currently implementing or plans to implement in their supply chain operations and offices</td>
</tr>
<tr>
<td>Q7. Which factors affect the decision for implementing a sustainable management practice</td>
</tr>
<tr>
<td>Q8. What are the expected benefits from implementing a sustainable management practice</td>
</tr>
<tr>
<td>Q9. How important is the implementation of sustainable management practices from the suppliers</td>
</tr>
</tbody>
</table>

Validity/Reliability

The Cronbach’s alpha between the two scales in questions seven and eight in the questionnaire, shows very high internal consistency at .92. It appears that there is strong internal consistency for this pilot study questionnaire. This questionnaire was also shown to three experts in the field who concur that it is measuring what it intends to measure.

ANALYSIS

The central questions to this study looked at: (a) the implementation of sustainable management practices in the supply chain operations, production and office environment, (b) perceptions of factors affecting decision for the implementation of sustainable practices and, (c) the company’s expectations from applying sustainable initiatives. Data were analysed using SPSS (Statistical Package for Social Sciences) with frequencies and cross-tabulations undertaken to determine relationships and correlations between variables. The basis for the analysis was formed by the following eight hypotheses:

1. Are Medium and Large Enterprises more sustainable than Small and Very Small Enterprises?

The researchers ran a correlation analysis between the size of the enterprise and implementation of sustainable management in the supply chain and office business environment. It appears there is a positive moderate correlation between the size of the companies and objective to introduce a reverse logistics plan (r = .41, p < .05). Because it is a positive correlation, it appears that the ME/LE firms explain more of the variation in ratings for a reverse logistics plan, thus they seem to be keener into applying sustainable strategies.
2. Is company size associated with the ranking of factors affecting decisions for the implementation of sustainable practices?

There are no significant relationships between company size and the ranking of factors affecting decisions for the implementation of sustainable practices. This non-significant finding might be as a result of a Type 1 or Type 2 statistical error. It is certainly true that the sample size is small for this particular study.

3. Is company size associated with the ranking of company expectations from applying sustainable initiatives?

Pearson correlation coefficients show no significant association between the size of an enterprise and the ranking of company expectations from applying sustainable initiatives.

4. Is company size associated with the ranking of sustainable supplier initiatives?

Pearson correlation coefficients show no significant association between company size and the ranking of sustainable supplier initiatives.

5. Does a dedicated Corporate Social Responsibility (CSR) policy indicate a more sustainable company?

There exists a significant difference between having a dedicated CSR policy and ratings for improved working conditions (t = -3.098, df = 28, p < .05, r = .50); reduced carbon footprint (t = -2.476, df = 28, p < .05, r = .42); harmonize with regulatory framework (t = -2.312, df = 28, p < .05, r = .40), and improve the company’s image (t = -3.027, df = 28, p < .05, r = .57). The homogeneity of variance test has not been violated for these analyses. The size effect differences were calculated as r = square root of (t²/ t² + df).

6. Is there an association between the implementation of sustainable management practices in the supply chain with the perceived company expectations from applying sustainable initiatives?

It appears there is an association between the implementation of sustainable management practices in the supply chain and some perceived company expectations from applying sustainable initiatives. There is a negative association between Introduce a company lean management initiative and reduce carbon footprint (r = -.40, p <.05). There is also a negative linear relationship between Collaborate with sustainable transportation service providers and improving working conditions/reduce carbon footprint, respectively (r = -.41, p < .05, r = -.37, p < .05). There is also a negative relationship between Invest in supportive ICTs (e.g. telematics) to monitor and rationalize transportation activity and improve the company’s profile (r = -.38, p < .05). Lastly, there is a negative relationship between introduce an environmental best practice certification scheme and improve the company’s profile/improve working conditions, respectively (r = -.38, p < .05, -.47, p < .05).

7. Is there an association between the implementation of sustainable management practices in the office with the perceived company expectations from applying sustainable initiatives?

A correlation analysis showed there are some relationships between implementation of sustainable management practices in the office with the perceived company expectations from applying sustainable initiatives. There exist a strong negative linear relationship between awareness ratings for construction of sustainable facilities (buildings) and ratings for reducing the carbon footprint (r = -.53, p < .01). There exist a strong negative linear relationship between awareness ratings for efficient energy management in offices (insulation, Led lighting, etc) and ratings for reducing the carbon footprint (r = -.39, p < .05). There exist a strong negative linear relationship between awareness ratings for construction of sustainable facilities (buildings) and ratings for improving the company’s image (r = -.40, p < .05).

8. Do company perceptions about the factors affecting decisions for the implementation of sustainable practices share a positive relationship with the company’s expectations from applying sustainable initiatives?

A correlation analysis showed that company perceptions about factors affecting decisions for the implementation of sustainable practices shared a relationship with the company’s expectations from applying sustainable initiatives. The results are summarised in table 2.
TABLE 2
SUMMARY OF RESULTS WHEN TESTING PERCEPTIONS AND EXPECTATIONS FROM THE IMPLEMENTATION OF SUSTAINABILITY INITIATIVES.

<table>
<thead>
<tr>
<th>Gain financial profit</th>
<th>Improve market positioning</th>
<th>Improve supply chain positioning</th>
<th>Improve company’s profile</th>
<th>Improve working conditions</th>
<th>Reduce carbon footprint</th>
<th>Harmonize with regulatory frameworks</th>
<th>Improve the company’s image</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operational disruptions due to implementing the initiative</td>
<td>r = .38</td>
<td>p &lt; .05</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Training needs</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overall company strategy</td>
<td>r = .37</td>
<td>p &lt; .05</td>
<td></td>
<td></td>
<td></td>
<td>r = .41</td>
<td></td>
</tr>
<tr>
<td>Competition behaviour</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>r = .38</td>
<td>r &lt; .05</td>
</tr>
<tr>
<td>Availability of UK / EU funding opportunities</td>
<td>r = .58</td>
<td>p &lt; .01</td>
<td>r = .58</td>
<td>p &lt; .01</td>
<td>r = .52</td>
<td>r = .40</td>
<td>r = .45</td>
</tr>
<tr>
<td>Market demand</td>
<td>r = .40</td>
<td>p &lt; .05</td>
<td>r = .53</td>
<td>p &lt; .01</td>
<td>r = .57</td>
<td>r = .46</td>
<td>r = .45</td>
</tr>
<tr>
<td>Customer influence</td>
<td>r = .41</td>
<td>p &lt; .05</td>
<td>r = .50</td>
<td>p &lt; .01</td>
<td>r = .57</td>
<td>r = .39</td>
<td>r = .48</td>
</tr>
<tr>
<td>Ability to estimate/quantify benefits</td>
<td>r = .56</td>
<td>p &lt; .01</td>
<td>r = .39</td>
<td>p &lt; .01</td>
<td>r = .44</td>
<td>r = .46</td>
<td>r = .48</td>
</tr>
</tbody>
</table>

CONCLUDING DISCUSSION

According to the findings on the 1st Hypothesis, a positive correlation shows that the ME/LE firms seem to be keener into applying sustainable strategies. However, the findings for Hypotheses 2, 3, and 4 highlight the need for further research including a larger sample of companies, in order to identify suitable sustainability implementation strategies and match them with the different company size levels. We need to extend the survey to more large companies as results show they are more interested in meeting sustainability targets and compare small and large companies to identify what it is that creates the different responses. However, since 99% of the EU Agrifood sector comprises of SMEs, we also need to identify what will make a sustainability management strategy attractive and functional for an Agrifood SME. Many efforts from SMEs towards this direction are in vain due to a lack of information and vision on environmental performance and market mechanisms. The complexity of interconnected economic activities in supply chains and the complexity of environmental assessment require thorough expertise, which usually lacks from the Agrifood SMEs. This highlights the need for an integrated approach; sustainability practices have to be coordinated throughout the entire supply chain.

Our future research, built on this preliminary study, will scrutinize the needs of Agrifood companies for successful implementation of sustainability strategies, according to their size, focusing on the needs of SMEs. This will lead to the development of a model that will enable adoption of sustainable measures based on a needs and strengths analysis of the companies.
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THE CASE STUDIES OF INNOVATION IN HOTEL IN BANGKOK, THAILAND

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THE CASE STUDIES OF INNOVATION IN HOTEL IN BANGKOK, THAILAND

by

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ABSTRACT

The main objective of this study is to investigate the factors influencing the innovation in the service industries especially in hotel sector established in Thailand. The tourism industries are now one of the most important service sectors of the country as Thailand becomes one of the most attractive destination for tourism in South East Asia. The samples of the case studies were selected for the in-depth interviews which include 3-star economy hotel, 5-star international hotel, 5-star small luxury hotel, 3-star large hotel and 4-star large hotel. For each hotel, case material was gathered on various dimensions of technology and management style. Historical information was also gathered on innovation progress and milestones since start up. Influence innovation factor or determinants are also included.

KEYWORDS
Innovation, Service Innovation, Hotel Industry, Innovation Determinant

INTRODUCTION

Globalization has led to dramatic increase of intense competition, rapid technology development and also changed demand of customer. Therefore, all organizations aim to compete to survive in business world. Innovation is regarded to be an important factor for all firms to stay competitively in the market. (Hobday et al., 2003; Rush et al., 2007). Innovation is the source of economic growth and it is an essential element in determining and maintaining competitiveness and ensuring the long term survival of enterprises (Tidd & Bessant, 2010). Advanced economies of the world are increasingly dominated, in terms of employment and value added by service activities. In the year 2010, the totals GDP of Thailand are accounted for agriculture 12.4 %, manufacturing industry 44.7% and service industry for 42.9%. (Central Intelligence Agency, 2011)

As innovation is one of the main determinant for competitiveness but innovation theory mostly developed for manufacturing sector (Sundbo J, Gallouj F., 2000) It is very important to apply innovation theory to service sector. Since there is a lack of innovation studies in the hospitality sector (Francina, Mattsson, 2009). Therefore the objective of this paper is to investigate and analyze the innovation behavior for hotel industry located in Thailand. The study helps to develop the understanding of innovation development and activities/factor that drive to innovation and performance in this industry. The material drawn from five case studies is used to identify the main characteristics of innovations and factor that stimulate to innovation.

This paper is structured as follows: the following literature review section introduce a theoretical framework of innovation, service innovation and innovation in hotel industry. Then describe the interviewed hotel characteristic and relevant factor that stimulate to innovation.

INNOVATION THEORY AND THAI TOURISM

The differentiating characteristics of services from manufacturing are given by many researchers but there have share some common theme of service nature. According to Gallouj and Weinstein (1997) the distinctive feature of service can be conclude as follows. First, there is a close interaction between production and consumption. Second is the intangibility content of services. Third, the important roles play of human resource as a key competitive factor because services require human effort to interact directly with the customer. Thus, service production depend heavily on the knowledge and skills of people involved in process (Sirilli G. 1998, Jaw C, 2010).
Innovation is characterized as a process of transforming new idea generation into new or improved products, services or processes and successful commercializes (Rogers 2003, Tidd et al., 2001,). Based on Oslo Manual, (OECD 2005), the broad definition of an innovation is the implementation of a new or significantly improved product (goods and services), or process, a new marketing method, or a new organizational method in business practices. But the minimum requirement for an innovation is that it needs to be new or significantly improved to the firm and it must be implement to achieve economic value such as it make some profit or it can increase firm efficiency. First, product innovation which is the introduction of a good or service that is new or significantly improved with respect to its characteristics or intended uses. Second, process innovation is the implementation of a new or significantly improved production or delivery method. This includes significant changes in techniques, equipment and/or software. Third, an organizational innovation is the implementation of a new organizational method in the firm’ business practices, workplace organization or external relations. This include human resource development, management commitment that intend to increase firm’s performance. The last type, a marketing innovation is the implementation of a new marketing method and the opening of new market. It can be involving significant changes in product design or packaging, product placement, product promotion or pricing.

There are the distinctions between incremental and radical type of innovation. Radical Innovation is the fundamental changes that represent revolutionary changes or major change for example; the introduction of a totally new type of machinery or technological revolution. Incremental Innovation is the changes which are insignificant and minor change. Incremental refers to continuous and small improvement to existing thing.

The tourism sector is a high source of revenues for Thai Economy. The tourism industry includes a wide range of activities such as restaurants, entertainment, transportation and accommodation. By an accommodation type, mostly of tourists stayed at hotels, thus, hotels are the major part of accommodation. Hotel operations vary in sizes, functions, and costs. The hotel business is a people-oriented service. Therefore, human resources play a significant role in the quality of service delivery (Mullin, 1993). The following figure 1 shows the increase number of tourist arrival to Thailand.

**FIGURE 1**
NUMBER OF INTERNATIONAL TOURIST VISITED THAILAND, 2001-2010

Source: Department of Tourism (2008 - 2010), Ministry of Tourism and Sports

Next figure shows the internal supply chain for hotel by capture all transaction in a visual diagram. The innovation can occur in any point in this blue print. Therefore, we can classify the activities that stimulate innovation or improvement as the driving factors to innovation.
FIGURE 5
INTERNAL SUPPLY CHAIN IN HOTEL

Sources: “Service Management: Operation, Strategy, Information Technology” by James A. Fitzsimmons and Mona J. Fitzsimmons, 2008 Figure: Hotel Activities Blueprint

The physical evidence at the top of figure shows what customer will see and experience. Any vertical flow line crossing the “line of interaction” depicts a direct contact between the customer and organization. Paralleling the customer actions are two areas of contact-employee actions. Above the “line of visibility” are actions in full view of the customer which is the level of involvement of customer in the service delivery process. Below the “line of visibility” are activities that are not seen by the customer which is the support process that generates capacity requirements.

CASE STUDIES

With the aim to explore service innovation in hotel industry, this study selected 5 hotels which are located in Bangkok for an in-depth interview. The hotels are separated into five characteristic which are 3-star economy hotel, 5-star international hotel, 5-star small luxury hotel, 3 star large hotel and 4-Star large hotel. Thus, the different hotel characteristic can describe the main innovation factors in different dimension. The following summarizes the characteristics of all hotels in the case studies that we conducted from the interviews.

TABLE 1
CHARACTERISTICS OF INTERVIEWED HOTELS

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Case A</th>
<th>Case B</th>
<th>Case C</th>
<th>Case D</th>
<th>Case E</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chain</td>
<td>Accor</td>
<td>Ramada</td>
<td>Thai-own</td>
<td>Thai-own</td>
<td>Thai-own</td>
</tr>
<tr>
<td>Star</td>
<td>3 (Economy)</td>
<td>5 (International Hotel)</td>
<td>3</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Size (rooms)</td>
<td>108</td>
<td>525</td>
<td>94</td>
<td>590</td>
<td>400</td>
</tr>
<tr>
<td>Employee</td>
<td>55</td>
<td>400</td>
<td>190</td>
<td>332</td>
<td>250</td>
</tr>
<tr>
<td>Type of innovation</td>
<td>Process</td>
<td>Process</td>
<td>Organization</td>
<td>Marketing</td>
<td>Marketing</td>
</tr>
<tr>
<td>Level of innovation</td>
<td>Incremental</td>
<td>Incremental</td>
<td>Incremental</td>
<td>Incremental</td>
<td>Incremental</td>
</tr>
</tbody>
</table>

Case A

The hotel design focus on the concept of colorful in order to capture a feeling of well-being and comfort that never seen before in an economy or a budget hotel. Hotels are very concerned about the environment so the hotel innovation is focus on green world concept such as they let customer to make a decision whether they want to change the bed sheet or not. If the customers want to save the world energy then the maid does not need to change the bed sheet of the room. In this way, the customers is helping to save the energy and help prevent global warming by not wasting useless energy on washing machines. They believe that this activity is very innovative and helps to reduce the cost of production.

They ranked the factors and activities for innovation by the following. The first important factor is "Customer driven" since they believe “Customer is a King”. Therefore making customers satisfied with their service is the most important factor in the hotel strategy. Thus, their innovation mostly comes from their customers via customer complain and requirement. The hotel has classified employees into groups because when customers complain about anything, the hotel will know which group got the complaint. Then the hotel management will hold a meeting to solve the problem that
the customer complained. The second important factor is “Management Support”. The hotel joined Accor hotel chain which gains a lot of benefits from being in an international brand name chain because it has transferred the management standards to them, and they also provide training courses to develop employee service skills. They believe that the international brand name chain already achieved customer loyalty which is the reason that they have more competitive advantage than independent hotel. The third important factor is “Human Resource Development”. The hotel provides training and learning process every year to increase service efficiency which every employee have to take training course of at least 6 hours per years. This training is to make employee know how to treat customer and how to make customer satisfied with their service the most. Moreover, the training includes time management for servicing such as check-in time, delivery foods, and clean rooms. In the chain group, there is an innovation award competition in order to encourage employee to generate new idea or innovation that help hotel to reduce cost and increase profit. Forth Linkage to other innovation system; such as association helps in term of collaboration to negotiate with the government to increase the tourism development policy. The last important factor is “Acquired Technology”. The hotel uses only database to keep the information of the customers for check-in and check-out system and also use for social network to put the advertisement on the Internet such as Facebook, Twitter and Flickr. Moreover, it is used to provided information and commercial for customers as a new marketing channel for new marketing innovation.

**Case B**

The hotel started from family business hotel and they believe that their location is the most attractive to the customers which is near Chao Phraya River. Due to the increase number of competitors and globalization, they realize that they have to improve themselves to increase the competitive advantage. The hotel also joined the Ramada Hotel Chain, and become a 5-star international hotel. The hotel business is very detailed and sensitive than manufacturing. Hotel business is almost called that it has a complete competitor market, since there are many of both demand, and suppliers. The hotel develops marketing innovation by developing brochures by user analysis method and Google maps. They create membership systems to secure local market, from others hotel competitors. Since it became a 5 star hotel, they expand the market to include the medical tourism, and senior citizen. Improving employee skills and talents are the best way to satisfy the customers need. Thus, human resource development is important. This hotel is seeking for proactive personality than training non-proactive employee to new skills. They developed intranet system to increasing work process efficiency and also increasing revenue by tracking customer and collect customer information. Therefore, technology is also important for this hotel. They have adopted technology more than creating their own new technology because of they are not the market leader and do not have enough capital to invest on creating new technology research. Hotel set up the Information Department for controlling communication within organization and also handle website of the hotel. They bought the internet network from their supplier to provide the internet to the customer, since there were a lot of complaints from customers about the internet fees. For external environment, competitor is also important factor in stimulating innovation. Finally, they are also making business alliance to reducing cost, increasing efficiency and revenue. The customer-driven factor is the most important for innovation follow by human resource development, technology, management support and then competitor.

**Case C**

In the past, customers believed that the best service are from the large 5 star hotel with a lot of facilities and great accommodation but now the market has changed their perspective. Small hotels could have a 5 star service which is fulfilled with all accommodation and get along with 5 star hotel standards. This hotel has about 70% occupation from 94 rooms every day on average.

Marketing innovation was created to change customer perspective for small luxury hotel. The strategy of hotel is to train, recruit employee by using EQ test, psychologist test, language test and the manager guts feeling to recruiting employees. Not only skilled, talent and service that employees have to satisfy the customer but also have to be sincere, cheerfulness, respect and service mind. The hotel has significantly improved on training and the hotel accommodation such as technology, room amendment, and decoration. The hotel is running without chain support and believes that the difference is about the reputation and of the chain systems.

They rank the factors that stimulate an innovation as follows, customer, management, human resource development, acquired technology and linkage. The hotel has a policy to train employees annually, and the manager will have a meeting every single day for sharing information, problems, and knowledge. Hotel needs government to set policy to increase barriers to entrance in hotel business in order to avoid a price war and the oversupply of hotel business.
Case D

This hotel is a family hotel without a chain. In the past, there were only German customers but the market has expanded to Middle East customers and some of European, Asian, and American. The hotel focuses target customer in the Middle East and they receive slogan as “If one come to Thailand, one has to stay at this hotel”. This is the marketing innovation of the hotel by introducing new target customer. Most of the customers are walk-in customers. The hotel has to renovate room every year. Most of the customers are an elderly age group since it is located very close to the hospital so it very easy to go to the medical center and receive their medical care and treatment at hospital.

They ranked the important factors and activities for innovation by the following. The first rank is customer driven, as they have the motto “Customer is a King”. The second rank is human resource development. Every employee must have a service mind, a good personality and always think positive. The personality and character is very important for employees. Hotel provides the training and learning process in every year to increase service efficiency. Every employee must study Arabic language especially the maid because they have to interact with customers. The third rank is acquired technology. They use technology to control electricity, water, air-conditioning in the hotel. In addition, they use database to store the information of the customers and use information technology for check-in and check-out system. The forth factor is the management support. This hotel highly concern about the quality of service including cleanliness and security. The leader commits to make customer or tourist feel like a sense of home-like. The last factor is the linkage to other innovation system. The hotel does not care about the competition but rather quality of the hotel is their main priority.

Case E

The most important factors and activities for innovation include customer driven and human resource development. The personality and character of employees are very important and everyone must have a good personality and always think positive. Hotel management provides training and learning process every year to increase service efficiency. Hotel management considers employee personality for each position. Moreover, the salary depends on employee performance. The additional factor is acquired technology. Hotel must have oven to make bakery, and some machines for mixing the drinks. Moreover, there should be computers in the office for accounting system of the hotel and the database to keep the information of the customers and to keep track of customer check-in and check-out. The forth factor is the management support. The leadership style is very simple because this is a family hotel. Thus, once there is any complaint or problem from customers they solve the problem together and discuss how to improve their services. The last factor is the linkage to other innovation system. Hotel management does not see the factor of competition important at all because they are more concern about the quality of the hotel services, customer trust and attaining customer loyalty.

DISCUSSION

The empirical analysis shows that innovations in hotel involve non-technological and technological innovations. Innovations provide opportunities to increase the efficiency and quality of the service delivery process, both in the front and the back office, whilst also facilitating the introduction of new service concepts. The factors that influence to the innovation development in hotels are shown in the following figure.
Therefore, customer’s comment and ideas are the most important to generate innovation to satisfy the customer demand. Human Resource Development; Hotel management developed training and learning process every year to increase service efficiency and also to improve employee skills and talent to satisfying customers need. Successful innovation management depends on the top management of the organization’s willingness to allow individuals, groups, organization to recognize newness. Technology including both software and hardware is also importance for hotel business because they have to follow the change in technology. For example, hotel business uses social network for marketing. They also use software to support their back office. They also use some technology to enhance the service quality. Finally, hotel management sees the linkage to other innovation system not an important factor to stimulate the innovation but it is the driver for innovation.

CONCLUSION

This article has discussed service innovation including characteristics and factor to innovation in the hotel industry located in Bangkok, Thailand. With the increase competition within hotel industry and substitutes industries; Service Apartment affects the hotel to innovate. In hotel business, organization innovations are important, as there is a strong emphasis on the development and implementation of organizational strategy and human resources development to satisfy customer. Hotel management developed small changes or incremental innovations from adaptations of existing service or a new way to deliver a service. Since common characteristics of the hotel sector include participation of customer and service provider. Based on the interviews, all case studies suggested that key success factors driving toward innovation are from their customers and human resource development.

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THE STUDY OF COMMUNITY POTENTIAL IN TOURISM DEVELOPMENT

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ABSTRACT

The study of the development possibility by using logistics system in setting up the complete tourist service center for Samut Songkhram province has the following objectives, i.e. to study the tourist satisfaction of the attractions in Samut Songkhram province, to study community potential and stakeholder regarding logistics management for attractions development in Samut Songkhram province, and development possibility by using logistics in setting up the complete tourist service center for Samut Songkhram province. In this study, the population is the group of Thai and international tourists. However, the study focused at Thai tourists by using sampling method and assigned various attractions around Samut Songkhram as the area of study. The researchers specified sample size of approximately 400 from tourists in the area. The researchers used formula in calculating the size of sample in this study.

KEYWORD
Tourism, Samut Songkram, Community, Logistics

INTRODUCTION

The development of tourism industry in Samut Songkram by logistics tools to reach its most efficiency point is one of the main focuses of Thai government’s policy. As the tourism sector is always one of the main income for Thailand, both local and foreign tourist always spend a massive amount of money for travel and accommodation each year. There are lots of important issues about tourism management such as the tourist flow management, the tourism information flow management and the financial flow in the tourism industry. In this research, the principle, the objective of the research, the research difficulty, the research limitation, the research value, the literature review, the research methodology, the research operation and the conceptual research framework will be mentioned.

PRINCIPLE

Tourism is the activity which creates both manufacturing and service industry to satisfy the need of the tourism. Tourism also play important role for the developing of the country so the Thai government aimed to promote the tourism as its first priority. Samut Songkram, the smallest province in Thailand but has plenty of tourist attraction such as Don Hoi Lot, King Rama II Memorial Park, Amphawa Evening Floating Market, Bang Noi Floating Market, Tha Kha Floating Market, Bang Nok Kwaek Market, Bang Kung Barracks, Wat Bang Kung, Wat Phet Samut Worawihan, Wat Amphawan Chetiaram, Wat Bang Kaphom, Wat Chula Mani, Wat Satthatham, Finding Buddha footprint model in the 9 temples, Krom Luang Chumphon Shrine, In-Jun Siamese Twin, Salt Fields and Watch fireflies at night. The reason which makes Samut Songkram become the favorable choice of tourist is the location which is not far from Bangkok, so the tourists can explore Samut Songkram in the way they prefer (Samut Songkram Province Office, 2011).

However the economics recession and the H5N1 crisis make a large effect to Thailand tourism especially in Samut Songkram which the number of tourists was decreased in both foreigner and local tourists. As Mr.Haruhiko Kuroda, the president of Asian Develop Bank (ADB), mentioned “The H5N1 crisis has create the large negative effect to the tourism and airline industry in Asia for the past 2-3 years”. From the H5N1 crisis, Thailand’s income from tourism industry has been decreased so the government and the private sector start to pay more attention and promote the local tourism more often. Tourism Authority of Thailand (TAT) focused on Thai Culture and Conversation Tourism in 2009 by launch the “12 Months 7 Stars 9 Suns” and “Follow the King Rama V Footstep” campaign and Samut Songkram is
one of the participated provinces that also promote the conversation tourism. The reason which Samut Songkram should be the part of the campaign is Samut Songkram has strongly maintained the life style and identity of itself so Samut Songkram should receive the encourage from both government and private sector to improve itself to be “Ecotourism Province” of Thailand. Also from the second main strategy of Samut Songkram development plan which is “To make Samut Songkram be the center of Ecotourism as the identity of Samut Songkram”

Moreover in 2007, the Ministry of Social Development and Human Security announced the human security index which mentioned “Samut Songkram is the province which has the most human security in Thailand”. Seven elements of the quality of life index are

1. Health
2. Education Level
3. Working
4. Physical Environment
5. Lifestyle
6. Community Environment
7. Culture and Belief.

The human security index showed the potential of Samut Songkram in developing the quality of life in the community. Samut Songkram also has the qualified leader in the community such as Lieut. Patcharodom Ounsuwan, the mayor of Amphawa District, who managed to develop Amphawa District by the idea of sustainable development in sufficient economy. Moreover the Samut Songkram is full of local network-coordinators who play the important role in coordinate between the NGOs and the locals such as Samut Songkram tourism club, local Samut Songkram press, Klong-Klon mangrove forest preserve center, local artist and local philosopher.

However the researcher also realized that there are only a few of the information centers about tourism in Samut Songkram which might not let the tourism industry in Samut Songkram such as transportation business, souvenir store, local restaurant and OTOP operation center OTOP be able to operate in its best condition and also cannot create the identity and become well-known to both foreigner and local tourists. And there is no implementation of the logistics tools into the tourism development even though logistics is the necessary strategy to increase the competitiveness in the business especially the tourism business which focuses on service and the satisfaction of the tourists.

In a globalization world, the concept of tourism logistics is extremely important for communities that rely on tourism as the major source of income. Assistant Professor Komsan Suriya noted in the year 2008 that tourism logistics relatively similar to the subject of tourism and transport, but cover more extensive details. In fact, tourism logistics mainly covered the physical flow, information flow, and financial flow.

In addition, Mingkwan Kawsa-ard, in 2010, added that tourism logistics is more sensitive than product logistic since tourism logistics transfer human from one place to another, also each travelers share different interest. For instance, leisure-oriented tourist has dissimilar needs from recreational tourist and eco-tourism tourist.

Accordingly, tourism logistics management will highlight on the importance of convenience, safety, and punctuality which are the basic needs for every single type of tourist. Logistics for tourism management in Thailand is somewhat unfamiliar. Mr Mingkwan insisted that Thailand still focusing on selling rather than creating management support system which is in fact, the most essential parts of tourism. However, both management of tourism business industry and government organization are critical elements.

The research conducted by the Social Research Institute of Chiang Mai University, supported by the National Research Council of Thailand (NRCT), shows that within the South East Asia region, Thailand is second behind Singapore only in terms of tourism attractive but dropped down to third place after Singapore and Malaysia in terms of government management support. Furthermore, the study also showed that government management support is a major obstacle among Mekong sub-region countries since each country aimed to focus on marketing promotion but failed to improve the management system.

The researchers take into account the importance of tourism logistics or travel service system that focused on tourist flow management, tourism information flow, and financial flow at the same time. According to the preliminary survey, the researchers found that the level of Thailand’s tourist information management is adequate for local tourists but failed to meet the international standard for foreign travelers. Especially in providing public information, such as map information, lost and found, emergency service, tax refund, weather information service (weather forecast), tourism calendar, currency exchange, and important phone number such as the Tourism Authority of Thailand (TAT) call center, etc.
In addition, a perfect tourism logistics means to respond to green logistics trend in order to ease up the global warming issues. For instance, a comprehensive tourist service center that provides information on environmental protection as well as mutually solving the environmental problems by using public parking lot or using shuttle bus service to reduce air pollution.

The researchers pointed out that tourism logistics is very important for tourism development since ideal tourism logistics require collaboration as a cluster between local communities in Samut Songkram province and related organizations from both public and private sectors.

The researcher interests in promoting tourist attraction in Samut Songkram province by evaluate potential of each community towards tourism development using logistics mechanism. Also, integrate management knowledge, science, political science, and political and administrative science together in Samut Songkram province to strengthen and fortify unity among the local people and community.

**OBJECTIVE OF THE RESEARCH**

1. To study the tourist’s satisfaction to the tourism attraction in Samut Songkram.
2. To study the potential of the community and stakeholder in terms of logistics management and development of tourism attraction in Samut Songkram.
3. To develop the logistics framework in order to establish the tourist one-stop service center of Samut Songkram.

**RESEARCH DIFFICULTY**

For this research, the researchers might face the difficulties which are

1. No collaborative from the population
   In this research, the researcher expected to have a good cooperate with the populations of this research which are tourists, government agencies and the business owners. But for some business owners who might feel that the answer that was given to the researchers may affect to the business. This may causes the research questionnaires might not 100% correctly as it should be.

2. Area and Distance of the population
   Although the populations of this research have already been chosen, those populations spread around Sanut Songkram. And those business owners might have a difficult in business which might cause the problem and obstacle to this research.

3. Data collection and Data Security Problem
   To ensure the population who answer the questionnaire that the information they were given will be safe and not publish with the name, the researcher will pay attention to the data security and the information will be well-collected and the name of the population will not be disclosed to the public.

**RESEARCH LIMITATION**

1. Area Limitation
   The metropolitan district of Samut Songkram has 11 sub-districts, Amphawa district has 12 sub-districts and Bangkontee district has 13 sub-districts.

2. Content Limitation
   This research is focused on the development of tourism attraction in Samut Songkram by the logistics tools to improve the community. This research also focuses on the cooperative of the communities to develop the tourism attractions and the local law and regulation in order to study about the every feasible ways to develop the tourism in Samut Songkram.
RESEARCH VALUE

1. Community’s Benefits
   - Train the local philosopher to be the presenter of the local tourism.
   - Have a change to work and share the information with the academician in order to establish the tourist one-stop service center
   - Create the job opportunity and increase the income of the local from the tourist one-stop service center

2. Tourist’s Benefits
   - Tourists will be able travel around Samut Songkram easily and comfortable.
   - Tourists will be able to receive the tourist information about Samut Songkram thoroughly.

3. Academic Profession’s Benefits
   - There will be the research which support the tourism in Samut Songkram and will be the first model for referencing the following research about tourism.

LITERATURE REVIEW

1. Local Community and Tourism Management.

1.1 Definition of local community.

The Royal Institute Dictionary explains that the ‘local community’ is the area and familiar level between individuals as well as the certain fundamental bond that makes a difference to the neighborhood. It has a limit self sufficiency economy compare to the social. By the way, local community has a closer and deeper sympathy that toughen integrity such as race, national origin, and religion. Such meaning is conform to the one provided by Chayan Wattanabhumi (2537:43), stated that ‘local community’ is a village where each member of society share a kinship and has a close relationship between one another in both formal and informal ways. Most of the members are work in agricultural and related fields, share social value of supporting each other as well as retain some aspects of traditional life in the midst of change causing by development process and modernity.

Sproule stated that ‘community’ is a group of people who lived in the same geographic area and share a marriage relationship, religious belief, political aspect, or companionship. Moreover,

Prawet Wasi (1992) indicated that ‘local community’ is an integration of a group of people who share the same objective regardless of the exact geographic area. The group mutually interact, given generosity, conduct activity, learning about community, and establish a local organization which is not the district council. However, district council is a government organization while local administration mainly organized by villagers with an aim to manage their local tasks as much as possible as well as forming a policy on forest and other resources management to connect with other communities as a network.

2. Tourism management in local community

2.1 Community readiness

The readiness of the community is the ability of community to participate in tourism management.

1) Resources availability: Ecosystem related tourism, for example, the community with internal/external resource with noticeable ecosystem or having community relation both in terms of utilization and conservation, etc.

2) Having a local organization or group of people with interest in ecotourism management in parallel with other function of community management.

3) The internal and external cooperation or interaction about conservation, tourism, education and public health which resulted in learning awareness. Pride development within community pride. Thailand Institute of Scientific and Technological Research (TISTR), stated that the community will be carried out effectively, showing public involvement extensively on the basis of self sufficiency and operated by the three main principles,

- Each member must be able to participate in the decision making on local development.
- Each member must put utmost afford in attempt to improve their community.
- Each member must be able to share the benefits of development equally.
3. Development of tourism professionals.

The Tourism Authority of Thailand has given emphasis on development of tourism personnel. Providing essential information plus training session towards student, undergraduate, tourist guide, public official, employee, monk, and novice as well as those evolved in tourism-related businesses, for instance, receptionist, food service staff, chauffeur, street vendor, etc.

The training will focus on providing knowledge about the environmental preservation, instructing volunteers to facilitate travelers as well as maintain tourism resources.

The success of tourism personnel development reflected three aspects of the mission including services, safety, and sustainability. As the result, the National Institute of Tourism Development has been established to instruct the main objectives, for example, to set up a team to provide a human resource development and strategic plan for tourism-related field, to support and coordinate with relevant agencies to prepare a training plan for the establishment of the National Institute of Tourism Development, also to set the benchmark for human resource development for tourism and curriculum development (Tourism Authority of Thailand, 2004) as follows.

1. Promote the development of service officer.
2. Promote the preservation and rehabilitate of the environment.
3. Encourage the participation of the local community.
4. Create the good tourism image.
5. Assign the focus group and develop the marketing plan.
6. Continuously publicize the tourism.
7. Develop the tourism attractions.
8. Develop the tourism activities to promote the tourism.
9. Develop the quality of local souvenir and the distribution of the souvenir.
10. Develop the readiness and service quality of the service facility.
11. Develop and improve the public utility.
12. Develop the primary information technology and the E-commerce system.
13. Develop and control the security system.

4. Tourism

World Tourism Organization or UNWTO defines the meaning of tourism as “The travel which travel for the recreational, leisure or business purposes.” But there are several meanings of “Tourism” which are

Mclntosh and Goeldner (1989) said “Tourism is the result of the phenomenon and relationship between the tourist and service operator which relate to the activity that can cause the satisfaction to the tourist or visitor.”

Berkarty and Medlik (1985) mentioned that “The definition of “Tourism” that was accepted in academic world is from The international Association of Scientific Experts in Tourism (AIEST) which was define by Hunziker and Kraft. Hunziker and Kraft define “Tourism” as the result of the experience and relationship from the travelling and temporary sojournring.”

Gee and Choy (1989) said “Tourism is the travel which make the traveler enjoy the trip and the traveler is the tourist.”

International Union of Official Travel Organization defined the definition of “Tourism” as
1. Temporary travel from the regular habitat to the other place.
2. The travel must be voluntary from the tourist.
3. The travel must not cause by work.

Seksan Yongvanich (1998) described the meaning of “Tourism” as “Tourism is the travel from the normal habitat to the other place temporary by the voluntary and because of the other reason than working and earning income.”
RESEARCH METHODOLOGY

The methodology of this research will be the area survey and in-depth interview with the focus group in order to collect the satisfaction data of both local and foreign tourists in Samut Songkram and the potential of the local community and logistics stakeholder in Samut Songkram which are travel agency, touring guide, transport company, local restaurant, souvenir store, accommodation sector and government agency.

The varieties and numbers of the tourism attractions in Samut Songkram, the increasing of the tourists, the inappropriate management of the tourism activities and the lack of linkage between each tourism attraction are the important problems of Samut Songkram’s tourism. As well as the lack of the connection between the tourist information center in Samut Songkram and the effective public relationship to the potential tourist are the problem of Samut Songkram’s tourism too but in terms of information flow.

The researchers expect the potential of the Samut Songkram tourism will increase and the tourist, the community and the stakeholder will receive the benefit from the tourist one-stop service center in Samut Songkram. So the tourist’s satisfaction will increase and the efficiency of Samut Songkram tourism will increase and sustain. This research process has been designed to 8 processes which are

1. Research Methodology
2. Conceptual Framework
3. Research Question
4. Research Hypothesis
5. Population and Sampling Procedure
6. Data Collection
7. Data Processing and Analysis
8. Data Interpretation and Reporting

RESEARCH OPERATION

This research will operate by the following 10 processes which are
1. Study the current situation and the opportunity of the research study then create the research topic.
2. Assign the objective and research question to find the answer of the research.
3. Design the methodology and choose the research tools to find the answer of the research.
4. Collect the data in both qualitative and quantitative data. There are 2 types of data which are primary data and secondary data. Primary data are questionnaires, interviewing and focus group meeting. Secondary data is to research the existed research.
5. Data gathering process.
6. Analyze the data by using the statistic program and test the assumption.
7. Create the draft of the research.
8. Collect the comments of the research and edited the research.
9. Submit the research to the funding organization.
10. Submit the finished research.

CONCEPTUAL RESEARCH FRAMEWORK

Conceptual Research Framework is important because it will help the research and the reader of this research can clearly understand the necessary of this research. The main issue is the tourism attractions in Samut Songkram because nowadays the tourism business is very important to the country income so to apply the logistics tools to the tourism business, the planning of the tourism attractions and tourism activities is necessary.

As the tourists in Samut Songkram is increasing constantly, this research will study the tourists’ satisfaction of the tourism attractions in Samut Songkram and also study the potential of the community and stakeholder to manage the logistics and develop the tourism attraction in order to apply the logistics to improve the tourism attraction efficiently.

This study will be the framework to improve the tourism business in Samut Songkram by establishes the tourist one-stop service center in Samut Songkram. And it will be associated with the study of the tourism business of the Samut Songkram in physical flow such as tourist movement, tourist’s baggage movement and comfortable of the trip, information flow such as tourist’s information, signs, instructions of each tourism attractions and cautions of each.
tourism attractions and financial flow which are the convenient of payment of transportation cost and accommodation cost. This will be the roadmap to develop the tourist one-stop service center in Samut Songkram which will increase efficiency of the tourism planning and promote the tourism sustainably.

**CONCLUSION AND RECOMMENDATION**

Studying research about guidance to develop logistic system to establish one-stop service for tourists in Samut Songkram has the following objectives

1. Studying about the satisfaction of tourists to attraction area in Samut Songkram
2. Studying about potential of community and stake holder of logistic management to attraction area in Samut Songkram
3. Guidance the developing logistic system to implement in established one-stop service for tourists in Samut Songkram province

Population in this study was Thai and foreign tourists group but in this study focused on Thai tourists group by sampling in studying area was around attraction areas in Samut Songkram province. Specifying size of tourist population in term of number coming in Samut Songkram average at 400 persons. Researcher inspected the perfection of questionnaire episode that they were completed for 397 copies, not completed for 3 copies that they were unable taken in processing so they were calculated by sampling formula

This research was prepared by collected data to analyst such as questionnaire had the studying of concept and theory related Chapter II in order to take it to be guidance for this study and research to reach the target specified by separate questionnaire for three sections as follows:

Section I. General data of respondents such as gender, age, education, career, average income per person, current address, province/country, family member and status

Section II. Data about the satisfaction of attraction area in Samut Songkram

Section III. Data about the potential of logistic management to develop attraction areas in Samut Songkram
Section I. General data of respondents such as gender, age, education, career, average income per person, current address, province/country, family member and status

This study found that tourists who answered the question was women for 52.6% and man 47.4%. From data shown that tourists who answered the question had the proportion between man and woman almost to be equal, it might affect travel at Samut Songkarn to be couple or group so the proportion between man and woman was not more difference. From tourist data their age were during 13-20, 21-28, 29-39 and 37-44 year-old, those ages showed that mainly they were the teenage, working age, and family group. The most ages was working age because this ages preferred to relax by traveling after work. Who answered the questionnaire was Thais at 100 percents from data shown that all of them were Thais. Thais preferred to go to Samut Songkarn, which was the attract area, than foreigner. Tourists group lived in ten provinces that the most they traveled at Samut Songkarn from data shown who answered the question lived in Bangkok and around Bangkok due to Samut Songkarn province was near these provinces and convenient transportation also taking a bit time included it had several attraction areas and beautiful places. From data shown that tourists who answered the question mostly they were single also the most attraction places was working age. Most of them were single and working age. The youths were not married so they preferred to free travel because it had several attraction areas. The tourists group who answered questions were mostly graduated Bachelor’s degree because who answered question were working age from Bangkok and around Bangkok that they preferred to travel in Samut Songkarn province. Tourists who answered the question were mostly studying Bachelor’s degree who traveled during weekend included government officer and private company. Tourists group who answered question mostly had income between 5,000 and 20,000 Baht, they were grade B or middle level because Samut Songkarn province was the attraction area which had expenditure not much high. The objectives of the most tourists who answered the question was relax, it was the convenience area and many beautiful places, expenditure not much also it was optimal with traveling on weekend. The most tourists who answered the question known more about Amphur Amphawa because it was well advertised and public relation or PR that made the tourists remember about the places and when they traveled Amphawa, they were impressed also this place was beautiful, good atmosphere, traditional community, and traditional culture of life style so this point become tourists were well-known about Amphawa.

Section II. Data about the satisfaction of tourists to attraction area in Samut Songkarm

From studying about the attraction areas in Samut Songkarn province was found that the tourists had experience to travel at Samut Songkarn. The most tourists who answered the question had never been there that was the first time of them. From data analysis was found that tourists had been there at the first time then they had been repeat there or more have been there than two times at this point shown that Samut Songkarn had the potential to create the impression and interesting for tourists to come traveling back. The season when tourists preferred to travel was during April to September when was the long weekend or many festivals for example Songkarn festival, end of semester of students and in summer season had been boosted about tourism because Samut Songkarn had many natural places and floating market as the result they could be good to relax. The characters of tourists to travel at Samut Songkarn were friends group or family or tour group, training, and seminar because attraction areas were concerned about traveling of natural, cultural and floating market that to be optimal with those travels. The most travel groups was the middle size for group members since 5 till 10 persons another character which was the family group was big size group was the number of tourists more than 20 persons this character group was the held-seminar and most character was tour group. The vehicles for tourists going to Samut Songkarn was popular divided for two kinds one was the private car which was the family another kind was the tour group service car like the bus which was the vehicles able to obtain many number tourists. The most tourists in Samut Songkarn were a day travel due to attraction area in Samut Songkarn was near distance and convenient transportation. For tourists went to the Samut Songkarn if they stayed overnight, they preferred to the resort mostly because it was good atmosphere and nature also it made tourists felt they were a part of there; moreover, they could absorb the cultural and lifestyle of Samut Songkarn community. Tourists liked floating market the most due to floating market was famous and well-known in Samut Songkarn. The selling point was the lifestyle of riverside person integrated with eating culture of local person and natural environment was the main point for tourists to remind Samut Songkarn province. On the whole the feeling of tourists to attraction areas in Samut Songkarn province mostly they were impressed. From this tourists analysis group was probably they went to Samut Songkarn in the first time another group they felt indifferent might be they went to Samut Songkarn many times but those feeling to be happened on tourists affected the repeating tourism here

Section III. Satisfaction of tourists to attraction areas in Samut Songkarn province in term of potential of community and stakeholder of logistic management to attraction area in Samut Songkarm

From studying about satisfaction of tourists to attraction areas in Samut Songkarn province in term of the potential of community and stakeholder of logistic management to attraction area in Samut Songkarm was found that the providing service for tourists had influence factors to make a decision traveling in Samut Songkarn province for example
the quality of route to go to attraction areas which was made the convenient transportation also to consider about the distance included quality of the resting place such as resort, hotel and home stay if the resting place has be created to selling point in attraction areas, apparently the tourists were impressed as a result tourists have decision to travel there again additional to create the variety for tourists to access the services and to create the satisfaction to tourists at middle level. The service was surveyed by accessing service of tourists. In term of facility to buy the car and train ticket place saw that these service the tourists were difficult to access also had not facility serve to them. Not only the news provided for tourists they could be good to access but also news of attraction areas and public attraction activity they could communicate that both of them were made tourists good understood. The subject was providing transportation service and communication were analyzed about the using service of tourists become fast to transport by car at attraction areas in Samut Songkarm which had many routes to access so the distance of transportation was reduced therefore tourists were satisfied. Satisfaction of tourists to attraction areas in Samut Songkarm province in term of taking care tourists and made them impressed was quality of food service in attraction areas because of the major attraction areas which tourists preferred to go there were floating market which was the variety of foods service and good test for tourists together with environment and local culture, all of these made more and more tourists impressed. As a matter of fact providing the security officer guarded in attraction areas that shown about taking care tourists and made them impressed and they felt encouraged more that there was officers to take care. Satisfaction of tourists to attraction areas in Samut Songkarm province in term of facilities about the providing service to tourists still not covered and not met standard particularly public transportation car service also still not be comfortable and had not quality for tourists actually this service was necessary for them and might be developed more quality. Satisfaction of tourists to attraction areas in Samut Songkarm province in term of safety was created the confidentiality for tourists, for instance not only safety on the route of tourists both the route to go to Samut Songkarm province and connecting route from attraction area to another attraction area were been comfortable and easy to access as the result they could take a bit time to arrive there but also safety of tourists using service was main attraction areas in Samut Songkarm for example floating market, temples and museums were both in charged and assisted by officers in community consequently tourists felt safety in that attraction areas in Samut Songkarm province by the way the quality of foods was important at attraction areas in Samut Songkarm where had the good test foods service which was healthy standard cooking in this province because it was cooked by natural material and fresh from local as a result it made tourists believed in that foods when they eat. Satisfaction of tourists to attraction areas in Samut Songkarm province in term of friendly environment, tourists had the ideas doing not both leave garbage and pollution from vehicle were important things therefore these pollutions would be either destruction nature or destruction traditional life style of Samut Songkarm community so these were the selling point of this province beside tourists went to there because it has good atmosphere, no pollutions and noise in significant attraction areas. Satisfaction of tourists to attraction areas in Samut Songkarm province was attractiveness tourists hence it was interesting and variety of attraction areas for instance floating market was not only the tourism center but also sold the feature riverside community and good test foods included environment of traditional culture community or ancient beautiful temples, Samut Songkarm was the one province which had most temples in Thailand as the result tourists needed to travel as oriented Buddhism mostly they were missed Samut Songkarm such another one province for the activity of attraction areas, connecting with other activities had been related and combined any way time management and attraction areas were combined so interesting and variety of goods, gifts of Sumut Songkarm were been quality product this mean that was the symbol of Samut Songkarm. Satisfaction of tourists to attraction areas in Samut Songkarm province in term of entertainment during transportation, interesting in the route during transportation were important because of Samut Songkarm was small and it had many places interesting and holding tourism activity related additional tourists could be complete travel within one day also there were many activities interesting such as giving the foods offering to monks in the morning, sailing to pay respect to Buddha, going to floating market and sailing to see firefly were activities held to boost entertainment for tourists impression. Satisfaction of tourists to attraction areas in Samut Songkarm province in term of facility provided for tourists who were most impressed with restaurant, clean and good test because Samut Songkarm was the source of fresh and new seafood the most important was it was not high price so knowledge center was covered and accessed by tourists who were served by this center very good another thing about the gift shop and souvenir not only had many products but also had feature and telling that it was products from Samut Songkarm further to create tourists were good impressed and remember.
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FLAGGING OUT AND ITS IMPACT ON AUSTRIAN ECONOMY: THE EVIDENCE OF THREE CONSECUTIVE RESEARCH PROJECTS WITH FOCUS ON THE UNIQUE POSITION OF AUSTRIA AS GATE TO EASTERN EUROPE

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FLAGGING OUT AND ITS IMPACT ON AUSTRIAN ECONOMY: THE EVIDENCE OF THREE CONSECUTIVE RESEARCH PROJECTS WITH FOCUS ON THE UNIQUE POSITION OF AUSTRIA AS GATE TO EASTERN EUROPE

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ABSTRACT

The aim of this paper lies in describing, analysing and assessing the importance of flagging out of transport vehicles and its impact on the Austrian economy as well as on quantifying the overall macroeconomic costs. It shall further contribute to a systematic and rational discussion of the topic. Several publications have shown the significance of the problem - however there is still no study which reviews the related development over an extended period of time and addresses the basic consideration leading to the implementation of these strategies. The flagging out of transport vehicles, which means the licensing of national motor trucks abroad, has become a popular strategy in the transport industry (particularly in Austria) following growing cost pressures over the past years (Kummer et al., 2003, 2006, 2009). The topic of operating non-national trucks on an international as well as national scale is not new to the European road haulage (as the example of Luxembourg shows) but flagging out seem to have increased considerably after the EU enlargement of 2004 (Butzke, 1999; Bergrath, 2000; IRU, 2001; CNT, 2003; Kummer et al., 2006; Cordes et al., 2006). The practice has become attractive especially for medium and large companies. Due to recent changes in cabotage regulations by the European Union the trend seems to persist as the degree of competition in the transport industry remains relevant. (ECORYS, 2004; Spendel, 2006; Knorre, 2008)

KEYWORDS
Flag Out, Transport Vehicle, Macroeconomic Costs

EMPIRICAL EVIDENCE OF THREE CONSECUTIVE RESEARCH PROJECTS IN AUSTRIA

Research Design and Methodology

In 2003, 2006 and 2009 three subsequent waves of surveys on the topic of flagging out motor trucks by commercial Austrian road transport operators, respectively. It was assumed that flagging out can be reasonably performed by companies with a fleet of more than 20 tractive vehicles only. For smaller companies the related costs for founding and maintaining a subsidiary abroad would probably exceed the attainable cost savings. Therefore the survey was restricted to commercial Austrian road transport operators with a significant fleet of more than 20 motor trucks. Furthermore, these companies owned the majority of trucks above 2 tonnes maximum total weight registered in Austria (Statistik Austria, 2009; WKO, 2009). As according to our market knowledge a maximum of 100 road haulage operators are included in this category. Most of the relevant companies have been asked to participate in the panel. Surveys have been conducted in 2003, 2006 and 2009. This research design is conclusive as it is one of the most reliable longitudinal research methods which are frequently used to track the development of dynamic processes.

The sample size at the survey 2009 was 76 (Kummer et al., 2009). A net sample of 25 companies actually participated at all three surveys. The authors presume that due to the high coverage of the relevant population these rather small sample sizes are sufficient to draw valid conclusions about the amount and the impact of flagging out in Austria.

1 The studies were were conducted by the Institute of Transport and Logistics Management of WU Vienna /Vienna University of Economics and Business) on behalf of the Transport Department of the Austrian Chamber of Commerce.
For this a structured questionnaire was developed comprising 20 mostly closed questions including both questions of fact and questions of opinion. Questions raised in every survey were about the amount of drivers employed and the vehicles registered in Austria as well as abroad. Moreover motives of flagging out, preferred and actual host countries to flag out vehicles and cost structure of trucks abroad were addressed.

Several hypotheses and research questions have been raised. Moreover behavioural patterns and their respective changes over time have been investigated. It was assumed, for instance, that the Austrian transport policy is unable to sustainably influence the cost structure of transport companies in a way, which could stop the process of flagging out vehicles with cost savings remaining the predominant motive for flagging out. An indication could be the absolute decline of the stock of vehicles registered in Austria which consequently induces unemployment in the national transport industry.

**Status and development of flagging out in Austria**

In fact, data gives evidence that the attempts set by the Austrian government to reduce flagging out tendencies did not have any long-term effect. Therefore flagging out seems to be a dominant and sustainable cost saving strategy as the number of vehicles flagged out has already reached a significant high level. Based on corporate planning data it could be forecasted that in 2011 almost every second vehicles will not be registered in Austria (compare Figure 1). This will lead to high losses of tax-income as quantified later.

Based on the data examined by the surveys of 2003, 2006 and 2009 a continuous increase of motor trucks flagged out could be assessed. It turned out to be valid when asking them after trucks actually flagged out afterwards from 2004 to 2009.

The decline of the flagging out rate from 2006 to 2007 (compare Figure 2) could be attributed to the following:

- decrease of the motor vehicle tax (the tax was reduced significantly by 50 percent by July, 1st 2007)
- cost increase in attractive flagging out countries, e.g. direct and ancillary labour costs
- general economic revival in 2007

As a result the Austrian road freight transport companies, especially smaller hauliers, seem to have reflagged their trucks to Austria around 2007 due to recurring economic benefits. Because of the economic slump this trend was only short-dated as the given tax incentives were not sufficient. Therefore in 2008 and 2009 the amount of trucks operated by commercial Austrian hauliers registered abroad raised again. Moreover, taking projection of the respondents in 2009 how many trucks they want to flag out and estimates about total number of trucks in commercial operations registered at Austria given, in 2011 the majority (50.6 %) of trucks run by Austrian hauliers with a fleet of more than 20 trucks will be registered abroad. According to the respondents especially the flagging out of vehicles in the long-distance transport was referred to as essential for economic survival. Whereas the flagging out of vehicles in short-distance transport is not yet required, it will get more important in the future particularly if the Austrian government will not support the transportation sector by means of reduced taxation or comparable measures.
Favourite countries for flagging out

Figure 3 depicts the most preferred countries for registering trucks abroad. Eastern European countries integrated to the EU in 2004 and in 2007 are thus preferred by most respondents. The EU 15 has lost attractiveness within the three waves of surveys in 2003, 2006 and 2009. In 2009 Portugal was no longer named. Also Poland, Slovakia, the Czech Republic or Slovenia have lost attractiveness. This can be traced back inter alia to a first alignment of wage levels to European Standard.

Motives for flagging out

The most important explanatory variables in all three subsequent surveys are the direct and ancillary labour costs closely followed by the motor vehicle tax. Furthermore the motive ‘better market position in host countries’ was one of
the key drivers in 2003 but has lost importance over time. This could be ascribed to the fact that the European long-distance transport market becomes more homogeneous. Hence the market visibility in only one country, e.g. in the mother country, becomes less important. Other reasons for flagging out can be found in figure 4:

**FIGURE 4**
MOTIVES FOR FLAGGING OUT 2003-2009

**Impacts of flagging out on the national economy**

In order to assess the impact of flagging out on the overall economy, fiscal losses for the Austrian government were quantified. In the following tables the burden of flagging out for the Austrian government is quantified both in proportion of trucks being registered abroad and fiscal losses from loss of taxes etc.

Table 1 gives an aggregated survey of the overall financial burden.

**TABLE 1**
BURDEN OF FLAGGING OUT 2006-2009 AND ESTIMATES 2010-2011

<table>
<thead>
<tr>
<th>Year</th>
<th>Fiscal losses caused per truck flagged out in EUR</th>
<th>Proportion of trucks flagged out in percent</th>
<th>Trucks run by companies with a fleet of more than 20 trucks</th>
<th>Total amount of trucks being flagged out in EUR</th>
<th>Fiscal loss for Austrian government in EUR</th>
</tr>
</thead>
<tbody>
<tr>
<td>2006</td>
<td>45.106</td>
<td>32.4</td>
<td>14.348</td>
<td>6.877</td>
<td>310.195.488</td>
</tr>
<tr>
<td>2007</td>
<td>45.687</td>
<td>29.0</td>
<td>14.793</td>
<td>6.055</td>
<td>276.633.453</td>
</tr>
<tr>
<td>2008</td>
<td>45.391</td>
<td>31.9</td>
<td>14.292</td>
<td>6.691</td>
<td>303.713.322</td>
</tr>
<tr>
<td>2009</td>
<td>47.107</td>
<td>36.3</td>
<td>13.863</td>
<td>7.884</td>
<td>371.389.932</td>
</tr>
<tr>
<td>2010</td>
<td>47.625</td>
<td>44.0</td>
<td>13.447</td>
<td>10.584</td>
<td>504.062.626</td>
</tr>
<tr>
<td>2011</td>
<td>48.149</td>
<td>50.6</td>
<td>13.044</td>
<td>13.344</td>
<td>642.498.112</td>
</tr>
</tbody>
</table>

Table 1 reveals that financial burden has increased from EUR 310 million in 2006 to EUR 370 million in 2009 and is proposed to double between 2006 and 2011 to EUR 640 million. The table is the result of a detailed analysis of labour-related costs and those costs depending on vehicles.

Positions (1) to (7) include labour-related costs and (8) to (12) represent vehicle-related costs of flagging out within one year (2009). In the following table 2 these costs are shown in detail.
A way to reduce flagging out could be the reintroduction of subsidies which were cancelled some time ago. However this support should be restricted to environmental-friendly and save vehicles. Thus there would not only be an incentive for investments strengthening economic prosperity but would also foster the modernization of the fleet. In addition, a reduction of the ancillary labour costs should be discussed. Eventually further to the fiscal and economical arguments a significant vehicle stock in Austria could be a factor to retain Austria’s attractiveness as a logistical location.

**DISCUSSION AND CONCLUSION**

The study revealed that national transport policy basically is not capable of provoking substantial changes of flagging out tendencies. Against this background a standardized European Regulation of vehicle registration taxes could be a starting point, in order to prevent competition among member states.

Flagging out transport vehicles still is a rather uncomplicated procedure in the European Union. Contrarily to the relocation of a manufacturing plants to countries with lower labour costs involving investments risks as well as and complex process reengineering, transport companies intending to flag out a vehicle only have to register it in a different country, an easy task with substantial effects on transport markets and national economies.

According to the results presented one vehicle flagged out leads to huge fiscal losses for the Austrian government. Nonetheless our findings suggest further investigation in order to indicate additional revenues which can be realized in those countries mostly preferred for flagging out. Especially in a holistic framework lost income in one particular country is accompanied by additional revenues in another one.

Although Austria has a unique geographic position in the heart of Europe which supports the trend of flagging out vehicles first expert interviews have already revealed that flagging out tendencies can also be identified in Germany. Moreover a first survey shows that due to the non-EU-member-status of Switzerland, the geographic location as well as due to enormous national pride this phenomena is less known and realised in Switzerland.
REFERENCES

AMS (2009), *Arbeitsmarktdatenbank des AMS*, Vienna.


ECORYS (2004), *Study on Road Cabotage in the Freight Transport Market*, ECORYS Nederland BV, Rotterdam.


PRACTICAL GAMES FOR SUPPLY CHAIN MANAGEMENT COURSES

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ABSTRACT
The purpose of this paper is to present practical games that can be used as a tool to teach student one aspect of supply chain management (SCM) course. We developed a game representing a supply chain structure that has three entities: supplier, plant, and customer. The game uses simple building block toys to practice order replenishment activities along the supply chain. The winner in this game is a supply chain team that achieved lowest supply chain costs. This practical games had been played and validated by 72 students who taken SCM and logistics management courses. The results show that most students who had played the game indicated that they are interested with the practical games. Validation results indicate that the students feel that the game is easy to understand and able to enhance their comprehension about supply chain management.

KEYWORDS
Teaching Method, Supply Chain Management, Practical Game, Supply Chain Cost

INTRODUCTION
Teaching of supply chain management (SCM) is one of emerging issues in SCM research. This issue had been discussed in academics meeting (e.g., INFORMS meeting in 1995, 14th annual North American research and teaching symposium on purchasing and supply chain management in 2003). It also had been published as special issues in academic journals e.g., production and operation management (POMS) in 2000, INFORMS transactions on education in 2006, operations and supply chain management: An international journal (OSCM) in 2009). Many universities teach SCM as an important part in other management subjects such as logistics or operation management. For example, Wassenhove and Corbey (1998) pointed out that all of the top MBA programs in operations management core have been augmented with significant content on supply chains.

The Beer Distribution Game (Beer Game) is a famous SCM simulation game that was developed by MIT Sloan School of Management in the 1960s. It simulates material and information flows of four players in a supply chain (factory, distributor, wholesaler, and retailer) from the factory to the retailer. This game is played by students to understand the barriers to supply chain performance and conveys key supply chain concepts (Sparling, 2002). Lee et al (1997) believe that main benefit for students who played Beer Game is easier to understand the existence and the characteristics of the “Bullwhip effect”. However, some researchers said that simulation games are ineffective teaching tools for students particular in undergraduate students who have no exposure to SCM subject and experience.

Many SCM experts criticize the Beer Game simulation. Kaminsky and Simchi-Levi (1998) pointed out that Beer Game does not provide a better way to manage the supply chain because their structure does not provide a realistic view of a supply chain. Kimbrough et al (2002) show the lack of player behaviors because they are not motivated to share information when they join in a supply chain. Chen and Samroengraja (2000) suggested that players do not know demand process and pattern of distributions in other entities. A better teaching tool is needed by the lecturers to deliver SCM courses to students. Zeng and Johnson (2009) pointed out that simulation games are ineffective teaching tools for students, particularly for undergraduate students who have no exposure to SCM subjects and experiences.
This paper presents a practical game as an attractive teaching method to help SCM undergraduate students to understand some materials in SCM. The building blocks and forms (purchase order, delivery order, others forms) are used to play the practical game developed. The research stages leading to this game has been developed in such a way, including pre-testing, to ensure that the game is understandable and capable of delivering messages clearly.

**LITERATURE REVIEW**

Academicians had discussed curriculum not only to revise contents of SCM course, but also to develop teaching methods and tools to deliver SCM. Several researches had been conducted to evaluate and design innovative ways in teaching SCM. Academic papers related to teaching SCM can be divided into two areas, i.e., curriculum (contents) and teaching methods and tools (processes). We list 17 articles related to teaching SCM in Table 1, classified based on the purpose and the focus. The focus could either be the curriculum or content (A) or the method of teaching (B). Curriculum is a set of course and their contents, whereas teaching method is the way and equipments (hardware and or software) needed to achieve these purposes of teaching. The teaching methods are divided into two categories, i.e., (1) simulation and (2) lab works.

<table>
<thead>
<tr>
<th>No</th>
<th>Authors</th>
<th>Year</th>
<th>The purpose of research</th>
<th>Topic Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Kaminsky and Simchi-Levi</td>
<td>1998</td>
<td>Develop a new computerized beer games as tools for teaching the value of integrated SCM</td>
<td>B (Beer game simulation)</td>
</tr>
<tr>
<td>2</td>
<td>Anderson and Morrice</td>
<td>2000</td>
<td>Propose a simulation game designed to teach service-oriented SCM principle and test whether managers use them effectively.</td>
<td>B (Simulation game)</td>
</tr>
<tr>
<td>3</td>
<td>Campbell et al</td>
<td>2000</td>
<td>Discuss four experiments and experiences with the use of SCM software (CAPS logistics software)</td>
<td>B (Software application)</td>
</tr>
<tr>
<td>4</td>
<td>Chen and Samroengraja</td>
<td>2000</td>
<td>Develop new game the stationary beer game that models the material and information flows in a production-distribution channel</td>
<td>B (Beer game simulation)</td>
</tr>
<tr>
<td>5</td>
<td>Jacobs</td>
<td>2000</td>
<td>Investigate the implementation of Beer distribution games in internet</td>
<td>B (Beer game simulation)</td>
</tr>
<tr>
<td>6</td>
<td>Johnson and Pyke</td>
<td>2000</td>
<td>Propose a framework for teaching SCM that are supported by material and pedagogy</td>
<td>A</td>
</tr>
<tr>
<td>7</td>
<td>Kopczak and Fransoo</td>
<td>2000</td>
<td>Develop teaching SCM though global project with global project teams</td>
<td>A</td>
</tr>
<tr>
<td>8</td>
<td>Mehring</td>
<td>2000</td>
<td>Develop Siemens brief case game supply chain simulator to provide a practical setting for experiential learning exercises about supply chains</td>
<td>B (Simulation game)</td>
</tr>
<tr>
<td>9</td>
<td>Vollman et al</td>
<td>2000</td>
<td>Investigate four issues of teaching SCM to business executives</td>
<td>Curriculum</td>
</tr>
<tr>
<td>10</td>
<td>Sparling</td>
<td>2002</td>
<td>Develops a strategy for teaching SCM that modified Beer Game simulation and provide the tools for accomplishing both an introdutory and a more advanced simulation.</td>
<td>B (Beer game simulation)</td>
</tr>
<tr>
<td>11</td>
<td>Reyes</td>
<td>2006</td>
<td>Describes how the well-known Shapley Value concept from cooperative game theory as supply chain management strategy teaching tools that can be used to solve the transshipment problem</td>
<td>B (game theory)</td>
</tr>
<tr>
<td>12</td>
<td>Liu et al</td>
<td>2006</td>
<td>Investigate how to use web-based learning system to assist the teaching of SCM</td>
<td>B (web based learning)</td>
</tr>
<tr>
<td>13</td>
<td>Sauber et al</td>
<td>2008</td>
<td>Identify the process of designing and measuring learning competencies in SCM program development</td>
<td>A (Learning competencies)</td>
</tr>
<tr>
<td>14</td>
<td>Gonzales et al</td>
<td>2008</td>
<td>Develop a new customer-centered SCM undergraduate curriculum using Quality Function Deployment (QFD), Benchmarking and other innovative quality techniques</td>
<td>A</td>
</tr>
<tr>
<td>15</td>
<td>Dhumal et al</td>
<td>2008</td>
<td>Present a game that can be used as a tool to educate students and managers on the issues in SCM and inventory management</td>
<td>B (Simulation games)</td>
</tr>
<tr>
<td>16</td>
<td>D’Atri et al</td>
<td>2009</td>
<td>Develop a simulation for supply chain and virtual enterprise that are based on the rules of the Beer Game</td>
<td>B (Beer game simulation)</td>
</tr>
<tr>
<td>17</td>
<td>Zeng and Johnson</td>
<td>2009</td>
<td>Develop a discovery-based laboratory as supplement operations management course when the fundamentals of SCM sections are taught</td>
<td>B (discovery-based laboratory)</td>
</tr>
</tbody>
</table>
In summary, most of papers related to teaching SCM investigated teaching methods and tools areas. It indicates that teaching methods and tools are still interesting by researchers. In teaching methods and tools, simulations game particularly the Beer simulation games are often developed as tools to teach students. However, a few articles develop practical game. They need attractive game to easy understand SCM concepts.

The above table suggests that research in the area of supply chain pedagogy is an interesting field. Game has been considered as a popular alternative way of the more traditional lecturing model. Many of the games designed by educators are computer-base, making it less interactive and less fun for students. For undergraduate students with no hands on experience in supply chain management area, it is important to design a game that provide a situation closer to real situation. As suggested by Zeng and Johnson (2009), some games are inappropriate for undergraduate students that have no practical experiences and are first-time learners for SCM course.

DESIGN OF PRACTICAL GAMES

The game is designed based on four aspects: (1) specific topics of SCM which will be covered in the practical game, (2) game description including the use of game equipments and tools, (3) rule of the game, and (4) game performance indicator. We have discussed four aspects in order to design the proposed practical games. We decided that this practical game covered a few supply chain introduction (about supply chain structure and responsibility of SCM manager), purchasing management and supplier relationships. Supply chain introduction is related to supply chain structure and the flow of information, money, and material along the supply chain. Purchasing management is the main topics that will be delivered in this game. The specific issue in each SCM material that are covered in practical games is shown in Table 2. This game uses simple structure of supply chain which includes (1) supplier with six players (two players), (2) plant (three players; one as manager and the two as assembler), and (3) customer (one player). The simple supply chain structure enables students to easily understand the interaction between supply chain members of supply chain. The players in chain and product and information flow in the proposed practical game are depicted in Figure 1.

Building blocks are used because easy to be assembled and many types of products can be built. The parts of building blocks represent components and the final assembly products represent the final products. The practical games use two final products, namely product A and product B. Some forms are provided such as purchase order form for SCM player, delivery form for supplier and SCM player, and performance form for customer player in each team.

FIGURE 1
PLAYERS AND INFORMATION PRODUCTS AND FLOWS IN PRACTICAL GAMES
The rule of the game can be described as follows. The game is started with first order that is placed by the customer to the plant. Amount of final product for each order, order time, and due date of order completion have been designed randomly by the researcher to represent uncertainty of orders in terms of time and quantity of product. The uncertainty condition enables players to use their own strategy to fulfill customer orders. There are a number of 15 orders from customers, which is played in about one hour. The customer orders are listed on Table 1.

**TABLE 1**

<table>
<thead>
<tr>
<th>No.</th>
<th>Product Type and Amount</th>
<th>Inter arrival time of order (menit)</th>
<th>Due Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Product A (3), B (5)</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>2</td>
<td>Product A (4), B (4)</td>
<td>7</td>
<td>4</td>
</tr>
<tr>
<td>3</td>
<td>Product A (5), B (4)</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>4</td>
<td>Product A (4), B (7)</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>5</td>
<td>Product A (10), B (12)</td>
<td>2</td>
<td>7</td>
</tr>
<tr>
<td>6</td>
<td>Product A (12), B (8)</td>
<td>4</td>
<td>7</td>
</tr>
<tr>
<td>7</td>
<td>Product A (3), B (3)</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>8</td>
<td>Product A (3), B (2)</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>9</td>
<td>Product A (3), B (4)</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>10</td>
<td>Product A (3), B (5)</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>11</td>
<td>Product A (5), B (4)</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>12</td>
<td>Product A (10), B (15)</td>
<td>3</td>
<td>7</td>
</tr>
<tr>
<td>13</td>
<td>Product A (13), B (15)</td>
<td>4</td>
<td>7</td>
</tr>
<tr>
<td>14</td>
<td>Product A (4), B (5)</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>15</td>
<td>Product A (5), B (5)</td>
<td>3</td>
<td>4</td>
</tr>
</tbody>
</table>

After receiving customer order, SCM manager must order the components that are needed to produce the amount of products in each type of products (Product A and B) to suppliers using purchase order form with due date. Amount of customers order and bill of material each product is an importance information that is used SCM manager to decide purchase order to supplier. SCM player gives due date to the supplier in order to anticipate on time completion of the order. The maximum order that is allowed is 100 unit of components per purchase order. Backorder cost will be charged if SCM player delivers final product overdue.

To measure the team performance in the practical game, we used four performance indicators such as (1) opportunity costs, (2) backorder costs, and (3) purchasing costs, and (4) inventory costs. Opportunity cost is a penalty charged to the plant if the plant could not fulfill customer order until the end of the game ($25 per unfulfilled order). Backorder cost is a penalty cost charged to the plant if it cannot fulfill order on time in accordance to customer due date ($5 per late order). Purchasing cost is charged $10 per purchase order and carrying cost is $0.5 per unit component/part per period.

**TESTING AND VALIDITY**

The proposed practical games have been played and validated by 72 students in 12 groups who are studying in SCM and logistics management courses. Validation is used to ensure the objectives of the game can be achieved. After playing the game, the students were asked three questions on their perception about the game. The first question is about whether or not they feel that the game is interesting. The second question is whether or not the game was easy to understand and easy to play. The results suggest that all students were interested with the game. Most of them said that they are passionate to compete and achieve the best performance among supply chain teams. They also said that the game could help them in understanding the interactions among the supply chain players. In addition, most students said that the rule of the game is easy to understand. Most students also said that this game is easy to be applied because of the use of simple description, simple rules and common equipments and forms such as building blocks, purchase order and delivery form.
Beside validating the technical aspects of the game, we also validate the course objective addressed in the practical game. We use an open questionnaire to know the level of understanding of each player after playing the game. Table 2 shows the detail achievement of course objectives.

**TABLE 2**

RESULTS OF COURSE OBJECTIVE ACHIEVEMENT

<table>
<thead>
<tr>
<th>Course objective in the practical game</th>
<th>Question</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supply chain structure</td>
<td>Please describe the supply chain structure</td>
<td>Most of students understand this point (87.5%)</td>
</tr>
<tr>
<td>Type of flow along the supply chain</td>
<td>Describe the type of supply chain flow and the direction for each flow.</td>
<td>Most of students quite understand this point (61.0%)</td>
</tr>
<tr>
<td>Supply chain manager responsibility</td>
<td>Describe the responsibility of supply chain manager</td>
<td>Most of students understand this point (98.6%)</td>
</tr>
<tr>
<td>Supply chain costs</td>
<td>Mention the costs on supply chain</td>
<td>All of students understand this point (100%)</td>
</tr>
<tr>
<td>Purchasing objective</td>
<td>Describe the objective of purchasing</td>
<td>Most of students understand this point (98.6%)</td>
</tr>
<tr>
<td>Purchasing process</td>
<td>Describe the purchasing process including the form needed</td>
<td>Most of students understand this point (86.1%)</td>
</tr>
</tbody>
</table>

Each group was also required to calculate the total costs achieved. As mentioned above, the total costs consists of four components, namely (1) opportunities costs, (2) back order costs, (3) purchasing costs, and (4) holding costs. Table 3 shows the results of performance each group using supply chain total costs. The results indicate that total supply chain management costs show large variations among groups. Some performance indicators are also largely different especially the opportunities costs. The type of purchasing strategy selected by each group influence the total supply chain management costs.

**TABLE 3**

THE RESULTS OF PERFORMANCE INDICATORS EACH GROUP

<table>
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<th>Back order costs</th>
<th>Purchasing costs</th>
<th>Holding costs</th>
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**DISCUSSION AND CONCLUSION**

The practical games have been developed, as attractive new games for SCM teaching. Experiments and validations of games had been conducted by undergraduate students. The results show the positive opinions from students who played the games. They feel that the game is interesting to play, easy to understand, and easily practiced. They also indicate that the game help them in understanding some materials in supply chain management particularly purchasing management and supplier relationship. Nevertheless, there some opportunities for improving and extending the current game to incorporate more realistic situation, but can be played with less time.
REFERENCES


CONTAINER TERMINAL APPOINTMENT SYSTEM FOR SCHEDULING CONTAINERS’ PICK-UP OPERATIONS

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ABSTRACT

The stable growth of the worldwide maritime container traffic volume has enhanced not only bigger business opportunities, but also more intense competition among the container terminal operators (CTs). CTs are rallying to improve their container handling service for both their maritime interface and their landside interface partners. While many of the CTs’ studies have been focusing on the maritime side operations, we concentrate our study on the landside operations. Learning from a test case done in one of the biggest CTs in Europe, we remark that the application of the existing CT’s reservation system performs poor performance in coping with high occupancy level of containers pick up (import) requests. The existing system does not provide a specific confirmation regarding the permissible pick up execution time window to the upcoming drayage trucks (DT) clients. This lack of clarity limits the DTs’ and the CTs’ ability in doing their operational planning and scheduling. Several operational inefficiencies (e.g. high container reshuffle frequencies, high truck turn time, lengthy queue in the CT’s gate in area) are also reported due to this issue. Responding to the problem indications, we propose a conceptual design of a container terminal appointment system for scheduling the containers pick up operation.

KEYWORDS
Container Terminal, Scheduling, Maritime, Drayage Truck

INTRODUCTION

A CT is an important node that connects the container flow between the shipping lines and the inland carriers (Stahlbock and Voss, 2008). Taking the view of the CT’s customers, the CT conducts two types of operations: the marine interface and the landside interface operations. In this study, we focus on the CT’s landside interface operations. More specifically, we analyze the container import pick-up processes carried out for the drayage trucks (DTs).

Learning from the case in one of the biggest CTs in Europe, we focus on solving the challenges that rise within the landside service reservation area. It is reported that during the week, the CT has to respond to highly fluctuating pick up requests. This condition has created several disadvantages for all CT’s stakeholders (the CT, the DTs and the local government). During the busy period, the DTs normally spend unproductive hours waiting in queue for the start of service execution. Many times, this high DTs deposit propagates to the nearby satellite highways. As results, considerable traffic congestion and CO₂ pollution have brought a big concern for the local government. These issues certainly can bring negative impact to the port’s business attractiveness.
While the DTs and the local government receive negative impacts especially at the busy period, the CT is having problem in balancing its resources both in the busy period and the low occupancy period. While during the peak period the CT’s resources are being over utilized, during the low occupancy period the resources utilization level is low. It is a big challenge for the CT to deliver satisfactory DTs’ load out service in a more balanced resource utilization level.

Responding to the mentioned issues, we try to analyze the existing containers’ pick up reservation system and propose some improvement measures in a form of a decision support system (DSS) conceptual design. In presenting the discussion, we organize this paper as follows: In the next section, we review some related literatures. After that, we analyze the existing container pick up formalities and identify the problems that can be raised as improvement objects. Following the problem identification, we discuss the conceptual design of the DSS. Next, concluding remarks and directions for future research will be presented.

RELATED LITERATURES

Due to its practical significance, CT operation has received a big attention both from the practitioners and the research community. The topic has been very productive in generating new pragmatic and scientific innovations. While for many years the researches that analyze the CTs’ operations have been dominated by operations research (OR) studies (Steenken et. al., 2004, Vis and de Koster, 2003), the rapid advances in the information technology sector has urged the researchers to also consider the information system concerns (van Baalen et. al., 2009).

Concerning the operational scheduling topic, we can find a lot of studies concentrating on the scheduling issues of various CT’s resources (e.g. yard cranes, berth cranes, automated guided vehicles) (Hartmann, 2004). Despite the abundance of literatures, we can only find a few studies that discuss the scheduling of the landside services (Geweke and Busse, 2011). Huynh & Walton (2011) and Vidal & Huynh (2010) are some of few who concentrate on the landside operation’s scheduling. Huynh & Walton (2011) studied the impact of applying different scheduling rules (individual appointment system versus block appointment system) and the impact of limiting the DTs arrivals to the CT’s resource utilization and to the DTs’ turn time performance. They concluded that high arrival limit cap will lead to higher resource utilization and they also recommend the individual appointment rule over the block appointment one for better CT’s performance.

Although their study has brought valuable insights for setting up the proper appointment rule, we have to remark that the real world situation is highly dynamic. Disruptions which break the validity of the pre-planned schedule are often unavoidable. Thus, we need a scheduling framework that will guide not only in the appointment planning phase, but also in the execution monitoring, and the finalization of the container pick up activities. In response, we present a conceptual design of a decision support system for guiding not only the CT and the DTs in realizing a better performing schedule. Note that in this study we put the emphasis on the conceptual design of the information architecture rather than on the scheduling algorithm concerns.

CONTAINERS PICK-UP FORMALITIES

The containers’ pick up formalities consists of several steps that can be categorized into two main procedures: the pre-arrival and the on-arrival procedures. The pre-arrival procedure is the communication protocol that has to be finalized before a freight forwarder can dispatch its DT to the CT. The pre-arrival formalities standard is regulated by the United Nations Committee for Electronic Data Interchange for Administration, Commerce, and Transport (UN/EDIFACT). The formalities are explained shortly as follows: first the trucking company (TC) initiates a container pick-up permission request to the CT in the pre-notification message format (COPINO). Although the COPINO is filled with numerous details, in principal the message confirms three important issues: the container’s ID, the DT’s identity that will do the pick-up operation, and the proposed pick-up date.

Once the COPINO is received by the CT, several checks will be carried out: including the evaluation of the information completeness, the container in question’s presence, the customary clearance procedures, and other operational issues. Following the checks completion, the CT will send back an APERAK (Application Error and Acknowledgement) message that indicates the approval/rejection status of the COPINO message. If the COPINO’s request is approved, the TC can send its DT to the CT for the pick-up execution.

Once the COPINO is received by the CT, several checks will be carried out: including the evaluation of the information completeness, the container in question’s presence, the customary clearance procedures, and other operational issues. Following the checks completion, the CT will send back an APERAK (Application Error and Acknowledgement) message that indicates the approval/rejection status of the COPINO message. If the COPINO’s request is approved, the TC can send its DT to the CT for the pick-up execution.

After the finalization of the pre-arrival formalities, the on-arrival procedure can start. For the CT, the on-arrival procedure begins when a DT reaches the gate-in area. At the peak period, the DTs normally have to wait in a queue before receiving service. Whenever it is the DT’s turn, the gate-in officer will do several checks and will ensure that the DT’s pick-up service request has already been registered in the CT’s EDI system (via the COPINO-APERAK
mechanism). Following the completion of the checks, the officer will give permission for pick-up service execution, and will show the DT the location of the requested container. Next, the DT will go to the predefined location and wait for the quay crane to come and deliver the container. After the delivery, the truck will go to the gate-out for final administrative checks before departing from the CT.

PROBLEM IDENTIFICATION

After analyzing the pick-up formalities, we understand that the COPINO request approval is in principal based on the assessment of these three aspects: the presence of the container in question, documentation checks, and the proposed picking up date. Focusing on the last assessment point, we remark that the CT and the DT are basically agree on the date pick up date, but not on a specific timeslot. We conjecture that no clarity regarding the execution schedule specification is the cause that leads to unnecessary DTs’ waiting time, lengthy queue, and imbalanced utilization of the CT resources. If we can create an appointment DSS that is able to deliver a more specific pick-up schedule, the freight forwarders will only dispatch their DTs in accordance with the specified timeslot, thus the CT will only be occupied with the reservations. In response, we note a big urgency for implementing a better appointment support system.

APPOINTMENT SYSTEM DESIGN

Considering the existing containers pick-up formalities, we remark that the CT and the DTs are making informational contact during the pre-arrival and the on-arrival procedures. One natural approach is to combine the pick-up appointment agreement procedure in the pre-arrival formalities. Regardless of the scheduling method (Huyhn and Walton, 2011), it may be easier to clear the pick-up appointment within the COPINO-APERAK protocol. In this manner, both the CT and the DTs can foresee the pick-up (time window) schedule specification even before the dispatch of the DT. Note that after the pre-arrival formalities completion, the contact between the CT and the DTs will only be made later on the on-arrival executions. Between those two periods, no communication occurs. Following this scheme, both the CT and the DT will then attempt to execute the pick-up operations in line with the specified pick up schedule.

FIGURE 1
INFORMATION ARCHITECTURE CONCEPTUAL DESIGN
OF THE CONTAINER TERMINAL APPOINTMENT SYSTEM

In a real life situation, dynamism and disruptions are often unavoidable (Mao, 2011). Disruptions can occur either from the CT’s side (i.e. machine failures), the TC’s and DT’s side (i.e. traffic jam, order cancellation), or the environment (i.e. bad weather, road repair). Thus, the appointment system must offer a certain degree of flexibility in the scheduling process. In contrast with the existing formalities, in which the information are only exchanged during the pre-arrival and the on-arrival procedures, in our proposal, each business actor have to be connected to an information platform that enables them to communicate with his partners throughout the whole picking up process. With the platform, each actor will have the ability to arrange schedules, monitor the execution, transfer disruption notification updates on a real time basis, and make necessary corrective actions (i.e. operational adjustment, communicate with partners) to ensure the timeliness of the guided process. Rather inserting buffer slack time to accommodate operational uncertainties (Huyhn
and Walton, 2011), we aim to create scheduling flexibility and robustness by developing a system that offers proper information visibility for all actors involved.

We portray the initial conceptual design of the platform in Figure 1. As shown, we propose an integrated web system that will connect the TC, the DTs and the CT. The web application will guide the TC and the CT in finalizing the COPINO-APERAK requests approval along with the initial pick up appointment arrangement. Not only assisting in the pre-arrival period, the system will also enable the trucking company and the CT in monitoring the progress of the pick-up process progress (i.e. from the dispatching of the trucks until the finalization of the on-arrival procedure). The current advances in the internet handheld devices have made the track and tracing operationalization practical and (relatively) cheap. By offering continuous monitoring and communication capability, information visibility throughout the whole process can be created. Moreover, with the emergence of the recommender agent researches, those activities are even open for automation (Maes, 1994). This will create more reactive and more flexible scheduling, execution, monitor, finalization, and evaluation capabilities for every business actor in the network.

SUMMARY AND FURTHER RESEARCH

Triggered by the imbalanced landside service requests that cause several inefficiencies for many CT stakeholders (i.e. the TC, the DTs, the local government, and the CT itself), we have spotted an urgency to improve the current pick up formalities. In this paper, we present an initial conceptual design of a web appointment system that will guide the CT, the TC, and the DTs in doing the planning, execution, monitoring, and finalization of the pick-up activity. By implementing a system that enables all business actors in exchanging on-field condition on a real time basis, faster operational adjustments can be realized.

This paper has presented an initial concept of the appointment system’s information architecture. The concept has opened numerous ideas that can be further developed for prospective research. Just to name a few, the design of self-corrective appointment system that will automatically give schedule repair recommendation whenever disruption occurs is one prospective research topic. The design of market mechanism for the appointment slot reservation booking is also an important research topic. In short, the realization of container terminal (pick up) appointment system is a highly relevant topic that opens up a big space for novel practical and scientific contributions.

REFERENCES


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AN INVESTIGATION ON THE IMPACT OF STRATEGIC GREEN ORIENTATION ON THE IMPLEMENTATION OF GREEN SUPPLY CHAIN ACTIVITIES

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ABSTRACT

Green supply chain management has become an important practice in today business and manufacturing environment. The widely adoption of green practices in Malaysia manufacturing firms can be shown by the increasing number of ISO14001 certified firms. According to FMM directory, the number has been increased by more than 30% on 2009 compare to the year before. Barriers and factors in influencing firms to adopt in green practices are widely studied by the researchers in Malaysia context, therefore this study is interested in reveal the firms’ strategic orientation for adopting green practices as this is more important than only encouraging firms to practicing green. Total of three green strategic orientations (reputation, efficiency and innovation-based), and four types of supply chain green initiatives (green procurement, green manufacturing, green distribution and reverse logistics) have been identified to form the research framework and hypotheses development. Total of 342 ISO14001 certified companies have been selected for the survey section. This is to ensure that the respondents have a minimum knowledge on the environmental issues and policies. Multiple hierarchical regression analysis method has been applied to perform data analysis based on 36.5% return rate. Results showed that green initiatives are being adopted in this study and all the three strategic orientations have positive impact on firms’ green practices.

KEYWORDS
Strategic Green Orientation, Supply Chain Initiatives, E&E industry, Malaysia

INTRODUCTION

It has been increasing in consciousness of the environment in the last few decades. This is proven when people becoming more aware of the world’s environmental problems such as global warming, toxic substance usage, and decreasing in non-replenish resources (Nawroeka, 2008). This pushed government to aggressively release campaigns to promote environmental problem to people. Accordingly, in the past 10 years, the consumer product market has experienced a dramatic increase in eco awareness. These consumer preferences for sustainable products have resulted in a corresponding response from the business world to meet expectations (http://greeneconomypost.com). Thus, several organizations responded to this by applying green practices to their company, such as using environmental friendly raw material, reducing the usage of petroleum power, and using the recycle papers for packaging or following the basic principles established by ISO 14000. In spite of these efforts, questions still remain on whether green practices offerings equate to a sustainable business. Consequently, Urlaub (2010) argued that business sustainability is not exclusively environmentally focused but offer measures to save money and grow profitable businesses. Integrating sustainability concepts or green orientation into core business functions such as Green Strategy, Green Products and Marketing, Green Supply Chain, Green Facilities and Green IT/Admin enables businesses to become more nimble in a fast-changing world (Figure 1). In essence, business sustainability programs or strategic green orientation can be strategic motivations that encourage managers to adopt actions that aim at initiating, implementing, institutionalizing and better managing business relations to green.
The determinants of the factors that influence the implementation of green supply chain management adoption can be broadly divided into two areas: “external factors”, which linked to the stakeholders’ pressure; and “internal factors”, which is specifically business-led strategic process. In spite of the importance of both factors, however, the literature found that an analysis which focuses on such external factors does not allow for a complete understanding of firm behavior (Testa & Iraldo, 2010). Thus, Sharfman, et al., (2009) suggested that firm internal strategic orientations is an important element that can encourage an organization to adopt environmental practices with respect to its supply chain in order to obtain a competitive advantage, and should be given a highly attention. This is mainly due to the reason that the effect of environmental strategic orientations on green innovation for firm performance or competitive advantage is lasting paid much attention. This is the first gap that the study is trying to fill in.

This study, therefore, addresses the issue of green supply chains as promising area of study in the context of Malaysia. The study tries to identify the impact of strategic green orientation on the green supply chain practices adoption by the manufacturing company in Malaysia. The paper started with this introductory section which gives general idea about the research topic and problem of the study. The paper then explains the literature review on the green orientation and green supply chain activities. Next, the paper discusses the methodology and analysis of study. The paper ends with discussions and conclusions.

LITERATURE REVIEW

Green Supply Chain

A number of possible definitions of green supply chain management have been put forth over the past decade. The green supply chain management also known as “Environmental Supply Chain Management” or “Sustainable Supply Chain Management” as stressed out by Seuring (2004). In 1990s, Green, et al., (1996) defined green supply chain as the way in which innovations in supply chain management and industrial purchasing may be considered in the context of the environment. Similarly, Carter and Narasimhan (1999) refer the term green supply chain as environmental supply chain management that consists of the purchasing function’s involvement in activities that include reduction, recycling, reuse and the substitution of materials. On the other hands, Godfrey (1998) suggested that green supply chain is the practice of monitoring and improving environmental performance in the supply chain. The term ‘supply chain’ is basically describes the network of suppliers, distributors and consumers. It also includes transportation between the supplier and the consumer, as well as the final consumer, the environmental effects of the researching developing, manufacturing, storing, transporting, and using a product, as well as disposing of the product waste, must be considered (Messelbeck & Whaley, 1999).

Based on the literature review, many authors are exploring environmental initiatives within each of the major phases of the supply chain. However, in this study, the green supply chain management activities have been selected based on the highest frequency of and is presentable with the supporting studies from the researches. Therefore in
conclusion, the green supply chain activities for this study are divided into four phrases which are: green procurement, green manufacturing, green distribution and reverse logistics.

**Strategic Green Orientations**

Used informally, supply chain strategy is often confused with supply chain management. However, there is some truth to this definition, supply chain strategy really is a broader; it defines how the supply chain should operate in order to compete in the market place. Or in other words, supply chain strategy is an iterative process that evaluates the cost benefit trade-offs of operational components (Happek, 2005). The concept of strategic orientation is originally developed from the market orientation, which was popularly used to measure the firm performance particularly in the management literature (Matsuno & Mentzer, 2000). Lately, the practice was extended and focused specifically into customer orientation and technology orientation (Stewart & McCauley, 2002; Deshpande, et al., 1993). This is being support by Narver and Slater (1990), who found that market orientation was an important determinant of profitability for both commodity and non-commodity business and has lead to the understanding of the possibility of strategy orientation to influence the business decision because it also affect the business profitability. Based on the literature review, many authors are exploring environmental initiatives strategies in the firms supply chain practices. However, based on the frequency of the study in that particular field, the supply chain management activities are divided into three phrases which are: efficiency-based strategy, innovation-based strategy and reputation-based strategy.

**Efficiency-based Strategy**

Efficiency-based strategy in general not only facilitated companies to allow increase economic benefits, but also won the environmental benefits resulted from waste reduction and resources used efficiently. Hence, the environmental programs in this type of strategy primary directed firms to reduce cost and meet the operational optimization, and decrease environmental depredations at the same time (Simpson & Samson, 2008). The strategy also seek in minimizing the total product life-cycle costs and the productivity advantages are achieved through the adoption of environmental technologies that minimize the material and usage of energy resources in the manufacturing processes (Porter & Linde, 1995). Efficiently utilize the energy consumption also raised the significant attention and survey from PWC reported that more that 68% of the surveyed manufacturer companies claimed that power or energy consumption is become number one concern in planning the company strategy (PWC, 2008).

**Innovation-based Strategy**

Innovation-based strategy in this study defined as type of strategy guided companies to develop products from product life-cycle viewpoints, and give stricter environmental requirements to their suppliers, and even train them to adjust operational processes just followed the newest environmental regulations. The implementation of this strategy possess professional environmental expertise, and integrate specific relevant green activities, such as green design, green procurement to improve current supply chain processes, product developments. As mentioned, the innovation-based strategy forcing companies to invest additional resources and cultivate innovative capabilities to green supply chain managements (Simpson & Samson, 2008). In order to achieve this, firms required to adopt or develop technologies based on the industry sector involved and business nature that different from current practices to significant improve their environmental performance, there are three main elements that being highlighted and are necessary for technological change to occur which are willingness to change; motivate to change and the capacity to change (Ashford, 1993 & 2000).

**Reputation-based Strategy**

The reputation-based strategy in this study as adapted from Testa and Iraldo (2010) have been defined as the firms’ environmental performance of the whole product life cycle. The example includes setting up a co-operative “green” logistics with suppliers to reduce transport emissions, and make the customers and consumers aware of the system. This can significantly contribute to positive corporate image. Based on the survey outcome carried out by technology consultancy firm Bearing Point along with Supply Chain Standards on the global green supply chain survey across major global organizations revealed that the practices of green supply chain management has successfully improved the firms’ brand image and become one of the key factors that encourage organizations for practicing green (Cognizant, 2008).

**Research Framework**

Based on the depth study on the literature review specifically in the green supply chain perspective, which is one of the main areas that being focus by every parties with the high impact from the global climate issue. This research framework for this study have been developed and being illustrate in the figure below which include total of three main
variables for this study; strategy green orientations and green supply chain activities. The main reason for the research framework to be design in such a way is to study the strategy for companies adopting or applying the green supply chain activities in their operation practices.

**FIGURE 2**
THEORETICAL FRAMEWORK FOR THE RESEARCH STUDY

Through the study of the literature review, the company strategy green orientation can be classified into three main categories which include reputation-based, efficiency-based and innovation-based strategy (Testa & Iraldo, 2010). The research interested in finding the influence most strategy orientation that encourages the manufacturing firm in Malaysia to adopt in the green supply chain practices. The research is focusing on the manufacturing industries in Malaysia, the main reason is due to there is lack of the being done to examine the green strategy orientation in Malaysia and how it actually affects the decision make by the management team for adopting the green supply chain practice in the firm environment. As this is a new research study in the green supply chain practices in Malaysia, therefore there is no any barrel for selecting the sector of industries in Malaysia. However, it is interesting to investigate the different strategy adoption for different sector in the Malaysia context, therefore the manufacturing sector have been identified as one of the control variable. Firm size also have been set as the control variable in this study, the purpose is to observe the behavior between the large firm size and small firm size company in adopting green strategies.

Our study focuses on three important types of strategic green orientations: reputation, efficiency, and innovation. Reputation-led focus on the company image by implementing the green supply chain practices. Firm with reputation-led orientation has direct implication for green supply chain practice, the company is looking forward to improve the image by adopting the green practice in their business environment (Testa & Iraldo, 2010). Efficiency strategy is focus on company practice in reducing the unnecessary wastage and thus improve the firm benefit such as increasing in the product output, reduction in waste, manufacturing cost and so on (Simpson & Simson, 2008). Based on the authors, efficiency strategy not only increase the company profit but it also enhances the competitiveness of the company in the market place. Finally, innovation-led oriented is focusing on develop products from the product life-cycle viewpoints, and give stricter environmental requirements to their suppliers, the firm even train them to adjust operational processes just followed the newest environmental regulations. The companies utilizing this kind of strategy should possess professional environmental expertise, and integrate specific relevant green activities, such as green design, green procurement to improve current processes and product developments. Therefore, it is clear that innovation-led are influencing the firm to practicing in the green supply chain activities (Simpson & Simson, 2008). Based on the discussion above, the following hypotheses have been develop.

H1: Strategic green orientations have a positive effect on implementing green supply chain initiatives.
**RESEARCH METHODOLOGY**

**Population and Sample**

The study for this research topic is done for the individual firm in Malaysia. Therefore the unit measurement for this study is the organization. The population selected consists of all EMS ISO 14001 certified firms, the main reason of selecting the firms with EMS ISO 14001 certification is to ensure that the firms having some extend of expectation to be embarked to adopt in green supply chain initiatives (Darnall, Jolly a& Handfield, 2008). Darnall et al. (2008) concluded that high level of awareness on the environmental issues generated through adoption of EMS green supply chain initiatives. For this research study, the sampling frame represents all ISO 14001 certified firms in Malaysia. The sampling frame was obtained from SIRIM organization in addition to the Federation of Malaysian Manufacturers directory 2009 of Malaysian manufacturers (FMM, 2009). The total number in the list is 2255 manufacturing firms in Malaysia. However, only 342 companies have obtained the certification of ISO 14001 from the FMM directory. In order to obtained the more reliable data and findings from the limited sample size for this study, therefore the census sampling method have been applied for this research study as all the 342 companies will be selected and participate for answering the questionnaires.

**ANALYSIS**

**Response Rate**

Total of 342 ISO 14001 certified manufacturing companies in Malaysia have been selected in order to participate and provide input for the data collection based on the company list that obtained from the FMM directory. By applying censes method for selecting sample size determination, a total of 342 questionnaires was mailed to the respondents. Total of 125 completed questionnaires were received for the time period allowed to carry out the data collection and the respond rate is approximate 36.5 %. The respond rate is acceptable based on the previous research findings as mail survey method normally given low respond rate from the respondent (Vachon & Klassen, 2006; Sekaran, 2003). Table 1 below presents the summary data for the response rate of the survey.

**TABLE 1**  
**RESPONSE RATE OF THE SURVEY**

| Total questionnaires sent to the respondents | 342 |
| Questionnaires returned from respondents | 128 |
| Usable questionnaires (partially completed) | 3 |
| Usable completed questionnaires | 125 |
| Overall response rate | 37.4% |
| Usable response rate | 36.5% |

Electrical and electronics (E&E) industry presented more than half (69.6%) of the total respondent. This phenomenon is accepted in the Malaysia context as E&E is the largest manufacturing industry in Malaysia. Then the balance respondents are distribute among chemical industry, food industry, textile and wearing industry, basic metal product industry and others minor industry in different sectors. The table also shows that the new established firms (less than 6 years) are less and majority of the manufacturing firms (68%) in the Malaysia are well established (more than 10 years). Besides, almost all companies are large firms with the employee number more than 500 (75.2%) and MNCs accounted for about 80% of the respondent company while only 20% of the responded company is fully owned by Malaysia. Major product type of the respondent’s company is producing the consumer products, where the industrial product is approximate 38% and consumer product is about 52% from the total survey obtained. The data also shows that 63.2% of the firms dealing with more than 10 suppliers which indicate the large supplier base of these firms. Regarding the sourcing of input, the data shows that more than half (75.2%) obtain their input from the global sources and the rest obtain their input only from domestic and regional source. In order to have some understanding on the green supply chain adoption for the firms that participate in the questionnaire section, the data shows that almost half (55.2%) have implement the green supply chain practices in their corporate environment. However, majority of the firms are newly (less than 3 years) adopted in this green field (60% of the firms) and only about 24% of the surveyed companies recorded the implementation of the green supply chain initiatives in the company more than 6 years. As a reason, it is clear that majority of the firms (73.6%) do not form or identified a specific department in focusing on the firms’ green initiatives and the effectiveness of communication and interaction for all department in the company is low, only 4.8% of the respondent fell that the interaction among the department are highly effective in their firms’ environment. The finding is also indicate that the company that actively involved in green initiative obtained the satisfaction especially in perspective of strengthen the firm.
The profile of respondents for this study show that majority of the EMR responsible personnel in Malaysia manufacturing firms is hold by the manager level and above, result show that the percentage is more than half of the total respondents (68%). Also, by referring to the table below, majority of them are not a new joined in their organization (around 4 to 6 years attached with the company) and should able to provide a reliable response for this study.

**Factor Analysis for Green Supply Chain Initiatives**

Factor analysis was performed for all the items included in green supply chain initiatives. The analysis was started with the evaluation of the appropriateness of the data by applying correlation matrix for factor analysis. The intention of the test is to ensure the sufficient number of statistically significant correlation in the matrix. According to Hair, *et al.* (1998), the KMO measure and Bartlett’s test of sphericity, the KMO measure should obtain the minimum value of 0.6 and Bartlett’s test should be significant with p < 0.05 to ensure the sufficient number of statistically significant correlations in the matrix. From the Table 2 below, the KMO measure of sampling adequacy is 0.899. Also, Table 6 below indicates that the items for green supply chain initiatives were loaded into four factors with eigenvalues exceeding 1. The four extracted factors matched the four conceptualized types of green supply chain activities for this study which includes;

- **F1 - Green procurement**
- **F2 - Green manufacturing**
- **F3 - Green distributions**
- **F4 - Reverse logistics**

All items for green procurement loaded in factor 1 result in loading value above 0.45 (the specific limit of main loading value) and cross loading value below 0.35. Similarly, the same method is applied across the rest of the type of green supply chain activities with the factor loading shown above. Respectively, with the loading values above 0.45 and the cross loading value below 0.35, the total variance explained by the four factors is 82.95%. The result is acceptable with benchmarking to the recommendation for the total variance explained should exceeded with minimum 0.6 as suggested by Hair, *et al.* (1998).

**TABLE 2**

<table>
<thead>
<tr>
<th>Currently my firm ...</th>
<th>Factor</th>
<th>F1</th>
<th>F2</th>
<th>F3</th>
<th>F4</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>F1: Green Procurement</strong></td>
<td></td>
<td>GP2</td>
<td>GP1</td>
<td>GP11</td>
<td>GP10</td>
</tr>
<tr>
<td>Requires its suppliers to develop and maintain an environmental management system (EMS).</td>
<td></td>
<td>.902</td>
<td>.147</td>
<td>.237</td>
<td>.019</td>
</tr>
<tr>
<td>Provides design specifications to suppliers that include environmental requirements for procured items.</td>
<td></td>
<td>.897</td>
<td>.173</td>
<td>.241</td>
<td>.013</td>
</tr>
<tr>
<td>Evaluates its suppliers based on specific environmental criteria.</td>
<td></td>
<td>.883</td>
<td>.208</td>
<td>.239</td>
<td>.016</td>
</tr>
<tr>
<td>Makes sure that its purchased products must not contain environmentally undesirable items such as lead or other hazardous or toxic materials</td>
<td></td>
<td>.882</td>
<td>.164</td>
<td>.176</td>
<td>-.018</td>
</tr>
<tr>
<td>Regular supplier audit to ensure suppliers is compliance to the latest released environmental regulations.</td>
<td></td>
<td>.878</td>
<td>.156</td>
<td>.200</td>
<td>-.029</td>
</tr>
<tr>
<td>Purchase materials or parts only from suppliers who satisfy green partner environmental quality standards.</td>
<td></td>
<td>.805</td>
<td>.047</td>
<td>.327</td>
<td>.265</td>
</tr>
<tr>
<td>Build environmental criteria into supplier contract conditions.</td>
<td></td>
<td>.805</td>
<td>.014</td>
<td>.264</td>
<td>.197</td>
</tr>
<tr>
<td>Requires its suppliers to have a certified EMS such as ISO 14001.</td>
<td></td>
<td>.711</td>
<td>.167</td>
<td>.102</td>
<td>.266</td>
</tr>
<tr>
<td>Uses a questionnaire to collect information about its suppliers’ environmental aspects, activities and/or management systems.</td>
<td></td>
<td>.642</td>
<td>.141</td>
<td>.177</td>
<td>.180</td>
</tr>
<tr>
<td>Makes sure that its purchased products must contain green attributes such as recycled or reusable items.</td>
<td></td>
<td>.768</td>
<td>-.017</td>
<td>.163</td>
<td>.223</td>
</tr>
<tr>
<td>Select suppliers who control hazardous substances in company’s standard lists and obtain green certificate achievements.</td>
<td></td>
<td>.664</td>
<td>.068</td>
<td>.188</td>
<td>.293</td>
</tr>
<tr>
<td>Produces products that have reused or recycled materials in their contents such as recycled plastics and glass.</td>
<td></td>
<td>.116</td>
<td>.935</td>
<td>.192</td>
<td>.121</td>
</tr>
</tbody>
</table>
Uses life cycle assessment to evaluate the environmental load of its products.  

<table>
<thead>
<tr>
<th>F3: Green Distribution</th>
<th>GD2</th>
<th>.267</th>
<th>.156</th>
<th>.845</th>
<th>.101</th>
</tr>
</thead>
<tbody>
<tr>
<td>Makes sure its packaging is reusable.</td>
<td>GD3</td>
<td>.250</td>
<td>.183</td>
<td>.838</td>
<td>.138</td>
</tr>
<tr>
<td>Makes sure that its packaging has recyclable contents.</td>
<td>GD1</td>
<td>.280</td>
<td>.205</td>
<td>.840</td>
<td>.070</td>
</tr>
<tr>
<td>Minimizes the use of materials in its packaging.</td>
<td>GD8</td>
<td>.291</td>
<td>.254</td>
<td>.848</td>
<td>.180</td>
</tr>
<tr>
<td>Maximizes the use of renewable or recycled source materials</td>
<td>GD4</td>
<td>.316</td>
<td>.263</td>
<td>.849</td>
<td>.235</td>
</tr>
<tr>
<td>Avoids or reduces the use of hazardous materials in its packaging.</td>
<td>GD6</td>
<td>.278</td>
<td>.265</td>
<td>.852</td>
<td>.202</td>
</tr>
<tr>
<td>Meets market criteria for performance and cost</td>
<td>GD5</td>
<td>.246</td>
<td>.211</td>
<td>.859</td>
<td>.223</td>
</tr>
<tr>
<td>Makes sure that its distribution beneficial, safe and healthy for individuals and communities throughout its life cycle</td>
<td>GD7</td>
<td>.247</td>
<td>.251</td>
<td>.863</td>
<td>.175</td>
</tr>
<tr>
<td>Makes sure the products are transported using renewable energy</td>
<td>GD9</td>
<td>.209</td>
<td>.820</td>
<td>.173</td>
<td>.175</td>
</tr>
<tr>
<td>Produces products that are free from hazardous substances such as lead, mercury, chromium, and cadmium.</td>
<td>GM3</td>
<td>.060</td>
<td>.818</td>
<td>.150</td>
<td>.159</td>
</tr>
<tr>
<td>Produces products that are free from hazardous substances such as bismuth, silver, tin, gold and copper.</td>
<td>GM9</td>
<td>.094</td>
<td>.907</td>
<td>.182</td>
<td>.125</td>
</tr>
<tr>
<td>Increase product life-span resulting in higher efficiency and productivity.</td>
<td>GM5</td>
<td>.090</td>
<td>.894</td>
<td>.184</td>
<td>.094</td>
</tr>
<tr>
<td>Produces products that reduce the consumption of materials or energy during use.</td>
<td>GM6</td>
<td>.186</td>
<td>.884</td>
<td>.212</td>
<td>.190</td>
</tr>
<tr>
<td>Reduce power consumption in products such as ramps load/unload technology.</td>
<td>GM7</td>
<td>.055</td>
<td>.862</td>
<td>.152</td>
<td>.156</td>
</tr>
<tr>
<td>Makes sure that its products have recyclable or reusable contents.</td>
<td>GM4</td>
<td>.060</td>
<td>.818</td>
<td>.150</td>
<td>.159</td>
</tr>
<tr>
<td>Using lead-free to replace other substances such as bismuth, silver, tin, gold and copper.</td>
<td>GM8</td>
<td>.244</td>
<td>.816</td>
<td>.199</td>
<td>.183</td>
</tr>
<tr>
<td>Produces products that reduce the consumption of materials or energy during use.</td>
<td>GM2</td>
<td>.104</td>
<td>.927</td>
<td>.191</td>
<td>.111</td>
</tr>
</tbody>
</table>

**Factor Analysis for Strategic Green Orientations**

The same factor analysis method was also performed to test the validity of measures used in measuring the strategic orientation for green supply chain initiatives. The results obtained was summarizes in the Table 3 below. The table indicates that the data matrix fulfill and satisfied the requirements of factor analysis. The KMO value obtained from the data is 0.845 (above the recommended value of 0.6) and Bartlett’s test of sphericity is significant at p<0.01. Therefore the items are accepted for performing factor analysis. The items for supply chain green strategic orientations are loaded ad below;

- **F1 - Innovation-based**
- **F2 - Efficiency-based**
- **F3 - Reputation-based**

The loaded factors showing the eigenvalues to be exceeding 1; and these three factors are successfully explaining 75.12% of the total variances from the data being analyzed, this percentage gain meeting the recommended level of 0.60.
### TABLE 3
**ROTATED FACTOR LOADINGS FOR SUPPLY CHAIN GREEN STRATEGIC ORIENTATIONS**

<table>
<thead>
<tr>
<th>My firm ...</th>
<th>Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>F1</td>
</tr>
</tbody>
</table>

**F1: Innovation-based**
- Company is concerning and develop the product based on the life-cycle viewpoint. IB4 .926 .164 .218
- Company always allocated budget (Example: Annually budget review) for new innovation activities. IB1 .924 .155 .157
- Trainings and educations in innovations development are aggressively conducted by my company. IB7 .915 .136 .212
- Innovation culture is well groom in my company. IB6 .914 .161 .187
- Company management is focusing on innovation in the process and products in order to improve the current process and product development. IB3 .911 .175 .175
- Company is known as an innovative driven because all of the primary activities are based on innovation initiatives. IB5 .744 .121 .296
- Company is given stricter innovation requirement to the supplier, even train the supplier to adjust their operational process. IB2 .705 .300 .151

**F2: Efficiency-based**
- Company is interested in establishing economy benefit through improve the supply chain efficiency. EB4 .164 .862 .100
- Company is interested and looking forward to invest in the project that maximizes the productivity of the product. EB3 .081 .861 .206
- Optimization of the resources and enhancement of the value of the products are the most important strategies in my company. EB7 .161 .861 .004
- Company is concerning and work on reducing the non-value-added activities from the current processes. EB1 .075 .856 .160
- Company is highly strived for productivity improvement among the employees. EB6 .181 .749 -.054
- Company is obtaining the economic benefit through cost reduction initiative. EB2 .207 .705 .240
- Company is optimized the resources through collaborations with suppliers and customers. EB5 .199 .685 .221

**F3: Reputation-based**
- Company is concerning the environmental welfare and continues in developing the green product. PB4 .175 .157 .897
- The image of my company is enhanced through development of environmental initiatives. PB5 .148 .158 .863
- Consumer is recognizing the company product due to greening activities that carry out by the company. PB2 .189 .079 .804
- Company is making good effort on green activity and set/plan to set as the company policy. PB3 .306 .225 .756
- The company is well-known and contributes in the green initiative. PB1 .239 .067 .720

KMO ($\chi^2=2782.301$)

<table>
<thead>
<tr>
<th>Eigenvalues</th>
<th>Total Variance Explained (75.12%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.845</td>
<td>29.903 25.397 19.827</td>
</tr>
</tbody>
</table>

**Reliability Analysis**

Reliability analysis was also conducted in this study. Referring to Sekaran (2003), reliability test serve the purpose of ensuring the measures of variables have internal consistency across time and across the various items that measure the same concept or variable. The approach for measuring the data reliability in this study was using Cronbach’s alpha coefficients. The measures were considered to have sufficient level of reliability when Cronbach’s alpha values equal to or greater than 0.70 (Nunally, 1987). The values of Cronbach’s alpha for this study was presented in Table 8 below for all the measure variables. It appears from the table that the values of Cronbach’s alpha were exceeding 0.70 as
recommended and ranges from 0.803 and 0.979. These values well concluded that the measures variables having an acceptable level of reliability.

### TABLE 4
CRONBACH’S ALPHA FOR STUDY VARIABLES

<table>
<thead>
<tr>
<th>Variables</th>
<th>No. of Items</th>
<th>No. of Items Deleted</th>
<th>Cronbach’s Alpha</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reputation-based</td>
<td>5</td>
<td>0</td>
<td>0.904</td>
</tr>
<tr>
<td>Efficiency-based</td>
<td>7</td>
<td>0</td>
<td>0.920</td>
</tr>
<tr>
<td>Innovation-based</td>
<td>7</td>
<td>0</td>
<td>0.962</td>
</tr>
<tr>
<td>Green Procurement</td>
<td>13</td>
<td>2</td>
<td>0.975</td>
</tr>
<tr>
<td>Green Manufacturing</td>
<td>11</td>
<td>2</td>
<td>0.975</td>
</tr>
<tr>
<td>Green Distribution</td>
<td>8</td>
<td>0</td>
<td>0.979</td>
</tr>
<tr>
<td>Reverse Logistics</td>
<td>6</td>
<td>0</td>
<td>0.975</td>
</tr>
</tbody>
</table>

### Hypotheses Testing

In this study, all hypotheses were tested using the hierarchical regression. The control variables include type of industry; firm size (measured using number of employees). The control of these variables was conducted to clarify the real effect of independent on dependent variables.

### Effects of Drivers on Green Supply Chain Initiatives

The first hypothesis for this study predicts that three green strategic orientations (efficiency-based, innovation-based, and reputation-based) are positively influence the adoption of green supply chain initiatives (green procurement, green manufacturing, green distribution and reverse logistics). To test this hypothesis, a two-step hierarchical regression analysis was carried out. In step one, the analysis test the effect of control variable which is the firm size in this study on the dependent variable. The role of control variables is to isolate the effect from factors, other than those under investigation that may affect the dependent variable. In step two, the independent or predictor variables was introduced to test their marginal effect on the dependent variable.

### TABLE 5
THE RESULTS OF REGRESSION ANALYSIS BETWEEN STRATEGIC GREEN ORIENTATIONS ON GREEN PROCUREMENT

<table>
<thead>
<tr>
<th>Variables</th>
<th>Standard Deviation, β</th>
<th>Model 1</th>
<th>Model 2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Manufacturing Sector</td>
<td>-.124</td>
<td>-.038</td>
<td></td>
</tr>
<tr>
<td>Firm Size</td>
<td>.134</td>
<td>.099</td>
<td></td>
</tr>
<tr>
<td>Reputation</td>
<td>-</td>
<td>.275**</td>
<td></td>
</tr>
<tr>
<td>Efficiency</td>
<td>-</td>
<td>.248**</td>
<td></td>
</tr>
<tr>
<td>Innovation</td>
<td>-</td>
<td>.294***</td>
<td></td>
</tr>
<tr>
<td>R²</td>
<td>.033</td>
<td>.429</td>
<td></td>
</tr>
<tr>
<td>Adjusted R²</td>
<td>.017</td>
<td>.405</td>
<td></td>
</tr>
<tr>
<td>F</td>
<td>2.100</td>
<td>17.915***</td>
<td></td>
</tr>
</tbody>
</table>

Note: * p <0.05; ** p <0.01; *** p <0.001; Model 1 = Control variable was regressed on DV; Model 2 = Control variable and IV were regressed on DV

Table 5 presents the result of the two-step regression analysis of control variables and supply chain green strategic orientations on green procurement. Based on the result show in the table for Model 1, manufacturing sector and firm size do not appears to have a significant effect on green procurement activities and the data show that the control variable only able to explain 1.7% from the total variations in green procurement. With the additional of the supply chain green strategies apply as shown in the Model 2, the variables together shows the significant improvement and explains about 42.9% of the total variation in green procurement activities. Innovation-based strategy (β = 0.294, p < 0.001) appears to be more significant on influencing the green procurement activities compare to reputation-based strategy (β = 0.275, p < 0.01) and efficiency-based strategy (β = 0.248, p < 0.01). The results supported the hypotheses of H1.1a (reputation-based strategy positively effect on the implementation of green procurement), H1.2a (efficiency-based strategy positively effect on the implementation of green procurement), and H1.3a (innovation-based strategy positively...
effect on the implementation of green procurement). Similarly, the same regression analysis was perform for supply chain green strategic orientations towards the others green supply chain activities for this study which include; green manufacturing, green distribution and reverse logistics and the result for each pair of variables are shown in the Table 10 to Table 11 below followed by the explanations.

**Table 6**

<table>
<thead>
<tr>
<th>Variables</th>
<th>Standard Deviation, β</th>
<th>Model 1</th>
<th>Model 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manufacturing Sector</td>
<td>-0.76</td>
<td>-0.02</td>
<td></td>
</tr>
<tr>
<td>Firm Size</td>
<td>0.116</td>
<td>0.076</td>
<td></td>
</tr>
<tr>
<td>Reputation</td>
<td>-</td>
<td>0.178**</td>
<td></td>
</tr>
<tr>
<td>Efficiency</td>
<td>-</td>
<td>0.237**</td>
<td></td>
</tr>
<tr>
<td>Innovation</td>
<td>-</td>
<td>0.323***</td>
<td></td>
</tr>
<tr>
<td>R²</td>
<td>0.018</td>
<td>0.348</td>
<td></td>
</tr>
<tr>
<td>Adjusted R²</td>
<td>0.002</td>
<td>0.320</td>
<td></td>
</tr>
<tr>
<td>F</td>
<td>1.135</td>
<td>12.688***</td>
<td></td>
</tr>
</tbody>
</table>

Note: * p <0.05; ** p <0.01; *** p <0.001; Model 1 = Control variable was regressed on DV; Model 2 = Control variable and IV were regressed on DV

By referring to the regression results show in Table 6, the control variable alone (manufacturing sector and firm size) does not show a significant impact on the dependent variable (green manufacturing). However, with the addition of the independent variables (supply chain green strategies) on the regression analysis, the impact on the green manufacturing adopted by firms become significant and the variables explained 34.8% of the total variance for green manufacturing element. Further analysis on the results obtained in Table 6, innovation-based appear to be the most influences strategy among the three strategies that being study for the impact on implementation the green manufacturing initiatives (β = 0.323, p < 0.001), followed by efficiency-based strategy (β = 0.237, p < 0.01), and lastly reputation-based strategy (β = 0.178, p < 0.05). These results five support to the hypotheses H1.1b (reputation-based strategy positively affect the implementation of green manufacturing practices), H1.2b (efficiency-based strategy positively affect the implementation of green manufacturing practices), and H1.3b (innovation-based strategy positively affect the implementation of green manufacturing practices).

**Table 7**

<table>
<thead>
<tr>
<th>Variables</th>
<th>Standard Deviation, β</th>
<th>Model 1</th>
<th>Model 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manufacturing Sector</td>
<td>-0.171</td>
<td>-0.085</td>
<td></td>
</tr>
<tr>
<td>Firm Size</td>
<td>0.099</td>
<td>0.063</td>
<td></td>
</tr>
<tr>
<td>Reputation</td>
<td>-</td>
<td>0.269***</td>
<td></td>
</tr>
<tr>
<td>Efficiency</td>
<td>-</td>
<td>0.151*</td>
<td></td>
</tr>
<tr>
<td>Innovation</td>
<td>-</td>
<td>0.361***</td>
<td></td>
</tr>
<tr>
<td>R²</td>
<td>0.037</td>
<td>0.418</td>
<td></td>
</tr>
<tr>
<td>Adjusted R²</td>
<td>0.021</td>
<td>0.394</td>
<td></td>
</tr>
<tr>
<td>F</td>
<td>2.356</td>
<td>17.115***</td>
<td></td>
</tr>
</tbody>
</table>

Note: * p <0.05; ** p <0.01; *** p <0.001; Model 1 = Control variable was regressed on DV; Model 2 = Control variable and IV were regressed on DV

Table 7 above indicates the result on the regression analysis for independent variables toward the green distribution practices. The control variables (manufacturing sector and firm size) do not show any significant impact on influencing the dependent variables in this content as show in Model 1 for this analysis. Model 2 in Table 7 presented that the green strategic variables are significantly affecting the green distribution practices with cumulatively of the variables explained 41.8% of the total variance. Innovation-based strategy (β = 0.361, p < 0.001) and reputation-based strategy (β = 0.269, p < 0.001) appear to be more influencing compare to efficiency-based strategy (β = 0.151, p < 0.05) by referring to the results shown in the table. However, the results still enough to support the hypotheses H1.1c (reputation-based strategy positively affect the implementation of green distribution), H1.2c (efficiency-based strategy positively affect the implementation of green distribution), and H1.3c (innovation-based strategy positively affect the implementation of green distribution).
TABLE 8
THE RESULTS OF REGRESSION ANALYSIS BETWEEN STRATEGIC GREEN ORIENTATIONS ON REVERSE LOGISTICS

<table>
<thead>
<tr>
<th>Variables</th>
<th>Standard Deviation, β</th>
<th>Model 1</th>
<th>Model 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manufacturing Sector</td>
<td>-.110</td>
<td>-.036</td>
<td></td>
</tr>
<tr>
<td>Firm Size</td>
<td>.059</td>
<td></td>
<td>.015</td>
</tr>
<tr>
<td>Reputation</td>
<td>-</td>
<td>.215*</td>
<td></td>
</tr>
<tr>
<td>Efficiency</td>
<td>-</td>
<td>.295***</td>
<td></td>
</tr>
<tr>
<td>Innovation</td>
<td>-</td>
<td>.242**</td>
<td></td>
</tr>
<tr>
<td>R²</td>
<td>.015</td>
<td>.349</td>
<td></td>
</tr>
<tr>
<td>Adjusted R²</td>
<td>-.001</td>
<td>.322</td>
<td></td>
</tr>
<tr>
<td>F</td>
<td>.918</td>
<td>12.754***</td>
<td></td>
</tr>
</tbody>
</table>

Note: * p <0.05; ** p <0.01; *** p <0.001; Model 1 = Control variable was regressed on DV; Model 2 = Control variable and IV were regressed on DV

The effect of the green strategic orientations towards reverse logistics is shown in the Table 8. The analysis shows in model 1 indicate that the role of manufacturing sector and firm size are not significant in affecting the dependent variables. However, strategic orientations are significantly affecting the dependent variable with the efficiency-based strategy showing the most significant effect (β = 0.242, p < 0.001). Followed by innovation-based strategy (β = 0.244, p < 0.01), and reputation-based strategy (β = 0.215, p < 0.05). Total of 34.8% have been explained by the independent variables towards the variance of the dependent variables. The results again support the hypotheses of H1.1d (reputation-based strategy positively effect on the implementation of reverse logistic), H1.2d (efficiency-based strategy positively effect on the implementation of reverse logistic), and H1.3d (innovation-based strategy positively effect on the implementation of reverse logistic).

DISCUSSION AND CONCLUSION

Based on the research results obtained from the manufacturing firms in Malaysia, the level of adoption in green supply chain practices are still low. This can be observed from the result obtained for four main predetermined initiatives in green supply chain context; green procurement (mean = 3.0015), green manufacturing (mean = 2.8649), green distribution (mean = 2.8460) and reverse logistics (mean = 3.0080). The adoption of green supply chain practices for green procurement and reverse logistics are higher among the four elements and slightly above average, whereas the initiative adoption for green manufacturing and green distribution in Malaysia manufacturing firms are still below average from the survey findings. From the manufacturing firms’ green procurement perspective, Min and Gelle (2001) discover that regulation has a significant effect on driving the firms’ green procurement initiatives. Although the results is especially show significant in the US firms, however, with the nature of Malaysia manufacturing ownership that obtained from this study, almost 80% are foreign joint venture or fully owned by the foreigner, therefore the adoption for green procurement practices are exists in the firms’ internal environment even though Malaysia by itself do not emphasizes aggressively on the green procurement regulations to enforce the manufacturing company for practicing it according to IPGN.

The results also reveal that the reverse logistics practices are showing an improvement trend in Malaysia, this can be shown by compare to the study result obtained from Eltayab, et al. (2010) on the same area where reverse logistics appear to be less significant corporate green initiatives compare to green purchasing and eco-design. Lately, reverse logistics also have been classified as the practice that is indispensable from the modern supply chain (Chen, 2010). In Malaysia context, reverse logistics become more important for recovery the industrial wastes; besides contributes towards achieving sustainable industrial development and this has been highlighted in the National Policy on the Environment 2002 and in the statement of the Eight Malaysia Plan (Malaysia 2001). Based on the high level of encouragement from Malaysia’s government, the level of adoption of reverse logistic initiative in Malaysia have been significantly improved. The study on green manufacturing practices in Malaysia manufacturing firms found that the adoption level is still showing slightly below the average. Although there are lots of multinational companies that participate in this study, however, the firm size does not appear to be significantly impacts the green manufacturing adoption in Malaysia context. The similar condition also presents on green distribution practices in Malaysia context. The level of adoption for this initiative is not encouraging as shown in this study.
Implications of the Study

The findings of the study on the supply chain initiatives in Malaysia context have several implications on both theoretical and practical aspects. Discussion of the implications mentioned therefore divided into two major sections which are theoretical implications and practical implications. The study results shown that strategy green orientations are significantly impacting the green supply chain initiatives adoption in the Malaysian manufacturing firm and portrays their extent of adoption. The study also identifies the control variables which are manufacturing sector and firm size does not play a significant role on influencing the different types of strategies selection. However, this study outlined that the selection of the green strategy can be based on the type of green supply chain initiatives that company tried to achieve. Different strategic-based orientation adoption will determine the most significant outcome on the particular types of supply chain green initiative.

The outcome of this study found to be useful and enhance the knowledge and performance of managers in the business and public organizations mainly through below aspects; this research study addresses clearly the concept, the level of green supply chain adoption in real Malaysia context. The green supply chain initiatives that widely discussed in this study provide the real picture to the firms’ manager in order to make relevant decisions of adopting in green practices. The significance level of the study and on the green supply chain strategies towards the implementation of green practices in the firms’ environment provide the basic knowledge in order for manager to select the more appropriate strategy for motivate the firms’ green initiatives. Or in other words, the results obtained it enables the company’s manager to understand and adopt the different green supply chain strategy that suite most to their industry nature. This concept is very important especially for the manager expectation today that not only focus solely on the economic profit perspective but the managerial level also need to take consideration on the greening practice for any of the decision make in order to improve the competitiveness of the company among the industry and also in the international market.

Limitations and Recommendations

This study contains several limitations that need to taken into consideration when drawing generalizations or conclusions from this study. This study only focuses on manufacturing firms in Malaysia context, which mean non-manufacturing firms are excluded from this study (e.g. service organizations). Therefore the implication of the result towards the non-manufacturer sector should be paid additional caution. Also, this study is control the sample size and limited to ISO14001 certified companies. Therefore the results of similar practices on non ISO14001 certified firms in Malaysia are not being cover and the results should not be applied to the non-ISO14001 certified firms. Finally, this study is cross-sectional in nature, which measures the variables at single point of time. Therefore, the changes for this study outcomes are predicts especially green initiatives are still under development and lots of changes can be happen overnight. Therefore it is important to keep on updating and benchmarking the result from this study to the latest development on the green initiatives.

Directions for Future Research

Future studies can investigate on the effect of others supply chain green strategies. The significant effects of the three types of strategies measured in this study provide an initial input for the knowledge in the Malaysia context, further study on different strategic-based orientation are well encourage to reveal the best strategy for encouraging manufacturing firm to adopt green supply chain initiatives. Future study may incorporate more supply chain initiatives in their study to investigate the level of adoption in the manufacturing firms in Malaysia context, the result may vary across the period of time and with the new development on the green area.

Conclusions

As conclusions, the major research questions and objectives were achieved. However, in Malaysia context, the green supply chain still need further enhancement from different party to improve the adoption based on the current condition show. This study successful reveals the significant level of adoption for supply chain green strategic in Malaysia manufacturing firms, and all types of strategic green orientation showing a significant positive impact towards the implementation of green supply chain initiatives in firms’ environment. This study also successfully reveals that different strategy adoption by firm will impact in the different green initiatives outcome, therefore the strategy selection on adopting green practice should be carefully examine to ensure the strategy selected are appropriated or align to the green supply chain initiatives that firms desire to achieve. However, this study unable to prove the significant impact for the control variable which are firm size and sector of industry also contribute to the research findings, which means that from the study sampled firms, the sector and firm size do not play an significant role on influencing the strategic selection by firms.
REFERENCES


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Supplier Relationship, Outsourcing, and CRM
COMPARISON OF THE OUTSOURCING BY PRIVATE AND PUBLIC ORGANISATIONS: CZECH AND SLOVAK EXPERIENCE

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ABSTRACT

Outsourcing is already for longer period used in the private sector as the tool of rationalization of internal processes and as the result of New Public Management changes it was started to be implemented also in public organizations. The paper starts with brief introduction of the concept of outsourcing, both in relation to private and public sector practices. The core parts are devoted to the analysis of the experience with outsourcing of internal services in private and public organizations in the Czech Republic and Slovakia. On the base of research in the Czech Republic and also in Slovakia we analyze comprehensive information about outsourcing in the public sector organizations. Our data from different samples collected during last ten years show that outsourcing decisions in the public sector are really chaotic, ad hoc made, without any real ex-ante analysis. In such conditions there is the high risk that outsourcing will not deliver efficiency improvements. Data analyzing all important dimensions of outsourcing in the private sector were collected in Czechia via the questionnaire, sent in the beginning of 2010 to more than 1000 firms. The rate of response was relatively limited; total 142 questionnaires are included into the final sample. Such sample is not fully representative, but still provides effective picture about the situation. Important facts derive from answers. First, outsourcing is relatively frequently used by private firms in the country. Second, we may argue that the “quality” of implementation of outsourcing in the private sector in the Czech Republic is bit limited. Results from our analysis support general expectations that in conditions where the private sector is not able to deal with outsourcing perfectly (and the risk of corruption is relatively high), the practice of outsourcing in the public sector is of limited quality.

KEYWORDS
Outsourcing, Internal Services, Public Sector, Private Sector, Slovakia, Czech Republic

INTRODUCTION

This paper represents important result of our research project Optimising outsourcing in the public sector (P403/10/1892), financed by the Czech Grant Agency (GACR). Our main goals are improving the micro-economic theory about outsourcing in the conditions of the Central European economy with its important (post-transitional?) specifics and to draft management models for processes of outsourcing in public organizations, on the base of the identification of main factors influencing the efficiency of outsourcing in the respective branch (with focus on the Czech Republic).
To be able to achieve planned goals, we have to realise many theoretical and practical tasks. For sure, one of them is to discover, if the private sector practice could serve as the important benchmark for the public sector and to serve as the example of the good practices which should be implemented also in the public sector.

In this paper we first briefly introduce the concept of outsourcing (with focus on the public sector practice). Than we analyse the practice of outsourcing in the public sector (Czech Republic and Slovakia). The third step is the analysis of outsourcing in the private sector in the Czech Republic. The final end is to compare situation and to draft conclusions on this base.

OUTSOURCING AND OUTSOURCING IN THE PUBLIC SECTOR – BRIEF THEORY REVIEW

Outsourcing represents the situation of delegating of originally own activities of a economic subject to an external supplier. Graever (1999) defines following purposes of outsourcing – organizational, process, financial, incomes, decreasing costs and employment. Other authors (like Fanta, 2005, Manning et al., 2008) add also other purposes for outsourcing, for example:

- Focus on Core Business — Resources (for example investment, people, and infrastructure) are focused on developing the core business. For example often organizations outsource their IT support to specialised IT services companies.
- Cost restructuring — Outsourcing changes the balance of this ratio by offering a move from fixed to variable cost and also by making variable costs more predictable.
- Improve quality — Achieve a steep change in quality through contracting the service with a new service level agreement.
- Knowledge — Access to intellectual property and wider experience and knowledge.
- Operational expertise — Access to operational best practice that would be too difficult or time consuming to develop in-house.
- Access to talent — Access to a larger talent pool and a sustainable source of skills, in particular in science and engineering.
- Capacity management — An improved method of capacity management of services and technology where the risk in providing the excess capacity is borne by the supplier.
- Catalyst for change and innovations — An organization can use an outsourcing agreement as a catalyst for major step change that can not be achieved alone.
- Risk management — An approach to risk management for some types of risks is to partner with an outsourcer who is better able to provide the mitigation.

Outsourcing is used in the private sector as a tool of rationalization of internal processes already for long time and experience with it is relatively well evaluated in existing economic, logistics and management literature.

Outsourcing in the public sector started to be introduced in larger scale as the part of New Public Management (NPM) initiatives during last two decades of the previous century. Its theoretical base - the issue of privatization and contractualisation in public services was investigated by many authors (for example Cullis and Jones, 1987; Knapp and Missiakoulis, 1982; Stiglitz, 1997; Caves and Christensen, 1980; Weisbrod, 1988; Yarrow and Jasinski, 1996).

One dimension of NPM (see for example Pollit and Bouckaert 2000, 2004 and 2011; Lane, 2000; Cooper, 2003 and many others) is the introduction of market type mechanisms (MTM) into public sector and the marketization of the public service. The marketization of public services aims at a continuous increase in public expenditure efficiency, continual improvements in public services quality, the implementation of the professional management tools in the public sector, emphasis on devolution and delegation, emphasis on audit and inspection and, last but not least, the plurality system of ownership forms in public service delivering and emphasis upon contracts and market. The introduction of compulsory competitive tendering and market testing lead to the contracting-out of some in-house produced services in public sector.

Contracting and outsourcing (we distinguish between these two term in the following way: contracting = external production of public services, outsourcing = external delivery of internal services) represent one of the most prevalent types of privatization, mainly at the local government level. Under this arrangement, the government retains responsibility for provision of the service but hires private firms to produce the service. Contracting and outsourcing can also be explained as a binding agreement in which a public institution pays a private firm or non-profit organization to produce a specific level and quality of a public service or of an internal service in public organisations.

Contracting and outsourcing begin with the “organizational decision to make or buy a good or service” (Prager 1994, p. 176). As such, it is a fundamental decision faced by both public and private sector organizations. “To make or
“Should we buy?” is a question faced by public organizations when considering how public services should be delivered to their citizens. Public organizations must decide whether to produce goods and services internally or to acquire them from external sources.

To put contracting and outsourcing in perspective, it is necessary to consider pros and cons of internal and external forms of delivery. The possible positive results from outsourcing in the public sector are very similar to these in the private sector (see above), but the main focus is on optimising costs and quality. According to Prager, the general rule of public sector organization is to “internalize operations to the point where the costs of further expansion are perceived to be greater than the costs of acquiring the components or services in the market” (Prager 1994, p. 84). An important element of contracting and outsourcing is the process involved in establishing and maintaining a legal contractual relationship with a private firm. According to Shetterly (1998, p. 23), this process occurs in three phases; pre-solicitation, contractor selection and contract management. Two problems occur when the action and information of the private partner are not directly observable by the public partner: “moral hazard or the problem of hidden action and adverse selection or the problem of hidden information” (Arrow, 1985, p. 37). Moral hazard occurs because the behaviour of the private partner is imperfectly controlled. When behaviour is imperfectly controlled, it creates a situation where either shirking in performance of duties or inappropriate actions by the private partner adversely impacts the goals of the public partner. In the adverse selection problem, the private firm has some information that is not shared with the public sector organization and uses the information to make decisions that affect the public organization. The public sector organization in many cases have not enough information for ex ante evaluation of the private offers.

The crucial issue for success of contracting and outsourcing are transactions costs that may overweight direct costs savings from switch to external delivery (Pavel, 2007)

From all above, it is apparent that contracting and outsourcing may, but need not; improve the performance of the public sector. The final outcome depends on local conditions, including the capacity of the implementing body to execute the contracting process.

OUTSOURCING IN PUBLIC ORGANIZATIONS: CZECH REPUBLIC

We map the situation in the Czech Republic via two different field research in 2011, but still some time is needed to process all obtained data. Because of this we have to rely on older data collected by our team. The Table 1 provides first original data on the small sample of public organisations.

<table>
<thead>
<tr>
<th>Type of organization</th>
<th>Cleaning</th>
<th>Catering</th>
<th>IT systems</th>
<th>Accounting</th>
<th>Legal services</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>Educational bodies – total 11 organizations</td>
<td>1</td>
<td>2</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Hospitals – total 4 organizations</td>
<td>3</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>Culture – total 5 organizations</td>
<td>2</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Local government offices – total 17 org.</td>
<td>3</td>
<td>0</td>
<td>4</td>
<td>2</td>
<td>6</td>
<td>1</td>
</tr>
<tr>
<td>State administration offices – total 19 org.</td>
<td>9</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>

Source: own research

The Table 2 provides more recent data from 2009 from bit larger scale with slightly different methodology. From 500 contacted public organisations on 162 responded, frequently not to all questions.
TABLE 2
FREQUENCY OF USE OF CONTRACTING-OUT OF INTERNAL SERVICES –
THE CZECH REPUBLIC, 2009 (FIGURES DESCRIBE PERCENTAGE OF ORGANISATIONS
THAT CONTRACTED GIVEN INTERNAL SERVICES)

<table>
<thead>
<tr>
<th>Service</th>
<th>Number of responses</th>
<th>Percentage of outsourced services</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cleaning</td>
<td>158</td>
<td>6.96%</td>
</tr>
<tr>
<td>Catering</td>
<td>25</td>
<td>31.20%</td>
</tr>
<tr>
<td>Maintenance</td>
<td>132</td>
<td>11.36%</td>
</tr>
<tr>
<td>IT</td>
<td>125</td>
<td>38.40%</td>
</tr>
<tr>
<td>Transport</td>
<td>111</td>
<td>18.02%</td>
</tr>
<tr>
<td>Security</td>
<td>92</td>
<td>26.09%</td>
</tr>
</tbody>
</table>

Source: own research

From both tables it is visible that outsourcing is relatively frequent solution in all types of public organisations in the Czech Republic. Unfortunately, precise data about outcomes from public sector outsourcing in the country would be available only in late 2011 or early 2012 and we can just show one problem, highlighted by 2008 research – non-competitive awards of contracts to external supplier (Table 3). From 162 organisations that sent their responses to the questionnaire, only 31 responses by public administration bodies can be used (indicating that many organisations do not want to show that non-transparent and non-competitive awards are very frequent.

<table>
<thead>
<tr>
<th>Procurement method</th>
<th>Number of organizations</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Open tender</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Restricted tender</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Direct award</td>
<td>2</td>
<td>6.45%</td>
</tr>
<tr>
<td>Small scale procurement</td>
<td>13</td>
<td>45.16%</td>
</tr>
<tr>
<td>Unclear response</td>
<td>15</td>
<td>48.39%</td>
</tr>
</tbody>
</table>

Source: own research

OUTSOURCING IN PUBLIC ORGANIZATIONS: SLOVAKIA

Because of temporary limited availability of “outcomes” data from the Czech Republic we decided to provide our data from the Slovak Republic. We argue that these data are very much representative also for the Czech Republic (because of joint history and similar approaches to the public sector reforms and management).

The research was realised by our team in 2008 and 2009 and focused on most important dimensions of outsourcing of selected internal services - cleaning, catering, maintenance, IT, transport, and security the scale of outsourcing, deciding about outsourcing and way of selecting supplier, costs and quality of outsourced services. On the base of data obtained, we tried to compare efficiency of outsourced and in house produced services. The methodology was multifactor analysis, with following main factors:

- unit costs per employee (weight 20%),
- unit costs per production unit – Table 5 (weight 20%),
- quality (weight 30%) – measured by satisfaction of users and
- method of awarding contracts to external supplier (weight 30%) – scale from 100 for open tender to 0 for direct award, in house production = 0).

The planned sample was 300 public organisations from main sub-sectors - education, health care, social care/services, culture and sport, general administration; unfortunately only 127 organisations responded (Table 4).
TABLE 4
FINAL RESEARCH SAMPLE

<table>
<thead>
<tr>
<th>Service</th>
<th>Number of evaluated responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Administrative bodies</td>
<td>30</td>
</tr>
<tr>
<td>Education</td>
<td>62</td>
</tr>
<tr>
<td>Health care</td>
<td>14</td>
</tr>
<tr>
<td>Social care/services</td>
<td>13</td>
</tr>
<tr>
<td>Culture and sports</td>
<td>8</td>
</tr>
<tr>
<td>Total</td>
<td>127</td>
</tr>
</tbody>
</table>

Source: own research

TABLE 5
SELECTED PRODUCTION UNITS INDICATORS

<table>
<thead>
<tr>
<th>Service</th>
<th>Indicator</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cleaning</td>
<td>m²</td>
</tr>
<tr>
<td>Catering</td>
<td>Number of users</td>
</tr>
<tr>
<td>Maintenance</td>
<td>Number of actions</td>
</tr>
<tr>
<td>IT</td>
<td>Number of actions</td>
</tr>
<tr>
<td>Transport</td>
<td>Average km yearly</td>
</tr>
<tr>
<td>Security</td>
<td>m² of protected area</td>
</tr>
</tbody>
</table>

Source: own research

Because of the purpose of this article we do not provide all findings in absolute figures for all selected internal services (see Merickova et al, 2010). The summary data are presented by the Table 6.

TABLE 6
WEIGHTED RESULTS – EFFICIENCY OF INTERNAL VERSUS OUTSOURCED SERVICES
(FOUR CRITERIA)

<table>
<thead>
<tr>
<th>Service</th>
<th>Administration</th>
<th>Education</th>
<th>Health care</th>
<th>Social</th>
<th>Culture</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cleaning</td>
<td>Internal</td>
<td>63,72</td>
<td>83,32</td>
<td>87,81</td>
<td>-</td>
<td>83,71</td>
</tr>
<tr>
<td></td>
<td>External</td>
<td>100,00</td>
<td>100,00</td>
<td>100,00</td>
<td>-</td>
<td>98,71</td>
</tr>
<tr>
<td>Catering</td>
<td>Internal</td>
<td>57,65</td>
<td>50,40</td>
<td>100,00</td>
<td>40,65</td>
<td>60,84</td>
</tr>
<tr>
<td></td>
<td>External</td>
<td>100,00</td>
<td>100,00</td>
<td>87,94</td>
<td>100,00</td>
<td>97,59</td>
</tr>
<tr>
<td>Maintenance</td>
<td>Internal</td>
<td>38,61</td>
<td>73,19</td>
<td>88,20</td>
<td>63,93</td>
<td>68,32</td>
</tr>
<tr>
<td></td>
<td>External</td>
<td>100,00</td>
<td>100,00</td>
<td>100,00</td>
<td>100,00</td>
<td>100,00</td>
</tr>
<tr>
<td>IT</td>
<td>Internal</td>
<td>53,10</td>
<td>49,79</td>
<td>82,93</td>
<td>63,20</td>
<td>62,27</td>
</tr>
<tr>
<td></td>
<td>External</td>
<td>100,00</td>
<td>100,00</td>
<td>100,00</td>
<td>100,00</td>
<td>100,00</td>
</tr>
<tr>
<td>Transport</td>
<td>Internal</td>
<td>98,38</td>
<td>55,20</td>
<td>66,66</td>
<td>-</td>
<td>73,41</td>
</tr>
<tr>
<td></td>
<td>External</td>
<td>100,00</td>
<td>100,00</td>
<td>100,00</td>
<td>-</td>
<td>100,00</td>
</tr>
<tr>
<td>Security</td>
<td>Internal</td>
<td>59,88</td>
<td>48,34</td>
<td>72,54</td>
<td>-</td>
<td>58,09</td>
</tr>
<tr>
<td></td>
<td>External</td>
<td>100,00</td>
<td>100,00</td>
<td>100,00</td>
<td>-</td>
<td>100,00</td>
</tr>
</tbody>
</table>

Source: own research

Data obtained by questionnaires indicate that external delivery – outsourcing is more effective solution for most cases. Is this really true?

The first set of problem is, for sure, connected with our methodology, especially with the decision to evaluate in house production as fully non-competitive solution (value 0). To show the impact of such decision, we calculated results only for first three criteria (Table 7). Weights for both cost indicators were set to 30%, quality received 40%.
The second, even more important problem is the quality of cost data provided by public organisations. First, very few of them use accrual/full cost accounting and because of this fact, it is impossible for them to know the real costs (normally only direct costs are calculated) – we react to this issue in the last part of this subchapter.

If we abstract from above mentioned limitations, the data collected seems to tell that outsourced internal services are more effective. The consequence should be that outsourcing is the primary form of delivery. The reality is described by the Table 8 and may indicate that quite many public organisations do not assess their internal service delivery decisions.

### TABLE 8
THE SCALE OF OUTSOURCING

<table>
<thead>
<tr>
<th></th>
<th>Administration</th>
<th>Education</th>
<th>Health care</th>
<th>Social</th>
<th>Culture</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Catering</td>
<td>90,00 %</td>
<td>17,74 %</td>
<td>21,43 %</td>
<td>20,00 %</td>
<td>62,50 %</td>
<td>42,33%</td>
</tr>
<tr>
<td>Maintenance</td>
<td>27,59 %</td>
<td>14,52 %</td>
<td>35,71 %</td>
<td>42,86 %</td>
<td>25,00 %</td>
<td>29,14%</td>
</tr>
<tr>
<td>IT</td>
<td>25,00 %</td>
<td>27,59 %</td>
<td>42,86 %</td>
<td>25,00 %</td>
<td>37,50 %</td>
<td>31,59%</td>
</tr>
<tr>
<td>Transport</td>
<td>3,70 %</td>
<td>15,15 %</td>
<td>7,14 %</td>
<td>0,00 %</td>
<td>0,00 %</td>
<td>5,20%</td>
</tr>
<tr>
<td>Security</td>
<td>64,00 %</td>
<td>42,50 %</td>
<td>45,45 %</td>
<td>0,00 %</td>
<td>42,86 %</td>
<td>38,96%</td>
</tr>
</tbody>
</table>

Source: own research

Management of outsourcing

In the following text we investigate selected aspects of „outsourcing management“ – selection of external supplier, length of contract, payment methods and ways of monitoring the contract. All our data indicate that the quality of outsourcing processes is limited. Table 9 shows that non-competitive selection of external suppliers dominates (the same as in the Czech Republic – see previous subchapter).

### TABLE 9
METHODS OF SELECTING EXTERNAL SUPPLIERS

<table>
<thead>
<tr>
<th></th>
<th>Administration</th>
<th>Education</th>
<th>Health care</th>
<th>Social</th>
<th>Culture</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Open tender</td>
<td>14,10 %</td>
<td>15,25 %</td>
<td>7,69 %</td>
<td>0,00 %</td>
<td>0,00 %</td>
<td>7,41%</td>
</tr>
<tr>
<td>Restricted tender</td>
<td>10,26 %</td>
<td>0,00 %</td>
<td>0,00 %</td>
<td>0,00 %</td>
<td>0,00 %</td>
<td>2,05%</td>
</tr>
<tr>
<td>Negotiations</td>
<td>6,41 %</td>
<td>1,69 %</td>
<td>34,62 %</td>
<td>0,00 %</td>
<td>0,00 %</td>
<td>8,54%</td>
</tr>
<tr>
<td>Price bid</td>
<td>10,26 %</td>
<td>6,78 %</td>
<td>0,00 %</td>
<td>40,00 %</td>
<td>14,29 %</td>
<td>14,27%</td>
</tr>
<tr>
<td>Direct award</td>
<td>11,54 %</td>
<td>10,17 %</td>
<td>34,62 %</td>
<td>20,00 %</td>
<td>0,00 %</td>
<td>15,27%</td>
</tr>
<tr>
<td>No information= direct award</td>
<td>47,43 %</td>
<td>66,10 %</td>
<td>23,07 %</td>
<td>40,00 %</td>
<td>85,71 %</td>
<td>52,46%</td>
</tr>
</tbody>
</table>

Source: own research
For the competitive selection in the ratio of cases when the criterion of most economically advantageous bid compared to the lowest price criterion is approximately 50:50 (we do not feel that lowest price is optimum criterion for service contract award).

Another interesting contract management issue is the length of contract – the situation is described in the Table 10. The proportion of contracts with unlimited length is “fascinating”.

TABLE 10
LENGHT OF CONTRACTS FOR OUTSOURCED SERVICES

<table>
<thead>
<tr>
<th>Length</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Up to one year</td>
<td>24.03%</td>
</tr>
<tr>
<td>1 – 2 years</td>
<td>9.30%</td>
</tr>
<tr>
<td>Up to 5 years</td>
<td>13.18%</td>
</tr>
<tr>
<td>Unlimited contracts</td>
<td>53.49%</td>
</tr>
</tbody>
</table>

Source: own research

Method of payment is also important aspect indicating the quality of contract management. Data provided by the Table 11 are again not very positive.

TABLE 11
METHOD OF PAYMENT TO THE EXTERNAL SUPPLIER

<table>
<thead>
<tr>
<th>Method of Payment</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Performance based payments</td>
<td>37.21%</td>
</tr>
<tr>
<td>Combination of performance and fixed payment</td>
<td>6.20%</td>
</tr>
<tr>
<td>Fixed payment</td>
<td>56.59%</td>
</tr>
</tbody>
</table>

Source: own research

The last issue is contract monitoring. The Table 12 again indicates important deficiencies in contract management.

TABLE 12
FREQUENCY OF MONITORING OF SERVICES DELIVERY

<table>
<thead>
<tr>
<th>Monitoring Type</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regular monitoring according to contract</td>
<td>23.26%</td>
</tr>
<tr>
<td>Irregular monitoring according to need</td>
<td>51.94%</td>
</tr>
<tr>
<td>No monitoring</td>
<td>24.80%</td>
</tr>
</tbody>
</table>

Source: own research

All data above indicate that there exist important problems connected with “outsourcing management” in public organisations. To check the real situation we visited two public organisations in 2008 and we checked all 10 decisions (two organisations times 5 services). For sure, two organisations are not the representative sample, but results are depressive. All ten decisions to outsource or to keep in-house production were wrong, based on almost no ex-ante analysis and costs/quality calculations. The most visible case was IT maintenance in a local government office, where the yearly costs were higher than the market price for all computer stations in the office. The Table 13 provides calculations of selected versus optimum solution in one of these two bodies (several estimates, especially for overheads have been necessary, but the data should be close to reality).
TABLE 13
ESTIMATED COSTS FOR SELECTED VERSUS OPTIMUM WAY OF DELIVERY

<table>
<thead>
<tr>
<th></th>
<th>Selected form</th>
<th>Estimated yearly costs thousands €</th>
<th>Optimum form</th>
<th>Estimated yearly costs thousands €</th>
<th>Inefficiency level %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Catering</td>
<td>Internal</td>
<td>150,00</td>
<td>Outsourcing</td>
<td>93,00</td>
<td>38,00</td>
</tr>
<tr>
<td>Cleaning</td>
<td>Outsourcing</td>
<td>40,00</td>
<td>Internal</td>
<td>27,00</td>
<td>32,50</td>
</tr>
<tr>
<td>Security</td>
<td>Outsourcing</td>
<td>79,67</td>
<td>Internal</td>
<td>44,12</td>
<td>44,62</td>
</tr>
<tr>
<td>IT</td>
<td>Internal</td>
<td>350,00</td>
<td>Outsourcing</td>
<td>100,00</td>
<td>71,43</td>
</tr>
<tr>
<td>Maintenance</td>
<td>Internal</td>
<td>512,49</td>
<td>Outsourcing</td>
<td>300,78</td>
<td>41,31</td>
</tr>
<tr>
<td>Transport</td>
<td>Internal</td>
<td>113,84</td>
<td>Outsourcing</td>
<td>66,24</td>
<td>41,81</td>
</tr>
</tbody>
</table>

Source: own research

Relatively comprehensive picture about outsourcing in the public sector in Slovakia (almost fully valid also for Czech conditions – as already visible from our new research data) may be summarised by following statements:
- outsourcing is relatively frequent solution in the public sector in the Czech Republic and Slovakia,
- global figures indicate that outsourcing should be more effective solution compared to internal delivery,
- “outsourcing management” processes in public organisations are of very low quality – ex-ante analysis is not regularly realised, unit costs are not known, suppliers are selected dominantly in non-competitive way, contract management is of very low quality.

Such findings are partly contradictory to results of another our questionnaire (Table 14) – many municipal officers tried to respond in much more positive way compared to reality (for possible explanations see Nemec et all, 2011).

TABLE 14
SELECTED RESPONSES FROM MUNICIPALITIES (%)

<table>
<thead>
<tr>
<th></th>
<th>Strongly disagree/disagree</th>
<th>Agree/strongly agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. There is a strong commitment in my municipality continually to seek improvements in service delivery</td>
<td>3</td>
<td>4,11</td>
</tr>
<tr>
<td>2. My authority reviews the need for the services we provide at least once every three years.</td>
<td>12</td>
<td>37,20</td>
</tr>
<tr>
<td>3. Municipal employees are encouraged to question the continued need for each service to be provided.</td>
<td>13</td>
<td>25,79</td>
</tr>
<tr>
<td>4. My local authority delivers high quality services.</td>
<td>7</td>
<td>18,32</td>
</tr>
<tr>
<td>5. My authority regularly compares the costs of internal and external delivery alternatives of internal services (cleaning, catering, etc.)</td>
<td>x</td>
<td>17,37</td>
</tr>
<tr>
<td>6. My authority compares the costs of its services with other local authorities.</td>
<td>5</td>
<td>51,41</td>
</tr>
<tr>
<td>7. My authority regularly compares the quality of internal and external delivery alternatives of internal services (cleaning, catering, etc.)</td>
<td>x</td>
<td>22,05</td>
</tr>
<tr>
<td>8. My authority compares the quality of its services with other local authorities.</td>
<td>7</td>
<td>45,98</td>
</tr>
<tr>
<td>9. In my authority there is a zero level of corruption.</td>
<td>x</td>
<td>5,43</td>
</tr>
</tbody>
</table>

Source: Authors’ research for Czechia and Slovakia in 2008; Tonnisson and Wilson (2007) for Estonia

OUTSOURCING IN THE PRIVATE SECTOR IN THE CZECH REPUBLIC

To obtain information about practice of outsourcing in the private sector in the Czech Republic we decided to use standard questionnaire based on quantitative research. The questionnaire was sent in the beginning of 2010 to more than 1000 firms from ten selected sectors (agriculture + forestry + fishing, food production, textile production, building, manufacturing, other processing, retail trade, wholesale trade, IT+ telecommunications, other activity). List of firms to be contacted was created on the base of their size and their regional distribution with target to obtain representative sample.
The response rate was relatively limited; total of 142 questionnaires are included into the final sample (minimum 14 per selected sector). Such sample is not fully representative, but still provides effective picture of the situation.

The first issue was to find proportion of firms that use contracting. From the total sample 108 firms at the time of research used outsourcing, the rest (24%) did not use contracting in given period, but some of them have had already previous experience.

**Outsourced activities**

The firms from the first group provided data about types of internal activities/services which are outsourced by external suppliers. Following is list of main categories for which is used outsourcing:

- Area protection – 12.4 %,
- Cleaning – 11.5 %,
- IT services – 10.6 %,
- Work security, logistics, catering – each 8.8 %,
- Maintenance, accounting – each 6.2 %,
- Waste management, salaries administration – each 5.3 %,
- Marketing – 4.4 %,
- HRM – 3.5 %.

**Reasons for outsourcing**

The questionnaire used semi-open questions to obtain information why firms outsource. Main standard reasons known from the literature were presented, plus there was open space for describing other reasons available. Listed factors were evaluated as follows:

- costs reduction: 41 %,
- lack of qualified staff: 13 %,
- transfer of responsibility to supplier: 23 %,
- access to new know-how: 11 %,
- outsourcing activity is branch general practice: 4 %.

Especially small firms might be expected to cope with lack of qualified staff for some activities (accounting, IT), but the results of our research do not confirm this. Transfer of responsibility was mainly connected with waste disposal and security services. Very few other reasons for outsourcing were indicated by the sample (e.g. need to focus on core business as contracted firms are more specialized).

**Deciding about outsourcing**

Decision making processes for outsourcing were significantly correlated with reasons of outsourcing. Because the main goal of firms was costs savings, the core base for decisions was economic calculations of in-house versus external production (64 %). Other non-economic parameters were used in 28 % of cases. The data suggests that firms normally try to compare their own internal (full) costs with bids of external firms as the main decision making factor. From other methods risk analysis, quality analysis, disponibility of human resources and SWOT analysis were mentioned. If we summarize all responses, the findings are as follows:

- 39 % of firms use only economic calculations to decide about outsourcing,
- 22 % of firms use only non-economic calculations to decide about outsourcing,
- 37 % of firms use complex (economic and non-economic) calculations to decide about outsourcing,
- 2 % of firms do not use any ex-ante analysis to decide about outsourcing.

Structure of used methods for decision does not depend on size of a firm; all firms that do not use ex-ante analysis belong to small and medium enterprises group. The methods used also do not depend on type of the outsourced activity/service.

Some firms realize complex assessment of potential supplier already during ex-ante evaluation process (few of them as the main criterion for outsourcing decision). Main criteria are timelines, prices, volume of supplies and quality references. The open question is if such evaluations should be part of tender and not of ex-ante analysis.

Body making decision about outsourcing in firms differs significantly – owner, top management, delegated person, project team. Only in 15 % of cases specialized project team was created. In many cases – 51 % of firms (almost all small and medium firms) - did not designate any concrete person to be responsible for process of decision making.
Selection process

Tender of outsourced activities is generally compulsory in the public sectors and one might expect that this would be dominant strategy in the private firms too, dealing with their own resources. However, the results of our research do not confirm such assumption. Open or restricted tender was used only in 57% of cases (average number of competing firms was in majority of cases only 2-3, thus competition was not guaranteed), direct selection in 27% of cases and in 13% of cases the outsourcing was realized as the response to the concrete offer by external firm.

Contract management

Findings in this category are also relatively surprising. 26% of firms stated that they do not sign contracts with external supplier. Most of contracts were signed for unlimited period of supply. The question is obvious – how to penalize non-compliance if the contract does not exist? Responses from of firms also indicate that regular systematic control of results achieved by outsourcing is not always in place. Control processes during contract realization focus dominantly on costs analysis and supplies evaluation (timelines, scope and quality).

Opinion of firms about outsourcing

The firms were also asked to provide their global opinion about outsourcing, based on their data and experience. Results are as follows:

- outsourcing is economical decision – 60%,
- outsourcing is effective because of non-economic reasons – 34%,
- outsourcing is non-economic solution – 3%,
- outsourcing is not effective because of non-economic reasons – 3%.

The results indicate that Czech firms have very positive opinion about outsourcing and also really positive experience with outsourcing (79% of firms evaluated their outsourcing experience as positive), and accept this method mainly as cost-containment tool. Main experienced pros and cons of outsourcing are summarized in the Table 15.

<table>
<thead>
<tr>
<th>TABLE 15</th>
<th>OPINION OF CZECH FIRMS ABOUT PROS AND CONS OF OUTSOURCING</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pros of outsourcing</strong></td>
<td>Frequency of answers</td>
</tr>
<tr>
<td>Cost containment</td>
<td>28%</td>
</tr>
<tr>
<td>Possibility to focus on “core business”</td>
<td>19%</td>
</tr>
<tr>
<td>Savings – labour</td>
<td>11%</td>
</tr>
<tr>
<td>Transfer of responsibility</td>
<td>11%</td>
</tr>
<tr>
<td>Increased flexibility</td>
<td>6%</td>
</tr>
<tr>
<td>Better access to information</td>
<td>6%</td>
</tr>
<tr>
<td>Quality improvements</td>
<td>6%</td>
</tr>
<tr>
<td>Fast recruitment of new employees</td>
<td>3%</td>
</tr>
<tr>
<td>New technologies</td>
<td>3%</td>
</tr>
<tr>
<td>Know how</td>
<td>3%</td>
</tr>
<tr>
<td>Time savings</td>
<td>3%</td>
</tr>
<tr>
<td><strong>Cons of outsourcing</strong></td>
<td></td>
</tr>
<tr>
<td>Implementation problems</td>
<td>6%</td>
</tr>
<tr>
<td>Information leaks</td>
<td>6%</td>
</tr>
<tr>
<td>Delivery problems and difficulties to handle them</td>
<td>3%</td>
</tr>
<tr>
<td>Misuse of internal information</td>
<td>3%</td>
</tr>
<tr>
<td>Limited availability of representatives of supplier</td>
<td>2%</td>
</tr>
<tr>
<td>“Human factor failures”</td>
<td>8%</td>
</tr>
</tbody>
</table>

Source: own research

Reasons for not using outsourcing

Second part of our questionnaire was for firms that do not use outsourcing. These firms were asked to provide reasons for their decisions. The most frequent argument was that outsourcing is non-economic solution (almost all firms answered in such way). The second important argument was that there are no activities/services to outsource (50% of responses). Other reasons mentioned were: limited information about outsourcing, limited supply, risks and lack of trust.
Only one firm with previous experience with outsourcing stated that the main reason is bad experience (supplier in IT area misused access to internal information). This firm does not plan any outsourcing in future.

**COMPARING OUTSOURCING IN THE PRIVATE AND PUBLIC SECTOR**

As indicated in our introduction, knowing that the public sector approaches to outsourcing include many reserves (highlighted by data provided in the analytical part of our text), we tried to check if the private sector practice can serve as the positive benchmark and learning source for public organisations. This can be only partly confirmed.

The data collected in the Czech Republic, despite of limited size of our sample, indicate two core facts. First, outsourcing is relatively frequently used by private firms in the country. Second, we may see that “quality” of implementation of outsourcing in the private sector in the Czech Republic is a bit limited. In comparison with more developed countries, most firms use outsourcing as cost savings method and are not aware of more complex (mutual) benefits connected with outsourcing. Many firms do not use fully systematic approach to outsourcing process. Ex-ante analysis, outsourcing project preparation are frequently very amateur processes, mainly in small and medium size firms. Selection of supplier is not sufficiently competitive. Contract management failures are also visible. Despite of all realization problems, Czech firms trust outsourcing; important majority of them feels that outsourcing is positive tool supporting their global performance.

In brief this means that the situation in the private sector is only slightly better compared to public practices of outsourcing. Even private managers, especially in small and medium firms, do not have sufficient knowledge and skills to manage outsourcing decisions and operations. If we include the factor of much higher potential to corruption and “channelling” in the public sector, it cannot be surprise that such large reserves are highlighted by our data.

**CONCLUSION**

Our paper is based on analytical data about outsourcing in the public and private sectors in the Czech Republic and Slovakia. Its main conclusions are straightforward. Outsourcing in the public sector is frequently used solution, with obvious potential, which is significantly limited by large scale implementation/contract management problems and corruptive behaviour of some public officials. Unfortunately, private sector approaches cannot be commonly used as examples of best practice and direct learning source – private firms have very positive attitudes to outsourcing, but many of them are not sufficiently aware about the complexity of outsourcing processes and tools to deal with it.

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EMPIRICAL ANALYSIS OF INNOVATION LINKAGES IN JAPANESE SME: OPEN INNOVATION VS. SUPPLY CHAIN

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ABSTRACT

This paper aims to identify sources of innovation based on a mail survey to 5,300 SMEs conducted in October-November 2007. The sources this paper verifies are two categories of the information flow such as open innovation linkages and supply chain linkages. The former consists of research institutions such as universities, regional R&D institutions and firms in the same industry, while the latter is formed by other firms in their supply chains such as large firms as their customers or suppliers. This paper examines empirically which one has better performance in creating innovation by SMEs.

KEYWORDS
Open Innovation Linkage, Supply Chain Linkage, Cluster, Innovation, Upgrading

INTRODUCTION

The revitalization of Japanese SMEs (small- and medium-sized enterprises) is one of the most important issues in the Japanese economy, and weakening SMEs surely leads to a loss of competitiveness across all Japanese manufacturing industries, since the former is the essential basis for the latter. The reality of Japanese SMEs, however, shows that revitalization has not been achieved.

There are many sources of such information such as reverse engineering, licensing technologies from other firms, obtaining patents, and recruiting mid-carriers or senior engineers. The key players are universities or local R&D institutions which own technology. For innovation, SMEs have to equip themselves with higher level technology and management. One means to achieve this is the industrial cluster policy. For this purpose, the traditional approach is found, for instance, in Fujita, Krugman, and Venables [1999], and Porter [1980]. The essence of these theories lies in the flow of information generated by agglomeration; that is, in regions where firms, research institutions and other organizations agglomerate, collaboration and competition among those entities and organizations create positive motions for spontaneous upgrading or renovation. In the global context, Kuchiki and Tsuji [2005], [2008], [2009], Tsuji and Miyahara [2009], and Tsuji, Miyahara, and Ueki [2008] have proposed and verified a so-called “Flowchart Approach,” to agglomeration which successfully explains the recent growth of East Asian industrial clusters.

Recent interest has turned to transmission channels or networks of information flows, and this focuses on the kinds of information transmitted and received. This approach focuses on linkages in a cluster, which consist of various networks of all agents in a cluster, including information linkages, supply chain linkages, open innovation linkages, and
so on. In the context of this paper, the main issue is to verify that firms with a greater variety of linkages achieve more innovations.

**PROCEDURE OF MAIL SURVEY AND CONTENTS OF DATA**

**Sample of SMEs**

The mail survey was aimed to obtain fundamental data on the innovative activities of SMEs and their characteristics such as size, industry, and managerial orientation. The Small and Medium Enterprise Agency registered innovative 30,931 SMEs as of December 2007. These SMEs were located all over Japan, and sample SMEs were selected from all prefectures in the following way: The shares of each prefecture with respect to the total number of authorized SMEs was calculated, and by multiplying these shares by 5,000, our target number for sending out the questionnaire, the number of SMEs to be surveyed in each prefecture was obtained, and to these SMEs the questionnaire was sent.

**SME Category**

This paper asked SMEs for a subjective impression in the questionnaire concerning whether they think they are located inside a cluster. If they replied that they thought they were located in a cluster, the area was considered as a cluster, while if they did not think they were located in a cluster, they were considered as outside a cluster even if they were officially located inside an approved cluster. Thus we have two definitions of clusters, and accordingly there are four categories of SMEs. Thus this paper focuses on SMEs of category (II, III) and (0, I), and the former defined to be located inside a cluster, while the latter are defined as being outside a cluster. Table 1 and 2 show the size of SME in term of employees and the ratio of R&D expenditures to total sales, respectively.

<table>
<thead>
<tr>
<th>TABLE 1</th>
<th>FIRM SIZE: NUMBER OF EMPLOYEES</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Outside (0, I)</td>
</tr>
<tr>
<td></td>
<td>freq.</td>
</tr>
<tr>
<td>Less than 4</td>
<td>18</td>
</tr>
<tr>
<td>4 - 9</td>
<td>60</td>
</tr>
<tr>
<td>10 - 19人</td>
<td>57</td>
</tr>
<tr>
<td>20 - 49人</td>
<td>100</td>
</tr>
<tr>
<td>50 - 99人</td>
<td>61</td>
</tr>
<tr>
<td>More than 100</td>
<td>32</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>TABLE 2</th>
<th>RATIO OF R&amp;D EXPENDITURES TO TOTAL SALES</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Outside (0, I)</td>
</tr>
<tr>
<td></td>
<td>freq.</td>
</tr>
<tr>
<td>under 5%</td>
<td>137</td>
</tr>
<tr>
<td>5 - 10%</td>
<td>42</td>
</tr>
<tr>
<td>10 - 20%</td>
<td>34</td>
</tr>
<tr>
<td>over 20%</td>
<td>10</td>
</tr>
<tr>
<td>0</td>
<td>29</td>
</tr>
</tbody>
</table>

**R&D Collaborating Partners**

This paper focuses on information flow regarding innovation and upgrading, that is, from where and how SMEs obtain necessary information on technology and management. SMEs were considered to obtain information from collaborating partners, which is referred to as the “information linkage.” This consists of two sources, namely production partners and research institutions. In this paper, we refer to the former to as the “supply chain linkage” and the latter as the “open innovation linkage.” The former consists of customers, suppliers and firms in the same industries, while the latter includes universities and local R&D institutions. The R&D collaborating partners are summarized in Table 3. As for the numbers of R&D collaborating partners of SMEs inside and outside a cluster, the former had 363 partners, while
the latter had 358. The types of R&D partners are, however, quite different. SMEs inside a cluster have relatively larger numbers of open innovation linkages (215; 58.1%) than supply chain linkages (121; 32.7%), while SMEs outside a cluster have relatively larger numbers of supply chain linkage (248; 68.3%) than open innovation linkages (83; 22.9%). The two categories of SMEs thus have different sources of new information, and this paper will analyze how this distinction affected their innovation performances.

### TABLE 3
**R&D COLLABORATING PARTNERS**

<table>
<thead>
<tr>
<th></th>
<th>Outside (0, I)</th>
<th>Inside (II, III)</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>freq. %</td>
<td>freq. %</td>
<td>freq. %</td>
<td></td>
</tr>
<tr>
<td>1. Customer</td>
<td>148 44.98</td>
<td>123 41.84</td>
<td>271   36.97</td>
</tr>
<tr>
<td>2. Suppliers</td>
<td>74 22.49</td>
<td>62 21.09</td>
<td>136   18.55</td>
</tr>
<tr>
<td>3. Competitors</td>
<td>26 7.90</td>
<td>30 10.20</td>
<td>56    7.64</td>
</tr>
<tr>
<td>4. Universities</td>
<td>44 13.37</td>
<td>61 20.75</td>
<td>105   14.32</td>
</tr>
<tr>
<td>5. Public R&amp;D institutions</td>
<td>39 11.85</td>
<td>60 20.41</td>
<td>99    13.51</td>
</tr>
<tr>
<td>6. Others</td>
<td>27 8.21</td>
<td>27 9.18</td>
<td>54    7.37</td>
</tr>
<tr>
<td>7. Do not have</td>
<td>5 1.52</td>
<td>7 2.38</td>
<td>12    1.64</td>
</tr>
<tr>
<td>Total</td>
<td>358 100.00</td>
<td>363</td>
<td></td>
</tr>
</tbody>
</table>

### ESTIMATION OF INNOVATION AND LINKAGES

**Dependent Variables**

This paper defines industrial upgrading as follows: (1) from being subcontractors for simple work to producing intermediate goods; (2) from producing intermediate goods to final products; and (3) from simple to complex or precision work. Innovation consists of (i) supplying new products or services; (ii) introducing new production or supply methods; (iii) obtaining new customers; (iv) finding new suppliers; and (v) establishing new sections in charge of R&D. Question V consists of the following six options regarding upgrading and innovation:

V.1. We upgraded business activities; for example, we upgraded from being subcontractors for simple work to producing intermediate goods, from producing intermediate goods to final products, or from simple to complex or precision work.

V.2. We started supplying new products or services.

V.3. We introduced new production or supply methods, such as CAD/CAM, cell manufacturing systems, Internet marketing, or shortened distribution channels.

V.4. We obtained new customers.

V.5. We found new suppliers.

V.6. We established new sections in charge of R&D or venture businesses.

Question V.1. is related to industrial upgrading and Questions V.2.–V.6 to innovation. The questions are related to the period from January 1999- September 2007. SMEs responded either “yes” or “no.” We then took the number of “yes” responses from each SME as a dependent variable, 6 being the maximum value, and 0 the minimum. Table 3 shows the number of innovation and upgrading per SME inside or outside cluster in different periods.

### TABLE 4
**NUMBER OF INNOVATION AND UPGRADING IN DIFFERENT CLUSTERS AND PERIODS PER SME**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Category 0</td>
<td>2.39</td>
<td>1.88</td>
<td>1.51</td>
<td>1.45</td>
</tr>
<tr>
<td>Category I</td>
<td>2.38</td>
<td>1.95</td>
<td>1.46</td>
<td>1.34</td>
</tr>
<tr>
<td>Category II</td>
<td>2.45</td>
<td>1.99</td>
<td>1.69</td>
<td>1.32</td>
</tr>
<tr>
<td>Category III</td>
<td>2.76</td>
<td>2.04</td>
<td>1.77</td>
<td>1.53</td>
</tr>
</tbody>
</table>

### Explanatory Variables

Independent variables include those related to verification of the hypotheses concerning the information linkages, which consist of the supply chain linkage and open innovation linkage. The independent variables are as follows: (1) characteristics such as firm size in terms of the number of employees and the amount of capital, and the year
of establishment; (2) business performance, such as sales amount and profits; (3) managerial orientations, which express the attitude or behavior of top management toward upgrading and innovation; (4) location of SMEs inside or outside a cluster; and (5) distance from those partners.

**Estimation Results**

The result of the estimation is shown in Table 4, and significant variables are summarized as follows:

(a) Characteristics of SMEs and business strategy

Three variables related to the characteristics of SMEs are identified as other service industry, trend of sales, and R&D expenditures, but the size of firms, manufacturing industry, and cluster are not significant.

Regarding managerial orientations, the strategy of top management such as “Development of new product,” “Cooperation with other firm,” “Collaboration with other R&D institution,” and “Intellectual property right” are found to be significant at least at the 10% level. These attitudes coincide with reality.

(b) Collaborating partners

Among collaborating partners, “Customers” in supply-chain and “Public research institutions” are identified as significant, and the former has a positive sign, which is consistent with the discussion and results in the previous sections. The latter, however, is negative, and this seems to contradict reality. The proximity to collaborating partners has a negative sign, and this is the same as the results of the estimations in the previous sections.

**TABLE 5**

ESTIMATION RESULTS

<table>
<thead>
<tr>
<th>Question No.</th>
<th>Variables</th>
<th>Coef.</th>
<th>Std. Err.</th>
<th>z value</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>SME characteristics</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Q1.1</td>
<td>Elapsed number of years from establishment</td>
<td>0.1630</td>
<td>0.1224</td>
<td>1.33</td>
<td>0.183</td>
</tr>
<tr>
<td>Q1.2</td>
<td>Amount of capital</td>
<td>0.0960</td>
<td>0.0925</td>
<td>1.04</td>
<td>0.299</td>
</tr>
<tr>
<td>Q1.4.1</td>
<td>Construction</td>
<td>0.6459</td>
<td>0.4295</td>
<td>1.50</td>
<td>0.133</td>
</tr>
<tr>
<td>Q1.4.2</td>
<td>Manufacturing</td>
<td>0.3635</td>
<td>0.3239</td>
<td>1.12</td>
<td>0.262</td>
</tr>
<tr>
<td>Q1.4.3</td>
<td>Wholesale/Retail</td>
<td>0.4250</td>
<td>0.4195</td>
<td>1.01</td>
<td>0.311</td>
</tr>
<tr>
<td>Q1.4.6</td>
<td>Other service industry</td>
<td>0.7987</td>
<td>0.4798</td>
<td>1.66</td>
<td>0.096</td>
</tr>
<tr>
<td>Q1.7</td>
<td>Trend of sales (increasing 1, others 0)</td>
<td>0.3976</td>
<td>0.1753</td>
<td>2.27</td>
<td>0.023</td>
</tr>
<tr>
<td>Q1.9</td>
<td>Ratio of R&amp;D expenditures</td>
<td>1.9087</td>
<td>1.1244</td>
<td>1.70</td>
<td>0.090</td>
</tr>
<tr>
<td>Cluster (inside 1, outside 0)</td>
<td>0.2088</td>
<td>0.1793</td>
<td>1.16</td>
<td>0.244</td>
<td></td>
</tr>
<tr>
<td><strong>Managerial strategy</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Q3.2.1</td>
<td>Development of new products</td>
<td>0.3195</td>
<td>0.1885</td>
<td>1.70</td>
<td>0.090</td>
</tr>
<tr>
<td>Q3.2.2</td>
<td>Development of new technology</td>
<td>0.0470</td>
<td>0.2064</td>
<td>0.23</td>
<td>0.820</td>
</tr>
<tr>
<td>Q3.2.3</td>
<td>Development of new customers</td>
<td>0.2459</td>
<td>0.1910</td>
<td>1.29</td>
<td>0.198</td>
</tr>
<tr>
<td>Q3.2.4</td>
<td>More tie with current customers</td>
<td>0.0677</td>
<td>0.2214</td>
<td>0.31</td>
<td>0.760</td>
</tr>
<tr>
<td>Q3.2.5</td>
<td>Cooperation of other firms</td>
<td>0.4913</td>
<td>0.2629</td>
<td>1.87</td>
<td>0.062</td>
</tr>
<tr>
<td>Q3.2.6</td>
<td>Collaboration of other R&amp;D institutions</td>
<td>0.4725</td>
<td>0.2652</td>
<td>1.78</td>
<td>0.075</td>
</tr>
<tr>
<td>Q3.2.7</td>
<td>Accumulation of technology and know-how</td>
<td>0.3080</td>
<td>0.2068</td>
<td>1.49</td>
<td>0.136</td>
</tr>
<tr>
<td>Q3.2.9</td>
<td>Intellectual property right</td>
<td>0.6854</td>
<td>0.2799</td>
<td>2.45</td>
<td>0.014</td>
</tr>
<tr>
<td>Q3.2.12</td>
<td>Hiring spun off employees</td>
<td>0.4508</td>
<td>0.2854</td>
<td>-1.58</td>
<td>0.114</td>
</tr>
<tr>
<td><strong>Important partner</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Q7.4.1</td>
<td>Customers</td>
<td>0.3220</td>
<td>0.1882</td>
<td>1.71</td>
<td>0.087</td>
</tr>
<tr>
<td>Q7.4.5</td>
<td>Public research institutions</td>
<td>0.4375</td>
<td>0.2371</td>
<td>-1.85</td>
<td>0.065</td>
</tr>
<tr>
<td>Q7.6</td>
<td>Distance from partners</td>
<td>-</td>
<td>-</td>
<td>-2.29</td>
<td>0.022</td>
</tr>
<tr>
<td>/cut1</td>
<td>1.1259</td>
<td>0.9569</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>/cut2</td>
<td>2.1191</td>
<td>0.9609</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>/cut3</td>
<td>3.7148</td>
<td>0.9706</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>/cut4</td>
<td>5.6275</td>
<td>1.0090</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Number of Observation</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>468</td>
</tr>
<tr>
<td><strong>Log likelihood</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>636.09</td>
</tr>
<tr>
<td><strong>Pseudo R2</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.0355</td>
</tr>
</tbody>
</table>
CONCLUSION

We define the information linkage inside the cluster; this consists of the supply chain and open innovation linkages. The former is based on the networks of collaborating partners through transactions; customers, suppliers and firms in the same industry being typical entities, whereas the latter is based on networks of collaborating partners in research related to technology; universities and public R&D institutions being representative agents. We also consider one further linkage in the production network.

By constructing suitable estimation models, we have obtained the following results related to the above issues. By observing the data on collaborating partners, SMEs in cluster areas tend have more open innovation linkages, whereas those outside a cluster have more supply chain linkages. Since cluster areas are more populated and are denser in terms of economic activity, universities and research institutions were more likely to be located in those areas. Thus, in cluster areas, two types of linkages, SMEs with public R&D institutions as well as with supply chain, are identified. The latter is found to be significant, while the former is not confirmed. The contents and density of the latter are not identified in this analysis and further research will be required to examine this.

Several issues related to these models warrant further research. First, this analysis was not able to grasp the contents of information exchanged inside a cluster. For example, what kinds of information are transmitted and received, and how they are exchanged in forward linkages are questions that require answers. In addition, this mail survey was not able to capture the local innovation network, especially open innovation linkages.

REFERENCES


IMPLICATIONS OF PERFORMANCE-BASED CONTRACTING ON SERVICE OPERATIONS

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IMPLICATIONS OF PERFORMANCE-BASED CONTRACTING ON SERVICE OPERATIONS

by

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ABSTRACT

The growing importance of services in today’s business world is acknowledging both economically as well as academically. Many businesses see the provision of services as a major growth opportunity for both pure service providers as well as manufacturers that expand their offerings into the service sector. However, simply offering services as add-ons to hardware products does no longer suffice. With companies increasingly concentrating on their core competencies and sourcing out non-core activities to external providers, they demand integrated solutions, rather than having to compose a combination of products and services. As a result, full-service concepts have developed, with a specific form of them being called “Performance-based Contracting” (PBC). The main idea of it is that the customer defines a desired result (or outcome) and only pays for the performance delivered, rather than providing a detailed specification and paying for the resources consumed during service provision. A typical example is to purchase flight hours rather than an aircraft and separate maintenance services. This contribution seeks to introduce the idea of PBC as an evolving service concept, define its characteristics and analyze its implications on the operations of service providers. This will be done using a deductive approach. The conceptual characteristics and operational implications will be worked out based on a literature review that will result in a conceptual model of service operations management. The major characteristics of PBC are then matched to the model. The contribution is concluded with dedicated suggestions for further research.

KEYWORDS
Service Operations Management, Servitisation, Product-Service Systems, Performance-Based Contracting

INTRODUCTION

The growing importance of services can be recognized on economical as well as business level. In most major economies worldwide, the service sector is outgrowing the traditional industrial sectors (OECD, 2000). Companies add major service offerings to their physical products, turn their products into value service offerings or even abandon their goods-based business model in favour of an exclusive service business (Lay et al., 2009; Neely, 2009). At the same time, academia has developed service management into an independent research discipline (Grönroos, 2005; Gummesson, 1994). The basis is a number of characteristics of services that advocate for a clear differentiation to the management of physical goods. The most frequently cited are (Grönroos, 2005; Levitt, 1981; Zeithaml, 1981):

- intangibility, i.e. one cannot store services nor can their production be (fully) separated from their consumption
- customer interaction, thus some portion of any service is always provided in interaction with the customer
- heterogeneity and customisation, meaning that services are harder to categorise und usually required some adjustment to the customer in focus.

As a result, many academic contributions focus on the consequences of these aspects for e.g. service marketing, as there is no physical good that can be presented to the customer (Bitner, 1995; Zeithaml, 1981). It also seems that operations management for services is mainly discussed with a view capacity management, e.g. human resources scheduling (Machuca et al., 2007). However, many companies that offer services do so in connection with their physical goods. The development that manufacturers combine their products with services is also called “servitisation” (Vandermerwe & Rada 1988). The providers form a complex package of products and services (also “product-service-
system”, PSS) to provide the customer with a full solution (Mont, 2002; Baines et al., 2007). A specialised form of these “PSS” is when they are provided under the concept of “Performance-based Contracting” (PBC).

This innovative approach emphasises that customers, whether buying a product or a service, are actually seeking to receive an outcome, regardless how it is achieved (Grönroos, 2005; Vargo & Lusch 2004). PBC aims at providing this outcome, and tie the provider’s compensation to its successful achievement (Randall et al., 2010). However, research on PBC is still scarce (Hypko et al., 2010; Selviaridis, 2011). While a general understanding of the main characteristics has been developed, contributions on the detailed implications of PBC are not yet available. This goes in line with criticism that the discussion of PSS’ is still on a relatively general level and the actual implications for providers have not been sufficiently dealt with (Baines et al., 2009; Oliva & Kallenberg, 2003; Spring & Araujo, 2009).

This paper seeks to address this gap specifically for the implications of PBC on operations management taking the perspective of the providing company. Using a deductive approach, we first develop a generic model for service operations management (SOM). After introducing the major aspects of PBC this paper elaborates key consequences by PBC on operations and aligns them in the generic SOM model.

SERVICE OPERATIONS MANAGEMENT

Aware of the specific characteristics of services, research has discovered the field of service operations relatively early in the development of dedicated service management research (Levitt, 1972; Sasser, 1976). Several extensive reviews have analysed the body of topical literature since then, while no singular definition evolved (Chase & Apte, 2007; Heineke & Davis, 2007; Mabert, 1982; Machuca et al., 2007; Sullivan, 1982). Some of the existing contributions in SOM clearly differentiate the concept vs. physical goods operations management, some of them choose a more general approach to define the term. We selected two examples as the basis for our working definition in this paper:

- Johnston and Clark (2009) define SOM as “… the term that is used to cover the activities, decisions and responsibilities of operations managers in service organisations. (Johnston & Clark 2008, p. 4), while

- Slack, Chambers and Johnston provide a more general definition, covering both physical products services: “Operations management is the activity of managing the resources which produce and deliver products and services” (Slack et al., 2010, p. 4)

As a blend of these two definitions, our understanding in this paper is that SOM is the activity that, by deciding on and using resources, delivers a service to customer(s). This involves a number of dimensions that form the entity of SOM: customer and supplier relationships, service delivery and performance management.

The resources can be differentiated into transformed resources (e.g. customers) and transforming resources (e.g. provider’s facilities or staff) (Slack et al., 2010). Involving the customer is, as stated, a key characteristic of service management – not only as the recipient, but also as a resource in the service process (Bitner, 1995; Chase, 1978; Cova & Salle, 2008; Ng & Ding, 2010).

The service delivery aspect is usually described starting by using input resources. These resources include service personnel, but also materials and (physical) facilities as inputs (Grönroos & Ojasalo 2004). Sub-suppliers are not considered. The transformation itself is seen as a process, but what actually is transformed strongly depends on the service delivered, this could be the customer, material, information or a combination of them (Slack et al., 2010). Grönroos and Ojasalo (2004) for example differentiate three alternatives for customer involvement: almost no involvement of the customer (i.e. strong independence of the provider, joint service provision and when the customer enacts the service relatively isolated from the supplier.

At the end of the process, the result is provided to the customer. This result can be in various forms: in most service contracts, these are the “raw” transformed inputs or resources as a quantitative output (CAPS Research, 2003; Grönroos & Ojasalo, 2004). This is somewhat surprising, as the overwhelming share of research emphasises that customers are looking for a value (or an outcome) when buying a service (Grönroos, 2005; Vargo & Lusch, 2004). The outcome (qualitative result, value in use) as the result expected from the transformation is however also considered as a potential result of the service process (Axelsson & Wynstra, 2002). It is clearly also a responsibility of SOM to manage the performance accordingly.

Bringing these aspects together, we introduce the following SOM framework for our analysis, while the perspective of the service provider is taken:
The model is at this stage intentionally held broad, as service applications are a very diverse field (Fitzsimmons et al., 1998; Lovelock, 1983). For example, we can see that several options of involving the customers in the transformation process are possible. How these and other determinants are impacted by PBC solutions will be addressed later in this paper, after briefly introducing PBC itself in the next section.

**PERFORMANCE-BASED CONTRACTING**

For many manufacturers, services such as maintenance, repair and overhaul were seen as a necessary addition to their core product (Arnfield, 1968; Grönroos, 2005). However, services are also seen as a major revenue and profit potential for its providers (Monitor Group, 2004). For many types of complex equipment, the revenue generated throughout a lifecycle by far outweighs the initial purchase cost (Berkowitz et al., 2004). Still, most buyers did not recognise that by separately procuring equipment and support services, they were setting out the wrong incentives: once the investment in a piece of equipment is taken, suppliers’ revenue increases the more often MRO or other support services are needed.

This is where PBC comes in: the separation of initial purchase and operation is replaced by an ongoing operational responsibility of the provider to deliver a pre-agreed “performance outcome” which represents the value expected from the customer (Berkowitz et al., 2004; Driouchi et al., 2008; Randall et al., 2010). The compensation of the supplier is moreover linked to achieving this outcome (Berends, 2000; Straub & van Mossel, 2005; Sols et al., 2007). Consider an airline: what it needs is not just a plane that is brought to repairs and maintenance every now and then. It needs an operational or flying aircraft. In PBC, this would mean that he aircraft manufacturer would no longer sell a product an then services, but offer a solution, as here would be a “flying aircraft” (Kim et al., 2007). The compensation in this case could be based on operational availability or flight hours – thus, the better the system performance, the higher the revenues for the provider.
PBC takes a step forward for the credo of service management that customers expect a result. While many service contracts are specified by way of telling the provider what to do, and compensate based on the costs incurred (or estimated), PBC reimburses a result and leaves the how to performing the service to the suppliers discretion (CAPS Research, 2003; Gruneberg et al., 2007; Sols et al., 2007). By selecting an appropriate compensation mechanism, the supplier is motivated to deliver the result more efficiently. With a fixed price per unit (e.g. flight hour), the supplier will usually try to reduce costs to maximise its profit – while the result-orientation guarantees the outcome required by the customer (Berends, 2000; Kim et al., 2007; Reichelstein, 1992).

As stated, many manufacturers see huge potential in providing value-added services (Baines et al., 2009). They see the potential of generating more stable, plannable revenue over a longer term and within this, a chance for a higher profit margin (Cohen & Whang, 1997). The following table clearly illustrates the profit potentials of services in comparison to physical goods production, using exemplary manufacturing industries:

**FIGURE 2**

**PROFITABILITY OF SERVICES**

<table>
<thead>
<tr>
<th>Industry</th>
<th>Power Equipment</th>
<th>Rail Vehicles</th>
<th>Machine Tools</th>
<th>Paper Machines</th>
<th>Metallurgy Equipment</th>
<th>Average Ø</th>
</tr>
</thead>
<tbody>
<tr>
<td>Profit Margin</td>
<td>2-5%</td>
<td>3-6%</td>
<td>1-12%</td>
<td>1-3%</td>
<td>-3-6%</td>
<td>4%</td>
</tr>
<tr>
<td>OEM business</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Profit Margin</td>
<td>15-20%</td>
<td>8-10%</td>
<td>5-15%</td>
<td>10-15%</td>
<td>15-20%</td>
<td>14%</td>
</tr>
<tr>
<td>Service business</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Leverate Factor</td>
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<td>2</td>
<td>2</td>
<td>5</td>
<td>4</td>
<td>3,24</td>
</tr>
<tr>
<td>Service vs. OEM</td>
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<td></td>
<td></td>
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</tbody>
</table>


Customers in turn want to reduce their operational responsibility in support activities to better focus on their core competencies (Campbell, 1995; Ford et al., 2003). This is where we revisit the idea of PSS: they are provided as a solution, a complex service package, to the customer, which in turn no longer has to take care of maintenance or repairs – in some cases even operation. Therefore, although many industrial and service applications are possible, we claim that PBC usually involves a piece of complex equipment that is enhanced by a service package (Buse et al., 2001).

This has several implications for the value chain. For example, by defining the outcome understood as the value for the customer, a stronger cooperation between supplier and customer is expected (Conrad & Uslub, 2011; Guo & Ng, 2011): tying the compensation to the outcome goals of the customer, the supplier inhibits these goals for its own performance (Berkowitz et al., 2004; Randall et al., 2010). Nonetheless, if the full operation is transferred to a provider, the customer has to consider a major outsourcing risk: dependency on the supplier (Buse et al., 2001; Ng & Nudurupati, 2010; Quelin & Duhamel, 2003). However, the supplier also bears an increased risk, as it is taking over the responsibility for successfully operating a complex PSS (Randall et al., 2010). The compensation mechanism, including incentives, is seen as a way of balancing this, which brings up another issue (Kim et al., 2007). Most complex PSS (whether PBC or not) cover a breadth of goods and services which cannot be provided by one individual company, but far more requires a number of companies to contribute (Buse et al., 2001; Caldwell et al., 2009). In order to still relieve the customer of the operational responsibility, employing a system integrator is recommended to bundle the service provision (Gruneberg et al., 2007; Randall et al., 2010). The integrator however is challenged with balancing the risk transfer between the customer, itself and the sub-contractors (Ng & Nudurupati, 2010). In summary, it can be seen that PBC has major implications on operations management, as will now be analysed in more detail.

**IMPLICATIONS OF PERFORMANCE-BASED CONTRACTING ON SERVICE OPERATIONS MANAGEMENT**

From the previous discussion, we could already see that the result-orientation of PBC brings a number of complications to the already challenging field of PSS operations management. These will now be discussed further, taking the perspective of the PBC service provider.

We can assume that the customer requirements and expectations no longer are only considered at the end of the service process, but far more that they are determining the whole process, from the beginning (specification and subsequent determination of input requirements), towards the transformation process to the ex-post performance
management (Axelsson & Wynstra, 2002). As claimed by service management academics, the outcome for the customer really becomes the dominant scheme (Baines et al., 2009; Schalock & Bonham, 2003).

Concerning the input resources, it is clear that PSS rely also on physical goods, e.g. the equipment itself, but more importantly spare parts for the operational support. This requires that the operations, such as inventory management for spare parts, are aligned to the customer requirements in the contract (Kim et al., 2009). The separation of production and service provision that still dominates most PSS providers also needs to be replaced as the provider is now responsible for operating its system (Ng & Ding, 2010; Oliva & Kallenberg, 2003). Problems, such as repeated repairs, directly impact revenues and profits. This key aspect of PBC, the inherent need for optimisation, requires that product development, production and service functions need to collaborate more closely to find the most efficient way of providing the service to the customer (Belz & Wuensche, 2007; Ng et al., 2009).

Considering the complexity of PSS packages and the resulting integration of sub-suppliers, involvement of suppliers in system optimisation and risk transfer can also be critical. Therefore, subcontractors should be considered more actively in SOM for PBC (Ng & Nudurupati, 2010). The other option for a system integrator (provider) would be to solely bear the increased risk and not involve the suppliers in the outcome-focused contract. This would then have major SOM implications, e.g. restructuring of processes, risk management etc. (Gruneberg et al., 2007). However, what drives involvement of suppliers is highly dependent on the context of the PSS PBC contract in question, and has not been analysed sufficiently (Selviaridis, 2011).

But also the cooperation with the customer will usually become more closely in the transformation process, e.g. when a machine provider operates its equipment within the factory of the customer, or provides consignment stock of spare parts on the customer’s premises (Guo & Ng 2011). This usually involves a day-to-day interaction in service provision, leading to closer cooperation and communication, and a better understanding of the customer’s needs (Caldwell et al., 2009; Ng et al., 2009). Moreover, service provision is no longer an occasional service encounter, but an ongoing process (Gruneberg et al., 2007; Straub, 2007).

**FIGURE 3**

A SERVICE OPERATIONS MODEL FOR PERFORMANCE-BASED CONTRACTING

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Source: authors’ preparation
The above figure summarises the major implications of PBC identified for SOM, as is the consideration of suppliers as critical inputs, the closer collaboration of internal resources, the ongoing integration of the customer as in a repeated process – and last but not least, the outcome focus as the overarching element of “PBC SOM”.

**DISCUSSION AND CONCLUSION**

This paper intended to analyse the implications of the concept “Performance-based Contracting” to service operations management. To do so, we first developed a general model for SOM. We then described the conceptual characteristics of PBC. This provided the basis to align PBC in the general SOM framework.

We demonstrated that the immanent result orientation of PBC has a major impact on how service operations are carried out, resulting in a much closer alignment of customers, providers and their suppliers. We therefore advocate for a holistic perspective on PBC on operations management, as in a “Performance-based Supply Chain Management”. This would be impacted by our other major findings, the necessity to tailor service processes towards the customer’s needs in PBC and an integration of performance management as a process that runs alongside with service production.

Our study is limited in the sense that PBC solutions are claimed to be very customer-individual, therefore it is difficult to provide more concrete insights in how PBC affects SOM at this stage. We therefore suggest further research to collect empirical data, e.g. from case studies, to further illustrate PBC’s implications for SOM and thus allow a more in-depth view of the specific challenges. Moreover, as previously stated, we suggest taking a wider perspective on PBC’s implications along the supply chain. In that sense, PBC not only integrates products and services, but also customers and providers as well as their suppliers on both a strategic and an operational level.

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CHOOSING THE LOCATION OF THE BEST AIR CARGO HUB IN SOUTH EAST ASIA

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ABSTRACT

This paper seeks to explore the ideal location of an air cargo hub in South East Asia. Critical to this examination will be the study of the aviation industry in South East Asia, the study of the niche air cargo industry within the general aviation industry and the increasing needs for air cargo freight in the South East Asia. In particular the paper will seek to explore the correlation between the export business in Southeast Asia and its influence on the location of the air cargo hub.

KEYWORDS
Air Cargo, Transshipment, ASEAN

INTRODUCTION

Air cargo industry is an intricate web with various players and several activities. Some of the industry players include manufacturers and freight forwarders. Other players are shippers and off-airport freight consolidators. Some of the activities involved in the air cargo industry include loading of the shipments at the source and off-loading of the shipment at the destinations. Shipment through the air is generally expensive as compared to alternative shipment means. In this context, the goods to be transported through the air must justify the cost involved. The goods that are generally transported through air include time sensitive goods. The other category of items transported through air is high-value commodities. Some of the high value commodities are machinery and the assorted spare parts, and electronic items and their fittings among other items. On the other hand, highly perishable items that are typically transported through the air include vegetables, fish and cut flowers. In the context of high value goods and perishable goods, air cargo freight is seen to offer security and speed respectively. The air cargo is generally moved to its final destination through a hub-and-spoke networks of various air ports. According to Encyclopedia Britannica, a hub-and-spoke network is a system where the cargo is transferred to different aircrafts in different air ports until it reaches its final destination. South East Asia, which is divided into mainland South East Asia and maritime south East Asia, consists of eleven countries namely Malaysia, Viet Nam, Cambodia and Thailand. Other countries are East Timor, Singapore, Laos, Indonesia, Brunei, Burma (Myanmar), and Philippines. Malaysia is the only country in both mainland and maritime south East Asia that is peninsular (West) Malaysia and East Malaysia respectively. The other members of a set with west Malaysia include Burma, Cambodia, Vietnam, Laos and Thailand. On the other hand, the countries that compose Maritime Southeast Asia are East Timor, Philippines, and Brunei. Other countries making Maritime Southeast Asia are Indonesia and Singapore. The Southeast Asian countries, with the exception of East Timor, have formed an umbrella organization amongst themselves called the Association of Southeast Asian Nations (ASEAN). Traditionally, a majority of the ASEAN countries were monopolized by a small number of long established airline companies at the country level. Examples of such airlines include Malaysian Airlines, Garuda Indonesia, Singapore Airlines and Thai Airlines. However, the changing political landscape such as independence of the countries led to a radical shift in government policy in regards to aviation. This governmental shift contributed to the development of the airline industry in South East Asia. Among the radical shift in governmental policy was the prioritization of the establishment of a flag carrier to serve the transport needs of individual countries. The establishment of a flag carrier also served as a platform for the newly formed independent governments to boost their respective countries profiles in the international arena. These flag carriers that catered for both passenger and cargo transportation needs made immense profits in the post-independence due to several factors. The governmental protection enabled the airlines to charge exorbitant prices for their services. A good example of governmental
protection is the case of Thai airlines. The government limited establishment of domestic airlines consequently propelling the Thai airlines as the dominant domestic airline carrier.

The aviation industry in Southeast Asia has changed significantly in the last decade or so. The 1990s brought in new insights into the aviation industry due to the economic crisis sweeping Asia at that time. The economic crisis contributed to declining business for the airlines forcing some of them to be restructured. The declining business was in form of falling international travel to the Southeast Asia. For example, the international travel from Singapore fell by five percent while passengers on international route into and from Indonesia fell by 20 percent. These factors contributed to financial difficulties to the airlines used to governmental support resulting in the need for a governmental policy change. The dominant airlines were to a certain extent and in various Southeast Asia restructured to reflect the emerging economic dispensation. For example, Garuda Indonesia underwent forced restructuring programs before being scheduled for privatization. The restructuring of the airlines came along with liberalization of the aviation industry as well as limited regulation in the industry. The net effect was the creation of a more robust and competitive environment in the Southeast Asian countries airline industry. This led to the emergence of several new airlines in different ASEAN countries such as Tiger Airways (Singapore), Nok Air (Thailand), Lion Air (Indonesia), Value Air (Singapore), Lion Air (Indonesia), and One to Go (Thailand) amongst other airlines.

STATEMENT OF THE PROBLEM

The ASEAN countries are reputed for international trade mainly in the electronics and Information and Communication Technology products (ICT) which provide a major business opportunity for the air cargo industry. However, countries with relatively weak air cargo infrastructure have often depended on their counterparts within the ASEAN community to provide them with airfreight into international markets. With this context in mind, this paper will seek to identify an ideal location of the best air cargo hub based on the geographical location of the country, its economic strengths and infrastructure development.

LITERATURE REVIEW

Air Cargo Industry

Air Cargo refers to airlines involved in the transportation of cargo as opposed to passengers. Air Cargo which can be perceived as a derivative of the terms ‘cargo airlines’ or ‘airfreight carriers’ can be constituted as a subset of the larger passenger airlines. Basically, the air freight industry can be grouped into five major sets that include freight forwarders and passenger/freight carriers. Other members of the set are the integrated freight carriers, non-integrated freight carriers and postal services. Integrated air freight carriers basically offer an end to end solution to cargo transportation. Integrated air freight carriers are capital and human intensive ventures. They basically provide a complete solution to the cargo movement through having delivery trucks to collect customer cargo at their drop off points or from their offices. After picking the cargo, the integrated air freight carriers have terminals for sorting the cargo dependent on size, destination and other variables that vary from a carrier to a carrier. The carriers may then have long haul vehicles for inter hub transportations and airplanes for inter airport transportation. On the other hand, non-integrated freight carriers are often smaller compared to integrated air freight carriers; they are more specialized and serve a smaller geographical reach. Non-integrated freight carriers are often outsourced by freight forwarders for inter airport transportations. Often the cargo is transported to large airports for intercontinental or interstate flights. Freight forwarders act as the link between the airlines and the end customer. The freight forwarders may lease space in aircrafts for the transportation of client’s goods and contract ground transportation for efficient delivery of the cargo. Freight forwarders in essence buy bulk space in aircrafts and provide supportive logistics for the movement of cargo between locations which may also include warehousing and ground transportation. Freight forwarders are estimated to serve 80 percent of the global air cargo industry. The combination of passenger/freight carriers operate by the airline selling space in the ‘belly of passenger aircrafts’. This is often done for large aircrafts such as DC10. Often these services work best in a collaborative business arrangements with freight forwarders such that the airlines only handles the transportation bit while the freight forwarders handle the logistics of cargo movements such as pick up, sorting and transportation to the airport.
Air cargo industry in South East Asia

In a global context, the air cargo industry generated over $50 billion in revenues in 2005. This was revenue that was generated in direct revenues and therefore there was significantly more potential for indirect revenues in the ground handling of cargo and related logistics. It is estimated that almost 30 percent of the international export and import business is transported via air. In 2004, 35 percent of trade not transported on land and which had a value of $3 trillion, was conducted via air freight. In the recent years Southeast Asia has emerged a global economic powerhouse in relation to ICT and electronics products. This has continually placed a demand for airfreight services in the region. It is impossible to discuss the air cargo industry in Southeast Asia without mentioning the electronics industry in the region. The electronics industry in Southeast Asia has also contributed strongly to the respective countries’ economies. There are several push and pull factors that drive the electronics industry in Southeast Asia. Among the push factors include the governmental initiatives and foreign investments. The governments have taken measures to boost the electronics industry in Southeast Asia. Such governmental initiatives include governmental sponsorship of technology parks and trade conventions, improvement in educational infrastructure on electronics technology, and creation of a business friendly environment for electronics business. On the other hand, the electronics industry in Southeast Asia has continually received direct foreign investment due to the low costs in the electronics manufacturing process. The pull factors driving the electronics industry in Southeast Asia include strong domestic and export demands of the electronics products. The domestic and export demands are fueled by the strong technological uptake of new technologies in electronics and specifically in mobile phone technology. Among the Southeast Asia countries, Philippines and Malaysia have very strong electronics export business. In these countries the export business in electronics accounts for more than fifty percent of their total export business. Singapore and Thailand also have relatively strong electronics export business. In these countries the electronics export business accounts for more than 30 percent of their total export business. The role that air cargo industry plays in the international trade in Southeast Asia can’t be undermined. The industry is critical in keeping production lines running and keeping the labor force in gainful employment. The mostly high value cargo must be transported on time to meet the time deadlines as international trade thrives on meeting deadlines. The air cargo industry is greatly tied to the international trade. Southeast Asia has been a critical component in the international trade after its recovery from the 1990s economic crisis. It has since experienced the highest growth rates in Asia. While agriculture makes substantial contribution to the economic development in Southeast Asian countries, there is a greater sway towards services and manufacturing. The potential for air cargo services in the region can therefore not be overemphasized. For example, Singapore which has a reputation for efficiency in its manufacturing process and business acumen plays a critical role in air cargo industry. It sources components for its manufacturing process from other Southeast Asia and exports finished consumer goods to other Southeast Asian countries as well as other international markets. Among the factors boosting Air Cargo industry in Southeast Asia is the signing of the ASEAN Free Trade Agreements (AFTA) framework. According to the Chinese University of Hong Kong, the AFTA framework was signed in 1992, with an aim to increase the ASEAN’s region competitive advantage as a single production unit’. This resulted in elimination of trade barriers between ASEAN members and as much promoted trade between the member states. The increased trade between member states resulted in air cargo movement between the states either as finished goods or as components for manufacturing process. Due to strong manufacturing industries in Southeast Asia and removal of trade barriers between ASEAN members, the air cargo industry has grown to facilitate movement of consumer goods to international markets. According to Hong Kong Air cargo Terminals limited, Southeast Asia imported 24 million kilograms of cargo and exported 25 million kilograms of cargo in the month of April, 2011. To further elaborate on the critical role played by the air cargo industry in Southeast Asia, the statistics for February 2011 tonnage for international trade for different countries are provided below.

<table>
<thead>
<tr>
<th>Country</th>
<th>Import (KGs)</th>
<th>Export (KGs)</th>
<th>Transshipment (KGs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brunei</td>
<td>6,505</td>
<td>6,398</td>
<td>4,231</td>
</tr>
<tr>
<td>Malaysia</td>
<td>1,472,343</td>
<td>1,067,221</td>
<td>1,018,457</td>
</tr>
<tr>
<td>Myanmar</td>
<td>6,057</td>
<td>2,106</td>
<td>0.0</td>
</tr>
<tr>
<td>Philippines</td>
<td>1,505,573</td>
<td>799,577</td>
<td>834,537</td>
</tr>
<tr>
<td>Singapore</td>
<td>1,758,916</td>
<td>1,546,416</td>
<td>1,378,286</td>
</tr>
<tr>
<td>Thailand</td>
<td>2,548,852</td>
<td>1,384,018</td>
<td>887,495</td>
</tr>
</tbody>
</table>

Source: Hong Kong Air Cargo Terminals Limited
Perhaps it is significant to note the transshipment statistics of Singapore in comparison with the other countries. The geographical location makes Singapore to have advantage in transshipment business with an estimated over 60 percent of its exports comprising of the transshipment cargo. In the context of international air freight services, the demand for the same on a country by country basis in Southeast Asia is determined two major factors. One major factor is the geographical location of a country’s imports while the other factor is the final geographical destination of its exports. Often the air freight is used where other modes of transport are not suitable. The demand for the airfreight services is also dependent on the composition of import and export cargo as air freight is more cost effective for high value to weight ratio products. Generally cargo whose value is more than 20 dollars a kilogram is considered suitable for air freight. Regional airlines in Southeast Asia serve a significant portion of the airfreight traffic. For example, the Singapore-Bangkok route is easily served by regional airlines as well as the Kuala Lumpur-Bangkok route. The Singapore- Kuala Lumpur is easily served by cheaper than road transportation. The demand for air freight services in Southeast Asia is significant. For example, Singapore with a strong electronics industry accounts for over forty percent of Southeast Asia’s electronics exports. It also accounts for over forty five percent of Southeast Asia’s exports on ICT products. While a substantial portion of the international trade can be alternatively transported, the high value per kilogram of the electronics and ICT products makes them ideal for airfreight. The value of these products oscillates between ten dollars a kilo up to as high as 150 dollars a kilo. Apart from ICT and electronics goods, textiles and garments form a major component of airfreight business. For example, Indonesia contributes almost thirty percent of the regional supply of textiles and garments within Southeast Asia countries. The major consumers of Indonesia’s textiles and garments are Malaysia and Singapore. The two countries jointly consume up to 15 percent of the Indonesia’s output. While it is worth noting that quite a substantial amount of the textile and garment products are transported via container shipping, the high end textiles with very high value are typically transported via air. The demand for airfreight services is equally strong in other Southeast Asian countries. Philippines which has the US, Singapore and Japan among other countries as its main international trading partners, exported more than 70 percent (as measured by value) of its cargo through air in the year 2002. It is noted that up to fifty percent of the airfreights were consumer electronics goods. Other major trading partners of Indonesia include Republic of Korea and Holland. In the same year, Brunei’s international trade cargo totaled up to more than 30 million kilograms for both exports and imports.

**Major air cargo hubs serving Southeast Asia markets**

In Southeast Asia some of the largest air cargo hubs include Changi airport in Singapore, Suvarnabhumi Airport (New Bangkok International airport), Kuala Lumpur International Airport and Brunei International Airport amongst other airports. Changi airport in Singapore is one of the largest cargo hubs in Southeast Asia handling over 80 airlines. The airlines serve over 180 cities that are located in fifty countries around the world. It severs with annual capacity of handling three million tons of cargo. Also, it has been designated as a customs free trade zone. The implication of this designation is that the businessmen can handle all the logistics of the air freight such as sorting and packaging without the necessity of further documentation and legislation. The airport which has its cargo operations established in the forty seven hectare Changi Airfreight Centre (CAC), handled almost two million tons of cargo in 2008. The Changi Airfreight Centre (CAC) is served by three handling agents who operate the nine airfreight terminals in the centre. The agents include Singapore airport terminal services (SATS), and Swiss port Singapore. The other agent is Changi International Airport Services. The handling agents have the capabilities of handling both specialized and niche cargo. The Changi Airfreight Centre also has two express and courier center of which one is operated by SATS. The express and courier center operated by SATS handles non specialized express shipments and has forty thousand ton cargo handling capacity. The other express and courier center is operated by the DHL as part of its Singapore business. Basically the express and courier centers are meant to serve business aspects of which time is of essence. This may include perishable commodities. On the other hand, Suvarnabhumi airport in Bangkok, Thailand with a six million cargo handling capacity, handled over one million tons of cargo in the year 2008. The airport that started operations in 2006 was constructed to decongest the Bangkok international airport. The airport acts as the main hub for Bangkok airlines, Thai air Asia, and Thai Airways international amongst other airlines. Inaugurated in 1998, Kuala Lumpur International Airport (KLIA) has developed into one of the most important airports in Southeast Asia due governmental support. This has been part of Malaysia’s government improvement on its infrastructure to cater for its relatively growing economic growth. The airport was constructed through the need to decongest Subang International airport and the government of Malaysia has since then promoted the airport as a cargo hub as well as passenger hub. Kuala Lumpur International Airport has a capacity to handle over one million tons of cargo annually of which the government plans to build a new terminal by the year 2012. It is estimated that Kuala Lumpur International Airport has a capacity to expand to handle over five million tons of cargo yearly. According to Malaysian Industrial Development Authority (MIDA), Kuala Lumpur international airport has a designated free commercial Zone (FCZ). Malaysia airlines operates an advanced cargo center within KLIA. The KLIA advanced cargo center handled over 600, 000 tons of cargo in 2006 and covers over 100 acres of land. Other major international airports within Malaysia include Langkawi International Airport and Penang international.
The relative strengths of various air cargo hubs in Southeast Asia

Convenience and efficiency are critical factors in choosing the best and most ideal location of an air cargo hub in Southeast Asia. Convenience in relation to airfreight has to do with the ease of access to the air cargo hub from the various feeder airports, both locally and regionally, for transshipment business. On the other hand, efficiency has to do with technical expertise of staff, customer service, meeting of time deadlines and prompt execution of customer instructions. Therefore for efficiency and effectiveness, the air cargo hub must be strategically and centrally located for optimal service provision. These are critical components for ensuring a cost effective air and quality air cargo hub services. This should ensure that air cargo is transported swiftly to the destination market at the lowest possible cost. The economic strengths of various countries within the Southeast Asia are critical in the consideration for the location of the best air cargo hub in the region. This is partly informed by the fact that it is much easier to create a strong air cargo hub within a strong international trade environment as opposed to a country with limited international trade. The air cargo hub must be developed to meet the home international trade before it can serve regional international trade. Air cargo holding capacity is another critical consideration in the location of the air cargo. For the hub to serve regional air cargo traffic, it must be sufficiently big to cater for those needs. It must have sufficient storage capacity to adequate and effectively cater for the perishable commodities. On the structural front, in addition to the standard infrastructure for airfreight, the air cargo hub must have sufficient runway length to handle all cargo aircrafts. Considering the above conditions for an ideal location of an air cargo hub within Southeast Asia we are going to examine the suitability of two countries; Malaysia and Singapore. It should be noted that several factors have been used in narrowing down to the two countries. One of the critical components used was the tonnage of transshipment. From the figures given above it was noted that apart from strong import and export cargo tonnage, both Malaysia and Singapore had high transshipment cargo tonnage. In the month of February 2011, Malaysia and Singapore had 1,018,457 and 1,378,286 cargo tonnage respectively. This transshipment cargo tonnage is substantially larger than the next closest country that is Thailand and Philippines with 887,495 and 834,537 transshipment cargo respectively. In analyzing the suitability of the two countries, their geographical location and economic strengths will be factored in. Malaysia with a size of 329, 758 square kilometers is bordered by Thailand, Indonesia, and Philippines to the north, south and east respectively. Malaysia is divided into west (Peninsular Malaysia) and east Malaysia consisting of eleven and two states respectively to total to the thirteen states that make up Malaysia. Malaysia’s unique and strategic position gives an edge over the other Southeast Asian countries when it comes to location of an air cargo hub serving the region. It has capitalized on this advantage to develop a relatively strong transshipment business supported by six international airports. The six international airports in Malaysia are Kuala Lumpur international airport, Kota Kinabalu airport and Senai international airport. The other airports in Malaysia are Penang international airport, Kuching International airport and Langkawi international airport. Of the six international airports, Kuala Lumpur international airport has an extremely well developed air cargo center. In the international trade, Malaysia exports electronics and textiles. Other items that are exported to a certain degree include wood products, petroleum and palm oil amongst other commodities. On the other hand, Malaysia imports food and fuel. Other items that it imports include machinery and equipments. On the other hand, Singapore consists of 60 islands of which one is a major island and the rest are small islands. The 637.5 square kilometers big country, lies strategically in the middle of a sea route connecting far east to three major economic blocks; Asia, middle east and Europe. The main economic activities include manufacturing, goods transportation and financial services. Singapore is particularly noted for its strong electronics export businesses. International airports in Singapore include Seletar airport and Changi airport. Changi airport is reputed for efficiency in air cargo handling and is one of the biggest air cargo hubs in Southeast Asia.
METHODOLOGY

This section is thus made up of several components including research design, population, sampling, data collection methods and data analysis. In the context of research design, the study used descriptive research method because of several factors. This is because the researcher will only report the state of the affairs as they are and as such has on control over the variables. In this context, we will use a survey to find the out the population’s altitudes, business requirements and how various airport cargo hubs meet these requirements for us to draw an inference on the best air cargo hub in south east Asia. The population of the survey was drawn from Malaysia and Singapore among freight forwarders. The population was drawn from these two countries having eliminated the suitability of the other countries within the ASEAN community earlier on in our discussion. Accessibility to all the major air cargo hubs within the ASEAN community was virtually impossible due to time and financial constraints. Non probabilistic was used and as such samples were deliberately selected as opposed to selection by chance. Convenience sampling was used in choosing the nearest ‘n’ most convenient person to act as the respondent. The working sample size was obtained through continually repeating the process. This method was chosen due to its convenience and distribution of the respondents. Due to time and financial constraints, the data was collected through self-administered questionnaires. A total of 208 questionnaires were filled up. In the questionnaire there were both structured and unstructured questionnaires due to the nature of data being collected.

DISCUSSION AND CONCLUSION

It is evident that best air cargo hub in Southeast Asia must be able to meet complex market requirements. Among the major considerations is the fact that a majority of the air cargo business is for both within and outside ASEAN export markets. The hub must therefore have excellent infrastructure such as road and sea ports as well as feeder airports to adequately satisfy the market demands. In the context of the requirements stated above, Malaysia easily satisfies a majority the set requirements and as such would be the ideal place for the location of the air cargo hub. Several factors support this inference. The country’s location within a central place in the Southeast Asia makes it ideal for the strategic and ideal location for air cargo hub within the region. Another factor working for Malaysia is its competent and well advanced infrastructure among the Southeast Asia countries. West Malaysia also has a good road network that links major commercial towns as well as industrial towns to the airports. On the sea front, Malaysia is blessed with various international airports including Penang port, Kemaman port and the port of Tanjung among other ports. The good road network coupled by the presence of international seaports further aggregates Malaysia’s suitability for air cargo hub location. In addition to these factors Malaysia has well established international airports. These airports could act as feeder airports to the main Kuala Lumpur International Airport in addition to handling international air cargo business in their own rights.

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INCREASING PRICE TRANSPARENCY: IMPLICATIONS OF
CONSUMER PRICE POSTING FOR CONSUMERS’ HAGGLING
BEHAVIOR AND A SELLER’S PRICING STRATEGY

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INCREASING PRICE TRANSPARENCY: IMPLICATIONS OF CONSUMER PRICE POSTING FOR CONSUMERS’ HAGGLING BEHAVIOR AND A SELLER'S PRICING STRATEGY

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ABSTRACT

In an attempt to gain a better position in haggling, consumers often seek a seller's pricing information before going to that seller. Although traditionally difficult to obtain, such information is becoming increasingly available due to the emerging practices of "consumer price posting" (CPP), whereby consumers post and share their purchase price information in the Internet. In this research, we explore how CPP can affect consumer haggling and a seller's pricing strategy. In the absence of CPP, our model features two-sided uncertainty: a single seller does not know individual consumers’ willingness to pay; it adopts either a fixed price policy, or a haggling policy to screen consumers, whereas consumers do not readily observe the seller's pricing policy and thus are uncertain whether their haggling will be fruitful. In the presence of CPP, however, this consumer uncertainty can be resolved. Because CPP can improve price transparency, inhibit consumers' acceptance of a posted price and spur price haggling, it seems apparent that it should benefit consumers and hurt the seller. Yet our analysis shows that CPP can lead to less purchase, a higher price, and even a greater seller profit. These results sharply contrast to the price transparency literature and have important managerial implications.

KEYWORDS
Consumer Price Posting, Haggling, Bargaining, Two-Sided Uncertainty, Retailing, Game Theory

INTRODUCTION

Consumers not only search, but also create and disseminate information on the Internet. Nowadays, marketing-related user-generated-content (UGC) is abundant in online forums and blogs, ranging from promotions and deals to product and store evaluations and comparisons (Bailey 2005). The emergence of UGC has important implications for consumer behavior and firm strategies; a recent (2009) call for papers on UGC for a special issue of Marketing Science reflects its relevance and significance in marketing.

In this research we are concerned with a particular type of UGC, sellers' pricing policy and transaction price information posted and shared by consumers in the Internet. In an attempt to gain a better position in haggling, consumers often seek this information before going to a seller. Nowadays, such information is becoming increasingly available due to the emerging practices of consumer price posting (CPP). For example, at TripAdvisor.com, where real travelers write reviews and advice on hotels, flights, etc., a review titled "haggle before you book!" makes it known that at Residence du Vieux Port, a hotel in Marseille, France, visitors can haggle to get free buffet breakfasts.

In a consumer community Mymoneybog.com, having informed about secret promotions offered by local TV/Internet service providers, a consumer says, "I recently did followed a similar [haggling] process with my Internet provider (Comcast) and managed to save $12.00 a month for the exact same service I had before I called."
In Redflagdeals.com, a Canada's bargain hunting community, noticing that the posted price of a front load laundry pairs is $3199.98 at Future Shop, one consumer posts that "I bought these at FS [Future Shop] at the end of last month for $2657.46... I did have to haggle to get that price though."

Information about a seller's prices may not be an issue for consumers in markets where fixed price policy is a norm; in such markets, a seller charges the same price to all consumers, and this price, regular or promotional, is generally advertised, online and offline (Zhang 2009). However, that information can be of great value to consumers when prices may be haggled. Equipped with the information, consumers can better predict their shopping outcome and be better prepared to negotiate with the seller (Evans and Beltramini 1987). Such information, however, are often difficult to obtain. In traditional brick-and-mortar markets, it is quite common that consumers even do not know where and when they are supposed to haggle. Such ignorance is not limited only to cross region travellers who are unaware of local pricing norms. In North America, for instance, "it would never occur to most people to negotiate prices with their doctors for health care services but it turns out that doctors, hospitals and labs are willing to negotiate."

Likewise, although "a bargaining culture once confined largely to car showrooms and jewelry stores is taking root in major stores like Best Buy, Circuit City and Home Depot, as well as mom-and-pop operations," plenty of consumers still believe that prices in such stores are nonnegotiable (Richtel 2008).

There are many reasons that consumers often lack information about a seller's pricing information in markets where haggling is possible. Haggling usually takes place in the absence of audience, and so consumers rarely know the prices paid by other consumers. The fear of appearing foolish or looking cheap can hold consumers back from asking. Perhaps more importantly, the information source was traditionally limited only to consumers' personal experiences and word of mouth. Sellers seldom disclose the information, and when they do, it is often incredible: Sellers would try to convince consumers that their costs are high in an attempt to get consumers to pay more (Fudenberg and Tirole 1983). They would insist that their prices are firm and final, even though they would actually offer discounts to haggling consumers who are price sensitive.

In practice, sellers tend to conceal their haggling policy as well as their transaction prices, being afraid that otherwise the rise in haggling will make consumers highly price conscious and loyal only to the least expensive offer.

CPP can truthfully disclose sellers' pricing policy and transaction price information. Not surprisingly, CPP is not popular when fixed price policy is a norm. CPP is more popular when it provides consumers with price information beyond that advertised by sellers. And CPP is particularly inviting when it discloses secret deal information about which haggling consumers are otherwise uninformed.

In this research, focusing on CPP's role in improving price transparency, we investigate how CPP can affect consumers' haggling behavior and thus a seller's pricing strategy. Noting that CPP is initiated and welcomed by consumers and consumerists, we are particularly interested to explore whether CPP can have an adverse effect on consumers' interest. With an important feature that a seller's pricing policy may not be readily observable to consumers, our model is distinct from other models that allow a seller to adopt either haggling or a fixed price policy; these models generally assume that consumers readily observe a seller's pricing policy (Wang 1995, Desai and Purohit 2004). In our model, in the absence of CPP a seller's pricing policy can be revealed, but only after haggling, which is costly to consumers.

CPP affects consumer behavior as it provides consumers with more price information. The literature suggests that information about discounted prices can change consumers' willingness to pay (WTP); consumers may use a lower price paid by other consumers as a reference and thus become less likely to accept a posted price at point-of-purchase (Rajendran and Tellis 1994, Kalyanaram and Winer 1995). Information about a seller's prices may also be used by strategic consumers to determine not only whether but also when and how to make a deal with the seller. For example, once consumers realize that a product has been sold at a discount off a posted price, they will then believe that that posted price is negotiable (i.e., the seller adopts a haggling policy) and thus that discount should be available, as long as they haggle hard enough. On the other hand, once consumers realize that there was no lower price ever in the past, they will believe that the posted price is nonnegotiable (i.e., the seller adopts a fixed price policy), and thus be discouraged from haggling.

A seller can choose a fixed price policy or a haggling policy. Which pricing policy is optimal? What are the optimal prices under each policy? If a haggling policy is adopted, what level of haggling effort should a consumer exhibit in order for the seller to warrant a discount? More importantly, How can a sellers' above decisions be affected by the presence of CPP?
Conventional wisdom has it that increased price transparency benefits consumers and hurts sellers; the literature has long established that price advertising and decreased consumer price search costs will result in intensified price competition and lower prices (Kaul and Wittink 1995, Bakos 1997). Because CPP can improve price transparency, inhibit consumers' acceptance of a (advertised) posted price and spur price haggling, it seems apparent that it should benefit consumers and hurt the seller. Yet our analysis shows that the opposite can be true. In the presence of CPP, although consumers may haggle more aggressively, they can end up paying a higher price than when CPP is absent. CPP can even lead to a higher seller profit.

We derive these results in a bargaining model that features two-sided uncertainty. In our model, a single seller, who comes endowed with either a high marginal cost or a low marginal cost, markets a product to two types of consumers: "high-type" consumers who have a high WTP and high haggling cost, and "low-type" consumers who have a low WTP and low haggling cost. The seller faces an uncertainty: although the distribution of the two types of consumers' WTP and haggling costs are common knowledge, the seller does not know each individual consumer's type. To focus on interesting cases, we consider the situations where the seller, if it is of high-cost, will optimally adopt a fixed high-price policy only; serving the low-type consumers is unprofitable due to their low WTP, whereas the seller, if it is of low-cost, will optimally adopt either a fixed price or a haggling policy: it can adopt either a fixed high-price policy to serve the high-type consumers only, a fixed low-price policy to serve both types of consumers, or a haggling policy to screen (i.e., price discriminate) the two types of consumers. The haggling policy should be designed in such that under this policy the high-type consumers will reveal their type to the seller; they will choose not to haggle and thus pay a posted price, whereas the low-type consumers will also reveal their type; they will choose to exhibit a level of haggling effort (e.g., a certain period of haggling time) and thus obtain a discount off the posted price. Screening is feasible because of the positive correlation between consumers' WTP and haggling cost that we have assumed (Desai and Purohit 2004). Even though the discounted price is known to be obtainable, the high-type would choose not to haggle for it due to their high haggling cost.

Consumers also face an uncertainty. In our model, consumers do not know a priori the seller's cost type and pricing policy, although they rationally know that a high-cost seller will serve the high-type consumers only and will not budge on its posted price, and that a low-cost seller may adopt the aforementioned haggling policy and offer a discount to hagglers. Hence, from the consumer's point of view, haggling might lead to a discount, but only if the seller happens to be of low-cost. Otherwise, it will simply be a failed attempt and a waste of time. We assume that in the presence of CPP, a seller's haggling policy and low-cost nature will be revealed to consumers if it has ever offered discounts. In this case, because the consumer uncertainty is resolved, the two-sided uncertainty model in the absence of CPP degenerates to a one-sided uncertainty model; consumers' incentives to haggle will change accordingly.

A key finding of our research is that CPP, initiated by consumers and aims to equip consumers with more price information and benefit consumers, can possibly hurt consumers. The seller is a strategic decision maker. Once its low-cost nature and haggling policy are revealed, even the high-type consumers may be motivated to haggle. Anticipating this, in the presence of CPP a low-cost seller will either adjust its haggling policy to keep screening the consumers, or switch to a fixed price policy. Because the seller can revise its strategy according to consumers' price knowledge, the fact that consumers have more price information and greater incentives to haggle does not necessarily result in a lower price or greater consumers' surplus. This insight is robust in our two-selling-period model in which a forward-looking seller considers the effect of its pricing policy in the first period on its performance in the second period. In this model, in the presence of CPP, to maximize the profit from both periods, a low-cost seller may opt for a fixed high-price policy in the first period to avoid the adverse effect of discount information on second period consumers' WTP, even though a haggling policy could yield a greater profit for the first period alone. Therefore, our analysis exhibits an interesting equilibrium in which in the absence of CPP, a low-cost seller adopts a haggling policy, offering both a regular posted price and a discounted price and serving both types of consumers, whereas in the presence of CPP, it sticks to a fixed high-price policy, leaving the low-type consumers unserved and thus leading to fewer purchases and a lower seller profit.

Another key and perhaps more surprising finding of our research is that improved price transparency due to CPP can even result in an increased seller profit. When the outcome of price haggling is uncertain, consumers rationally expect a possibility of a fruitless haggling. However, in addition to this haggling cost that is due to consumers' opportunity cost of time, consumers may also incur a psychological cost--for example, consumers may feel like a failure and losing face-- when their haggling turns out to be unsuccessful. In fact, when consumers' such psychological cost is prohibitive, in the absence of CPP, no consumer would attempt to haggle, leaving fixed price policies the seller's only viable option. Because the existence of such psychological cost makes consumers less inclined to haggle, a seller that adopts a haggling policy has to set the discounted price low as a compensation to encourage price haggling. However, once the uncertainty is resolved in the presence of CPP, that compensation is unnecessary, enabling the seller that adopts a haggling policy to increase its discounted price and make a greater profit. We show that the larger the consumers'
psychological cost in case of an unfruitful haggling, the more likely it is that the presence of CPP increases the discounted price and thus the seller profit.

As an emerging phenomenon of UGC, CPP has not yet received any research attention. In this research, we focus on the role of CPP in improving price transparency. A general consensus in the literature is that price transparency reduces prices, benefit consumers, and hurt the sellers (Bakos 1997, Kaul and Wittink 1995). We contribute to this literature by establishing some opposite effects, in a rather simple retailing context. The insights obtained in this research might be generalizable to other institutions that increase price transparency.

Our results also have important managerial implications. Sellers that adopt a haggling policy rarely advertise their transaction prices. Rather, they seem to try to keep their deals a secret and regard consumer price haggling as something that ought to be forestalled to secure a higher margin. Our analysis, however, suggests that when consumers suffer a lot from the uncertainty, disclosing its haggling policy can result in a greater seller profit. It implies that profitability may be improved if a seller disseminates its haggling policy and transaction price information and supports and sponsors CPP activities. Our results also have implications for Internet policy makers. Greater price transparency does not necessarily result in lower prices. To increase social welfare in the era of the Internet, the decision on whether to support CPP and other practices that improve price transparency should be made on a case-by-case basis.

The reminder of the research is as follows. In the next section, we brief the related literature. Section 3 lays out a basic bargaining model with two-sided uncertainty and Section 4 analyzes the impact of CPP. Section 5 extends the model and Section 6 concludes the paper with suggested areas for future research.

RELATED LITERATURE

There has been extensive investigation of the effect of improved price transparency (due to the emergence of the Internet). A general consensus in this literature is that when consumers become more informed about prices, prices should decrease and consumers should be better off (Bakos 1997, Soh et al 2006, also see Kaul and Wittink 1995 for empirical studies of the effects of price advertising). To the best of our knowledge, there are only two exceptions. Bakos (1997) and Lynch and Ariely (1999) suggest that price information and product attribute information provided online can have different implications: to the extent that the Internet allows consumers to search more easily for product information than for price information, the Internet can increase prices. Lal and Sarvary (1999) show that there are situations in which the Internet can discourage consumer search for products' non-digital attributes and thus induce high prices. Different from these important studies, our research involves no product attribute information, and yet we establish that price transparency can lead to higher prices, in a rather simple retailing context.

Our work is related to the literature that addresses a seller's choice of haggling versus posted price policies in a retail market. Wang (1995) finds that if a seller has considerable bargaining ability and if the two price policies involve the same cost, bargaining is always better than a fixed price policy, because it enables price discrimination. Riley and Zeckhauser (1983) demonstrate that in a market with a single seller who serves buyers sequentially, a haggling policy is suboptimal, because its advantage of enabling price discrimination is more than offset by the losses it generates by encouraging buyers to refuse purchases at high prices. Desai and Purohit (2004) show that in a competitive market, a seller's pricing policy also depends on its rival's policy. Distinct from these models in which a seller's pricing policy is assumed to be readily observable to consumers, we assume that it may not be so in the absence of CPP. Hence, in addition to the uncertainty faced by seller, our model also features an uncertainty at the consumer side.

Our research is also related to the literature on bargaining under asymmetric information (Chatterjee and Samuelson 1987, Iyer and Villas-Boas 2003). In particular, as in our model consumers' price knowledge can be improved in the presence of CPP, our model resembles to some extent the bargaining models that allow privately owned information to be (credibly) revealed in the process of bargaining. Three papers have examined this interesting dynamic in repeated-transactions bargaining. Hart and Tirole (1988) and Schmidt (1993) consider a one-sided uncertainty model in which a seller knows her cost but is uncertain about a buyer's valuation. They show that when compared to single-transaction interaction, a buyer with private information tries even harder to convince the seller that his valuation is lower than the seller believes. Banks et al (2002) examine a two-sided uncertainty model in which bargaining parties can learn about each other's reservation price in their first transaction and then use the information in their second transaction. Our model also features two-sided uncertainty and in our extended two-period model the second-period consumers can also learn from the first-period consumers' price posting. However, there are important differences. We look at haggling in a retail market where consumers are heterogenous, whereas Banks et al (2002) (as well as Hart and Tirole 1988 and Schmidt 1993) looks at a business-to-business setting in which bargaining takes place between one seller and one buyer. Furthermore, Banks et al's (2002) focus on the information revelation process and both bargaining parties can learn,
whereas we assume that consumers buy the product only once and so the seller does not learn about individual consumers' type. Our assumption is plausible in infrequently purchased product categories or in tourist areas, where the number of consumers is large, the cost of acquiring consumers' individual information is high, and its benefit is low.

**BASIC MODEL**

Consider a market where a single seller markets a product to consumers who (arrive sequentially and thus) do not communicate with each other. The consumers are of two types. A proportion q of consumers are "high types"; they have a high WTP, \( v[h] \), for the product. The other consumers, with a proportion 1-q, are "low types" with a low WTP, \( v[l] \), where \( v[h] > v[l] > 0 \).

Both types of consumers can choose to haggle over price with the seller. Haggling is costly since haggling is time consuming and consumers have opportunity costs of time. In addition, many consumers suffer psychological distress when haggling—they either lack the skill to haggle or they think that haggling makes them look cheap.

Because consumers with higher income tend to be less price sensitive, more time constrained, and more inclined to save face, consumers' WTP and their haggling costs are positively related (Desai and Purohit 2004). Hence, we assume that a high-type consumer incurs a cost \( K[h](t) \) and a low-type consumer \( K[l](t) \), where \( K[h](t) > K[l](t) \) and t is non-negative and refers to the extent that a consumer engages in haggling. t is operationalized as the haggling time, which is observable to the seller. We assume that \( K[i](t) = k[i]t \), i=h, l. The insights of the paper are robust to other cost functions such as a quadratic function. The proportions, WTP, and haggling costs of the two types of consumers are assumed to be common knowledge.

The seller does not readily observe each individual consumer's type. It has two pricing policy options. We define \((p,t)\) as a "price scheme" designed by the seller, whereby a transaction price \( p \) will be charged if the consumer has haggled for a period of time \( t \). So, if the seller adopts a "fixed price policy", it offers a single price scheme \((p,0)\); \( p \) is haggling free, nonnegotiable, and posted in store, and the seller charges this single price to all consumers. We can show that \( p \) is either \( v[h] \) or \( v[l] \); it is easy to show that other prices are strictly dominated by these two. If \( p = v[h] \), the seller adopts a fixed high-price policy, serving the high-type consumers only and making a profit of \( \pi^H = q(v[h] - c) \), where \( c \) is the seller's marginal cost of the product. If \( p = v[l] \), the seller adopts a fixed low-price policy, serving both types of consumers and making a profit of \( \pi^L = v[l] - c \).

The seller can also opt for a "haggling policy". Under this policy, the seller also posts a price in store, which is available haggling free for all consumers. It also offers a discounted price to consumers if they have haggled for a certain period of time. That is, the seller prescribes two price schemes, \((p[h],t[h])\) and \((p[l],t[l])\), where \( p[h] > p[l], t[h] = 0 \) and \( t[l] > 0 \).

If consumers choose the second scheme, they derive a monetary utility \( U[i] = v[i] - p[l] - k[i]t[l] \). As the seller utilizes haggling to screen the consumers, it will set the schemes such that the high-type consumers prefer \((p[h],0)\) to \((p[l],t[l])\) and the low-type consumers prefer \((p[l],t[l])\) to \((p[h],0)\). A seller incurs a haggling cost in servicing and dealing with every haggling consumer. We assume that when the seller adopts a haggling policy, its cost is \( k[s]t \) if the consumer haggles for time \( t \).

Note that in our model, the two haggling price schemes are prescribed by the seller, the same as in Desai and Purohit (2004), and that this screening approach is most effective to the extent that WTP and haggling cost are highly correlated. Real world examples are abundant in marketplaces, for instance, airlines offer discount fares only to consumers who satisfy various restrictions. We note that a seller can discriminate consumers on the basis of some "exogenous" information (e.g., age, sex, first-time vs. second time buyer, etc.). However, these pieces of information, although relatively easy to observe and prove, are not necessarily good signals of consumers' WTP. A seller might be able to elicit more useful information on income, occupation, tastes, etc., by communicating and interacting with consumers, but such activities are costly and the seller understands that consumers may have incentives to provide untruthful information in their interest. Hence, in this research we abstract from cheap talks and assume that in the haggling process there is no exchange of hard information between the seller and consumers.

We assume that the seller comes endowed with a marginal cost \( c \) of the product, which is either high, \( c[h] \), or low, \( c[l] \). We assume that \( c[l] < v[l] < c[h] < v[h] \) so that we can focus on interesting cases (Banks et al. 2002). This assumption implies that a fixed high-price policy is the unique equilibrium strategy for a high-cost seller. In contrast, for a low-cost seller, a fixed high-price policy, a fixed low-price policy, and a haggling policy can all be optimal.
Consumers are rational. If they know the cost type of the seller, they can anticipate the seller's optimal pricing policy and price scheme(s), and behave accordingly. For instance, they expect that a high-cost seller will serve the high-type consumers only and will not budge on price, and that a low-cost seller that adopts a haggling policy will not offer a discount unless they have haggled for time (t_l). In equilibrium, these expectations are fulfilled and the consumers are not surprised by the outcome (Desai and Purohit 2004).

Consumers do not know the seller's cost type a priori, although they know the values of c[h] and c[l] and that c[l]<v[l]<c[h]<v[h]. These important assumptions imply that consumers have to take a chance when haggling. Haggling can lead to a discounted price, but only if the seller is of low cost; otherwise, it will be in vain. We assume that consumers have a prior belief that the probability of the seller being of high cost is r, and that of being of low cost is 1-r, where r®[0,1]. Hence, if they buy at the posted price (i.e., pick the scheme (p[h],t[h])), where t[h]=0 in equilibrium), they obtain a utility U{i}^\text{NG} = v[i] - p[h], i=h,l. If they choose to haggle (i.e., pick the scheme (p[l],t[l])), they will haggle for time t[l] and expect a utility E(U{i}^\text{G}=(1-r)(v[i] - p[l] - k[i]t[l]), where the superscript NG and G refer to "no haggling" and "haggling" respectively (we use G to avoid overuse of notation H). Note that here we assume that in their decision to haggle consumers make a trade-off solely between the monetary saving from the discount and the monetary cost of their haggling time. We relax this assumption and incorporate some behavior factors in the Extensions.

The game is as follows. 1). The seller determines its pricing policy and the associated price scheme(s). 2). Consumers observe a posted price that is haggling-free and determine whether to haggle for a discount. If they choose to haggle, they optimally haggle only for time t[l]. Then, if the discounted price p[l] is offered, the deal is made. Otherwise, consumers will leave the market without making a purchase.

Note that the bargaining mechanism adopted in our model is that the seller makes a take-or-leave-it offer and then the consumers either accept or reject it. This approach greatly simplifies our analysis and has been widely employed in existing bargaining models (Banks et al 2002). Our assumption that the seller holds the cards in bargaining is plausible in our research context. In general, "individual customers have very little bargaining power with retail stores." (The Industry Handbook: The Retailing Industry). This probably occurs because firms have been striving to differentiate themselves in product offerings (e.g., private labels; national brands but "bundled" with different locations or different levels of store services). According to the famous "monopoly price paradox" of Diamond (1971), sellers are able to charge monopoly prices, as long as consumers incur positive search costs, even if those costs are minimal.

Finally, we assume that all consumers have access to CPP, when it exists, and that the information provided in CPP can resolve consumers' uncertainty about the seller's pricing policy (for that product of interest). Hence, in the presence of CPP, our model degenerates to a one-sided uncertainty model. In the Appendix we show that the major insights obtained in this paper are robust even if we make a more realistic assumption that only a proportion of the consumers have access to CPP.

ANALYSIS

We now derive the seller's equilibrium pricing strategy. As we have assumed that c[l]<v[l]<c[h]<v[h], a high-cost seller optimally adopts a fixed high-price policy and serves the high-type consumers only. The following analysis is focused on a low-cost seller.

In the absence of CPP

If the seller adopts a fixed low-price policy, its optimal price scheme is (v[l],0). In this case, no consumer will haggle because they know that the posted price v[l] is already the best offer the seller can make. Hence, both types of consumers make a purchase and the seller makes a profit of π^H = v[l] - c[l].

If the seller adopts a fixed high-price policy, with an optimal price scheme (v[h],0), it only serves the high-type consumers. Consumers do not know if the posted price v[h] is negotiable or not, for a seller that adopts a haggling policy also posts the same price v[h] in equilibrium, as we show later. So, the low-type consumers will haggle and the seller will incur a haggling cost. Because the seller that adopts a fixed high-price policy has no motivation to screen consumers, it is reasonable to assume that its marginal haggling cost, k, is no more than k[s], the counterpart when the seller does employ haggling to screen consumers. For ease of exposition and without affecting the qualitative nature of our results, we assume that k=0. So the seller's profit is π^H = q(v[h] - c[l]). Easy to show that π^H >π^L if c[l]<((v[l] - qv[h])/(1-q)).

If the seller employs a haggling policy, it prescribe two price schemes, (p[h],t[h]) and (p[l],t[l]), which maximize π^G = q(p[h] - k[s]t[h]) + (1-q)(p[l] - k[s]t[l]) - c[l], subject to consumers' incentive constraints...
To show the impact of CPP, we compare the above results with those in the absence of CPP. Proposition 1 follows.

To solve this problem, first note that in equilibrium, \( p[h] \) must be greater than \( v[l] \), otherwise the seller would be better off charging a no-haggling price of \( v[l] \). It implies that in equilibrium, the low-type consumers would not switch to pick the price scheme \((p[h],t[h])\) (i.e., the last constraint, \(E(U[l](p[l],t[l]))\) is not binding) and thus the seller only needs to prevent the high-type consumers from switching to pick the price scheme \((p[l],t[l])\).

Also note that \( t[l] \) must be zero, otherwise the seller can reduce it to zero and in the mean time increase \( p[h] \) to \( p[h]+k[h]t[h] \); one can see that this revised price scheme results in a greater seller profit while maintaining screening the two segments. Given that \( p[h] > v[l] \) and \( t[l]=0 \), the seller's profit now becomes \( \max\pi^{G} = q\pi^{H} + (1-q)(p[l]-k[s]t[l]-c[l]) \), subject to \( U[h]^{NG} \geq 0 \) (i.e., \( v[h]-p[h] \geq 0 \)), \( E(U[l]^{G}) \geq 0 \) (i.e., \( (1-r)(v[l]-p[l])-k[l]t[l] \geq 0 \)), and \( E(U[h]^{G}) \leq U[h]^{NG} \) (i.e., \( -k[h]t[l] \leq v[h]-p[h] \)). Now the last two constraints are equivalent to \((p[h]-rv[h]-k[h]t[l])/(1-r) \geq v[l]-((k[k]+(1-r)k[s])/(k[h]-k[l])) \), which implicitly requires \( t[l]=((p[h]-v[l])(1-r)-rv[h])/(k[h]-k[l]) \). Because the seller wishes to set the haggling time \( t[l] \) as small as possible and the price \( p[l] \) as greater as possible, it sets \( t[l]=((p[h]-v[l])(1-r)-rv[h])/(k[h]-k[l]) \) and thus \( p[l]=v[l]-((k[l](v[h]-v[l])/(k[h]-k[l]))) \). Substituting these results into the seller's objective function, we can show that if \( qk[h]-k[s](1-q) > k[l] \), then \( ((\epsilon\alpha^{G} + \epsilon)p[h]) > 0 \). In this case, the seller will optimally set \( p[h]=v[h] \). Thus, \( t[l]=((1-r)(v[h]-v[l]))/(k[h]-k[l]) \) and \( p[l]=v[l]-((k[l](v[h]-v[l])/(k[h]-k[l]))) \). Otherwise, \( ((\epsilon\alpha^{G} + \epsilon)p[h]) < 0 \) and then the seller will set \( p[h] \) as low as possible and thus the screening schemes will collapse.

Therefore, the equilibrium haggling policy consists of \((v[h],0)\) that aims at the high-type consumers, and \((v[l])-(v[h]-v[l])k[k]((k[h]-k[l])((1-r)(v[h]-v[l]))/(k[h]-k[l]))\) that aims at the low-type consumers. The seller makes a profit of \( \pi^{G} = qv[h] + (1-q)v[l] - ((k[k]+(1-r)k[s])/(k[h]-k[l]))c[l] \). Note that consumers obtain zero surplus and the seller extracts all of the surplus. Because haggling incurs costs, from the social welfare perspective, there is a surplus loss; this is the price the seller has to pay to screen the consumers.

The haggling policy outperforms the fixed-price policy if \( \pi^{G} > \pi^{L} \), i.e., if \( \epsilon^{G}(\epsilon)p[h] > \epsilon^{L} \). This is intuitive. The lower the seller's cost \( c[l] \) and the higher the low-type consumers' willingness to pay \( v[l] \), the greater the gain from serving the low-type consumers as well. The haggling policy outperforms the fixed-low-price policy if \( \pi^{G} > \pi^{L} \), i.e., if \( qk[h]-k[s](1-q) > k[l] \). The haggling policy is more likely to be optimal if the seller's marginal haggling cost \( k[s] \) is small and if the proportion of the high type consumer \( q \) is large.

In the presence of CPP

For CPP to be operative, there must be consumers who have made a purchase and posted their purchase price information online and consumers who are planning to make a purchase and thus access CPP. In this basic model, however, we only consider one selling period and assume that a seller's pricing policy becomes observable due to the presence of CPP. We assume that a seller will adopt a haggling policy if haggling yields a greater profit than a fixed price policy (i.e., if \( \pi^{G} > \max(\pi^{H},\pi^{L}) \)), where the subscript CPP denotes the presence of CPP). Note that this model is static and the seller is myopic. In a two-selling-period model that we analyze later, a (low-cost) seller will consider the implications of its first-period policy for second-period profitability, and consequently, it may strategically choose a policy that is suboptimal for the first period alone but optimal if both two periods are concerned.

In the presence of CPP, the seller's fixed price policy remains to be either \((v[h],0)\) or \((v[l],0)\), the same as in the absence of CPP. However, the schemes under a haggling policy are changed now that consumers face no uncertainty--they know that the seller is of low cost for sure. We simply substitute \( r=0 \) into the previous results to get the equilibrium results in the absence of CPP. It consists of \((v[h],0)\) for the high-type consumers, \((v[l]-((v[h]-v[l])k[k]((k[h]-k[l])((1-r)(v[h]-v[l]))/(k[h]-k[l])))\) for the low-type consumers, and \( \pi^{G} = qv[h] + (1-q)v[l] - ((k[k]+(1-r)k[s])/(k[h]-k[l]))c[l] \). It is easy to show that the seller prefers a fixed-price policy to a fixed-low-price if \( \pi^{G} > \pi^{L} \) (i.e., if \( c[l] < ((v[h]-qv[h])/(1-q)) \)), that the seller prefers a haggling policy to a fixed-high-price if \( \pi^{G} > \pi^{H} \) (i.e., if \( v[l] < ((v[h]-v[l])k[k]((k[h]-k[l])c[l])) \)), and that the seller prefers a haggling policy to a fixed-low-price if \( \pi^{G} > \pi^{L} \) (i.e., if \( qk[h]-k[s](1-q) > k[l] \)).

To show the impact of CPP, we compare the above results with those in the absence of CPP. Proposition 1 follows.
Proposal 1: In the model specified above, the presence of CPP has the following effects:

- If \( k_s > \min\{(v[l]-c[l])/(v[h]-v[l]),(k[h]-k[l])/(1-r),((qk[h]-k[l])/(1-q))\} \), the seller adopts a fixed price policy and CPP has no effect.

- If \( k_s < \min\{(v[l]-c[l])/(v[h]-v[l]),(k[h]-k[l])/(1-r),((qk[h]-k[l])/(1-q))\} \), CPP results in a change from a haggling policy to a fixed low-price policy.

- If \( ((v[l]-c[l])/(v[h]-v[l]))-(k[l])/(1-r),((qk[h]-k[l])/(1-q))\) \), CPP results in a change from a haggling policy to a fixed high-price policy.

This proposition shows that when haggling is optimal, the presence of CPP results in prolonged haggling time. This finding is important. In the presence of CPP, because consumers know that a discount is available; their incentives to haggle are enhanced. Anticipating this, the seller has to extend the haggling time so as to keep deterring the high-type consumers from haggling. Indeed, we can show that the seller optimally prolongs the haggling time for the discount but leaves the posted and discounted prices unchanged. Hence, somewhat surprisingly, although consumers have greater incentives to haggle and become more aggressive in haggling, the seller does not reduce its transaction prices. Because CPP does not affect prices but prolongs the haggling time, the seller's profit is decreased (i.e., \( \pi^G > \pi_{CPP}^G \)).

Because CPP results in a decreased haggling profit, it affects the seller's adoption of a haggling policy. Figure 1 illustrates the parameter space of the seller's equilibrium policy in the absence of CPP and in its absence. Note that when haggling is adopted, the seller enjoys the benefit from price discrimination and in the mean time incurs a haggling cost. When the seller's marginal haggling cost \( k_s \) is low, the benefit outweighs the cost and thus haggling is preferred to a fixed policy. When \( k_s \) is high, on the contrary, the cost outweighs the benefit and thus a fixed price policy is preferred. When \( k_s \) is at a medium level, however, the benefit and cost are more evenly balanced, which gives rise to the possibility of policy change. More specifically, because CPP results in a decreased profit from haggling, the seller that adopts a haggling policy in the absence of CPP may switch to a fixed price policy in the presence of CPP. Therefore, CPP shrinks the parametric space for a haggling policy to be optimal. This finding lends support to the common intelligence that haggling is less likely to be optimal in markets with higher price transparency.

When the seller is better off shedding its haggling policy, it can either sticks to a fixed high price if its marginal cost of product \( c[l] \) is large, or a fixed low price if \( c[l] \) is small. In the former case, since the discounted price is no longer available, the low-type consumers do not make a purchase; consumer participation is reduced. Although the high-type consumers make purchases, they obtain zero consumer surplus. In the latter case, all consumers purchase and their total surplus is increased now that the high-type consumers obtain positive surplus.

It is generally believed that price transparency benefits consumers. However, Proposition 1 indicates that although improved consumers' price knowledge can hurt the seller, it does not necessarily benefit consumers, because the seller can adjust its pricing policy and price scheme(s) according to consumers' price knowledge. In the extension that follows, we show that these insights are robust when CPP can affect consumers' WTP and in a model with multiple selling periods. However, we also show that when behavioral and psychological factors are considered, CPP can even increase prices and benefit the seller.

CONCLUSION

This research explores how the emerging trend of CPP, by improving price transparency, affects consumers' haggling behavior and a seller's pricing strategy. In a rather simple retailing context where a seller can utilize haggling to screen consumers, we show that improved price knowledge due to CPP can resolve consumers' uncertainty in haggling and thus enhance their incentives to haggle with a seller that adopts a haggling policy. Interestingly enough, consumers do not necessarily benefit from improved price knowledge, and being more aggressive in haggling does not necessarily lead to a greater discount. From the seller's point of view, price transparency does not automatically mean a decreased profit or that a haggling policy is less likely to be optimal. A seller can respond to consumers' improved price knowledge in three ways. The first is to shed its haggling policy and adopts a fixed price policy instead. In this case, unless its marginal cost of product is sufficiently low, it switches to a fixed high-price policy, thereby eliminating the discounted price otherwise available to haggling consumers and ruling out these consumers' participation into the market.

Alternatively, the seller can change from a fixed price policy to a haggling policy. This somewhat surprising transition occurs when in the absence of CPP, the uncertainty in haggling severely affects consumers' incentives to engage in haggling, whereas haggling becomes a viable policy in the presence of CPP since the uncertainty is resolved. Thirdly, the
seller can simply adjust its haggling price schemes, if its marginal haggling cost is at a medium level. In this case, to make screening effective, the seller must prolong the prescribed haggling time to deter the high-type consumers from haggling. The increased price transparency can even result in an increased discounted price for haggling consumers: when consumers incurs psychological cost in case of a fruitless haggling, the seller needs to offer a large discount to induce consumers to haggle, but such a compensation is no longer needed when the uncertainty is resolved due to the presence of CPP. Therefore, contrary to the existing price transparency literature, we show that improved price transparency can result in higher prices, less consumer participation, and even a greater seller profit. A seller can have greater incentives to adopt a haggling policy when consumers' price knowledge is improved.

Aiming to illustrate possible effect of price transparency on price increase, we employ a monopoly model and focus on the situation where consumers have no bargaining power. New sets of insights could be obtained if future research explores situations where consumers have some bargaining power. Another interesting research direction would be to examine the robustness of our insights in a competitive market. One can follow the Desai and Purohit's (2004) model and assume the sellers' pricing policies are unobservable. In the real world, some sellers are major, others are fringe, and they compete against one another. Because major sellers attract and serve more consumers than fringe sellers, it is plausible that CPP provides more price information about the former. A model that captures this differential information revelation ability should prove of great interest when it appears.

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ABSTRACT

In this paper, the authors analyse knowledge management (KM) practices in civil aviation industry and introduce a framework for better management of knowledge in aircraft engineering (AE). After comprehensive review of KM literature, this paper offers insights into the existing KM practices in AE using a case study in the Saudi Arabian Aviation industry (SAAI). The KM research data was collected through discussions and interviews as well as through observations during one of the author’s employment as aircraft engineer in the SAAI. Synthesis of these results with the KM literature was used to identify the gaps between the KM theory and current practices in AE. Finally, an operations-based knowledge management (OBKM) system framework was developed to address these gaps and overcome ineffectiveness in current practices.

KEYWORDS
Knowledge Management, Operations-Based Knowledge Management, Aircraft Engineering, Saudi Arabian Aviation Industry

INTRODUCTION

Civil aviation industry one of the toughest industries fighting for survival (Shaw and Smith 2003; Harvey and Holdsworth 2005). Rising oil prices, intense competition and safety concerns are some of the key factors that put constant pressure on bottom-line performance of the organisations this industry. Maintenance costs make up a major portion of the expenses. Consequently, sound knowledge management practices become crucial for success (Harvey and Holdsworth 2005), and luckily, organizations increasingly realize the importance of aircraft engineering knowledge as an asset which has initiated the need for retaining the critical knowledge within the organization (Tat and Stewart 2007; McNichols 2008; Allen 2010).

Most organisations in civil aviation industry including aircraft manufacturers, airlines and maintenance providers suffer from a loss of engineering knowledge due to job rotation, jobs reduction and retirements (Shaw and Smith 2003). Training and retaining an aircraft engineer can be very costly. A freshly graduated or recruited engineer may require a lot of experience before they can fully function as an aircraft engineer. This may take up to two or more years of on the job training
and mentoring (Shaw and Smith 2003; Emara 2009; AlGhalbi 2010). Moreover, incorrectly performed aircraft engineering activities can lead to high level of risks and are, therefore, constrained by the intensive safety regulations (Harvey and Holdsworth 2005). As a result, there is a need for effective knowledge management in the aircraft engineering field.

**OPERATIONS-BASED KNOWLEDGE MANAGEMENT**

The knowledge management literature mostly refers to KM solutions primarily based on IT-based tools and systems (Swan, Newell et al. 2000; Freke 2006). However in the past, a significant proportion of KM initiatives and projects have failed partly due to their single focus on IT-based solutions (Tsui 2005; BenMoussa 2009). A growing number of researchers argue that new approaches are needed to reduce the risk of failure of a KM initiative (Davenport and Glaser 2002; Tsui 2005; Keen and Tan 2007; BenMoussa 2009). By placing the main focus on the IT-based solutions, insufficient attention is given to the other aspects of KM which, for example, neglects the impact of employees’ willingness to share their knowledge (Swan, Newell et al. 2000).

According to a study by Edwards, Shaw & Collier (2005), many organizations tend to utilize generic IT tools rather than dedicated IT-tools for their KM approaches. This appears to be due to the insufficient consideration of contextual situations in the design of those tools. Whereas IT solutions should be tailored to carefully consider KM processes and contexts (Freke 2006).

Successful KM initiatives ought to achieve balance between management leadership, process management and people management and supported by IT solutions (Swan, Newell et al. 2000; Tsui 2005; Freke 2006; BenMoussa 2009). Recent research has confirmed that leadership, process and people aspects are critical success factors for KM initiatives (Holsapple and Joshi 2000; Tsui 2005; Wong 2005; Allen 2010).

One could argue that the current gap between IT-based KM approaches and people/process-based KM approaches is merely a result of different views shared the group of KM practitioners and KM theorists (Swan, Newell et al. 2000; BenMoussa 2009). Many researchers view IT-based KM tools as a vehicle for KM initiatives while leadership, process and people management build the foundations (Swan, Newell et al. 2000; Tsui 2005).

**Leadership Aspect**

The effect of leadership activities on KM performance has been the focus of recent studies. For example, Politis (2001) suggested that a “Knowledge-Enabled leader” is critical to an effective KM system. Likewise, Allen (2010) identified the effect of the front-line management behavior on willingness of aircraft engineers to share their tacit knowledge. He found that positive management behavior (attitude) increased employees’ willingness to share their knowledge during situations of job transfer.

**Process Aspect**

Process management has also been of interest of recent research into KM. Tat and Stewart (2007) studied KM implementation processes in Malaysian Aviation Industry. They proposed a model to implement KM in that industry. This model consists of four stages; awareness cultivation, objective definition, strategy adoption and action implementation. Such research suggests that during implementation of KM initiatives, any necessary IT-tools should be designed based on needs of the KM processes, and the context of KM systems. Without the proper understanding of the current context of the organization and the KM processes, the design of any technology tools to support KM is prone to failure.

**People Aspect**

KM systems rely for their successes on the involvement of, interaction with, and acceptance by people. Neglecting the people aspects will increase the chances of failure (Swan, Newell et al. 2000; Harvey and Holdsworth 2005). This is evident by the recent increases of the number of researchers focusing on the people aspect of the KM systems. McNichols (2008) examined the inter-generational tacit knowledge transfer within aircraft engineering community. The researcher found two major themes that influence the knowledge transfer: (a) the relationship quality between the sender and receiver and (b) the knowledge transfer enabling conditions. She recommended three strategies to maximize aircraft engineering knowledge transfer, consisting of building knowledge-sharing culture, establishing mentoring program and initiating team work.
Summary

The above discussion highlights the need for a multi-disciplinary KM approach for deeper understanding of all KM aspects (Kakabadse, Kakabadse et al. 2003). These aspects should be considered holistically in the design of KM systems. A sound KM system design must incorporate the leadership, process and people aspects. The holistic Operation-Based Knowledge Management (OBKM) model suggested by the authors, in Figure 1, facilitates such a design. This approach consists of three layers: approaches to KM, aspects of KM, and the elements of these aspects.

FIGURE 1
HOLISTIC OBKM MODEL

KNOWLEDGE MANAGEMENT CURRENT PRACTICES IN AIRCRAFT ENGINEERING

This section discusses KM current practices in aircraft engineering field in the Saudi Arabian aviation industry. Preliminary research data was obtained through discussions and interviews with senior aircraft engineers, and personal observations of one of the authors during his six years of work experience as an aircraft engineer with one the companies in the Saudi Arabian aviation industry. This organization is not only the largest private airline operator in the country but also represents the aircraft engineering best practices in the aviation industry. Accordingly, this organization will be used as a representative example of the Saudi Arabian aviation industry. The findings from this preliminary study highlight the main characteristics of the KM in the aviation industry.

The main objective of the preliminary data analysis was to find out how aircraft engineers comprehend, explore, and deal with KM concepts and ideas, and how they manage aircraft engineering knowledge in practice. This is discussed in following sub-sections KM Awareness, KM Perception, and KM Culture.

KM Awareness

As in other countries, Saudi Arabian aviation industry faces the challenges of an aging work force. There is an increasing awareness that this will cause a problem due to a widening skills gap and knowledge loss. However, this does not seem to be complemented by the awareness that knowledge management concepts and methods may help mitigate the negative impact on the organization of such issues. Furthermore, knowledge management is mostly confused with information management. This appears to be the result of insufficient understanding of the KM concepts (Harvey and Holdsworth 2005; Tat and Stewart 2007; McNichols 2008). More importantly, it is becoming increasingly manifest that the aviation industry has failed to implement systems to successfully source, capture and share aircraft engineering knowledge. Consequently, sources of aircraft engineering knowledge are less obvious and its importance as a competitive advantage less apparent.
**KM Perception**

While there is insubstantial awareness of the KM concepts in the industry, it is commonly believed that knowledge management is beneficial for the industry. The perceived benefits of better knowledge management include:

- Reduction of aircraft maintenance downtimes through knowledge sharing. Engineers will have broader knowledge base to perform their tasks and as a result the time needed to accomplish the task will be reduced.
- Reduction or elimination of silo behavior in handling expert knowledge. Consequently, this will mitigate the impact of experts retiring.
- Reduction of the learning curve of a new graduate or recruit to fully function as an aircraft engineer.

**KM Culture**

The aviation industry is a highly regulated industry. It follows rigorous guidelines for data recording and reporting for any maintenance action, incident and accident (Shaw and Smith 2003; Harvey and Holdsworth 2005) to ensure the airworthiness of the aircrafts and for monitoring the quality of the outcome. This data is required to be accurate and readily available and accessible to operators, engineers and maintainers (Harvey and Holdsworth 2005). Therefore, every organization in the industry needs to have systems to manage and distribute this recorded (explicit) knowledge.

In SAAI, such explicit knowledge is managed by IT systems which keep records and store aircraft engineering documentation. It is widely accepted that aircraft engineering explicit knowledge is relatively well managed in the aviation industry. In contrast, aircraft engineering tacit knowledge management seems to be rather underdeveloped. The learning environment in the aviation industry, especially between aircraft engineers, depends on a mentor-apprentice relationship or “tribal learning” (2003). This unique learning behavior where engineers learn tacit knowledge through experimenting, i.e. by following and imitating experienced engineers, “the tribal elders” (Shaw and Smith 2003) is also called on-the-job training. The absence of a senior engineer may endanger the whole process and will increase the learning curve, time and cost of such training. Rehiring retired engineering experts, for instance, as consultants is a reactive practice to mitigate the problem.

As described by Collison and Parcell (2001), a knowledge sharing culture is a focal point in KM initiatives. In SAAI, it seems to be a norm to reward individual performance rather than team performance. This imposes a challenge to promoting a knowledge sharing culture. Another challenge is due to the wide-spread perception in SAAI that knowledge is a source of power. Thus, sharing knowledge means sharing power.

Finally, there are some additional points relevant to the consideration of KM culture in the SAAI. For example, like many other industries SAAI is male dominant. Perception of KM initiatives and systems by different genders may impose some challenges. For instance according to Ong and Lai (2006), male and female employees may perceive e-learning systems differently. Therefore, any research must consider such possible gender-based defense mechanisms. In addition, Saudi Arabian culture is highly influenced by Islam. The effect of religious influence on KM, if any, needs to be taken into consideration and will explored further in this research in the future.

**Summary**

From the above discussion we can conclude that knowledge management appears to be immature in SAAI. Furthermore, aircraft engineering knowledge seems to be implicitly managed, in a more or less ad hoc manner. Through a comparison of the current practices in SAAI and KM theories, the following gaps have been identified:

- The level of knowledge management awareness among aircraft engineers is low.
- There is a perception that KM is beneficial. However, there is no common agreement on what are the KM intentions and objectives ought to be.
- The current modest KM practices, if they exist, are merely incidental to everyday operations, and not due to any deliberate focus on knowledge management.

**THE PROPOSED OPERATIONS-BASED KNOWLEDGE MANAGEMENT SYSTEM FRAMEWORK**

Based on recent operations management system literature (Pritinanondha 2008; Jayamaha, Grigg et al. 2009; Akpolat 2010) a management system framework was developed and proposed to overcome the gaps identified in the previous sections.
This framework includes the leadership, people and process aspects which are further divided into several elements consisting of leadership, process and people aspects.

**FIGURE 2**
THE PROPOSED OBKM SYSTEM FRAMEWORK

**Leadership Aspect**

This aspect entails the role of management in implementing and supporting KM initiatives. Planning and strategy development are the two main elements in this aspect. Those elements will drive the whole KM system toward business goals. This is achieved by aligning the KM strategies with the business strategies while providing the leadership support.

1. **Strategy development**: in this element, the relevant strategic actions need to be addressed for implementing and practicing KM initiatives. Moreover, KM strategies should be aligned with the organization strategy. Thus, the intended product of those initiatives is to achieve the organizational objectives. (Akpolat 2004)

2. **Planning**: management should design and plan the KM initiatives based on the organization goals and needs. Top management commitment ought to be visible in those plans. Also, employees’ involvement in the plan developing process is essential. In addition, the plans and strategies should be well communicated with the employees to encourage their commitment and realization of the KM initiatives.

**Process Management Aspect**

The process management aspect is included to ensure better process management to overcome KM challenges embedded in the organization’s systems. Guidance, monitoring and continuance improvement, and IT-support systems form the main elements of this aspect.

3. **Guidance**: of the KM system is done through policy, procedures and work instructions. Guidance is needed to provide main processes of the KM initiatives. This includes the day to day activities and course of actions.
4. Monitoring and Continual improvement: to insure that the system operates as expected. One of the main goals of this element is to monitor the performance and perform system maintenance to meet the intended goals and targets. The system goals can be defined as key performance indicators. These indicators are used to plan for system improvement.

5. IT-support: systems are needed to provide the platform in which the KM activities and processes take action. The contextually sensitive IT-support systems will serve the main OBKM needs. It includes systems to support explicit and tacit knowledge sharing. Moreover, it should be tailored to achieve the KM initiatives’ goals and objectives.

**People Management Aspect**

This aspect serves as a mechanism to highlight the OBKM influences and challenges from the perspective of the knowledge sender and receiver. Its elements are culture, teamwork and mentoring, and due consideration of these elements will ensure that the effectiveness of knowledge transfer between aircraft engineers is maximised. (McNichols 2008)

6. Culture: is considered one of the main elements that control the KM initiatives’ success or failure. KM initiatives should nurture knowledge sharing culture between the employees. Their willingness to share their knowledge will increase when they feel emotionally committed to the organizational vision and mission. Thus, management actions and behaviours need to establish a reason to care between employees. Also, they need cultivate the feeling that employees belong to something bigger than they are.

7. Teamwork: is another strategy management need to peruse. They should facilitate and encourage team work environment in the organization. Furthermore, management ought to reward team achievements rather than individual achievements. Team work is a cheaper and easier way to share employees’ knowledge.

8. Mentoring is an effective way to share employees’ knowledge. Management should support a structured mentoring program. This is by, providing adequate funding and show visible dedication to mentoring program.

**Summary**

The proposed framework, with its three layers and aspects, provides a holistic way to design effective knowledge management systems. While proposed within the context of the aircraft industry, the framework is generic enough to be of use within other industries as well.

**CONCLUSION**

This paper has presented some results of a study of knowledge management within SAAI, contracted the practices therein with best practice as evident in the KM literature, and has proposed a holistic framework to address the gaps that have been identified between the practice and the theory. This framework, called the OBKM, enables consideration of all the aspects that have been identified as contributing to potential or actual failures of knowledge management initiatives within SAAI. The framework itself is generic enough for application within industries other than the aircraft industry. Future steps of this research will include a validation of the framework through workshops, interviews and possible applications within SAAI.

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**PROCEEDINGS OF THE 3rd INTERNATIONAL CONFERENCE ON LOGISTICS AND TRANSPORT & THE 4TH INTERNATIONAL CONFERENCE ON OPERATIONS AND SUPPLY CHAIN MANAGEMENT**

15-17 December 2011, Kurumba Maldives Resort, Male, Maldives
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**Proceedings of The 3rd International Conference on Logistics & Transport and The 4th International Conference on Operations and Supply Chain Management**

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Thai Researchers’ Consortium on Value Chain Management and Logistics
The Thai VCML was established in July, 2002 with support from GS1 (formerly known as EAN) Thailand, the Federation of Thai Industries, and the Thai Logistics and Production Society. This consortium is between academics, practitioners and researchers in the area of logistics and value chain management located in Thailand. A working committee was established based on lecturers working in a number of private and public universities in Thailand. The objective of the committee was to support the development of a coordinating centre for logistics research and increase the collaboration among universities teaching logistics and value chain management in Thailand. The activities of this consortium can be summarised as follow:

1. Research – To become a focal point coordinating research activities in logistics and value chain management in the country.
2. Education – To become the repository of knowledge for logistics and value chain management in Thailand.
3. Academics conference – To organise an annual conference in order to disseminate and publish academic materials on logistics and value chain management to the general public. The conference provides an opportunity for consortium members to share knowledge, research work, and develop further collaboration within or outside their own organisations.
4. International network – To provide support to consortium members in liaising with international academic institutions, professional societies in the area of research, training, conference hosting, or academic exchange activity, and;
5. Domestic collaboration – To increase collaboration and coordination among consortium members.

Sepuluh Nopember Institute of Technology (Indonesia)
The history of ITS dates back to 1954 when The Indonesian Engineers’ Association held a national conference in Bogor. It was then that the idea of founding an Institute of Technology in Surabaya was instigated. Such an idea culminated during the Association’s first five-year annivarsary in Surabaya in 1957. On 17th August 1957, the Surabaya-Branch Association established a Foundation of Technical College, which was chaired by dr. Angka Nitisastro. On 10th November 1957 the Foundation launched the Sepuluh Nopember Technical College of Surabaya, which was officially inaugurated by the late President Soekarno, the first President of Indonesia. The college then had two departments: Civil Engineering and Mechanical Engineering. This private technical college was later awarded the status of state institute of technology under the Government Regulation No. 9/1961 dated 23rd March 1961, which marked the birth of the Institute on 10th November 1960. In 1977 ITS received a loan of US $ 25 million from the Asian Development Bank (ADB) for the development of its four faculties: Faculty of Civil Engineering, Faculty of Mechanical Engineering, Faculty of Electrical Engineering, and Faculty of Chemical Engineering. It was under this loan that the development of ITS’s campus in Sukolilo was funded. The first phase of this development was completed in 1982. ITS received another ADB loan of US $ 47 million in 1994 for the development of all of the faculties within the Institute, focusing on marine technology. This program was completed in 2000. In addition to these loans, a grant from the German Government/GTZ was also received (1978-1986) for the development of the Faculty of Naval Architecture. In the meantime, ITS has developed to be a big and important institute of technology with 5 faculties and two polytechnics as previously mentioned.

The Chartered Institute of Logistics and Transport (India)
The Chartered Institute of logistics & Transport is the leading professional body associated with logistics and transport. With over 33,000 members in over 100 countries worldwide, CILT holds unparalleled professional international recognition. Established in 1919 and receiving its Royal Charter in 1926, the institute has an exciting history behind it, but is always adapting to stay consistent with current logistics and transport issues. The Institute is represented worldwide with National Councils, National Independent Sections and Institute Branches. Each territorial organization is, in its own right, a separate organization representing the Chartered Institute of Logistics & Transport in their territory. They all share the common cause of achieving the institute’s primary objective.

National Institute of Industrial Engineering (India)
The National Institute of Industrial Engineering (NITIE) was established by the Government of India in the year 1963 with the assistance of United Nations Development Programme (UNDP) through the International Labour Organization (ILO) to create skilled professionals to improve industrial efficiency, productivity and management of resources. NITIE, an autonomous body, is governed by a Board of Governors comprising eminent personalities from the government, industry and academia. Since its inception, National Institute of Industrial Engineering (NITIE) has been providing solutions to the complex problems of industry and business. The institute was formerly known as the 'National Institute of Training in Industrial Engineering'. Later, the word 'Training' was removed and was rechristened 'National Institute of Industrial Engineering'.

Sponsors: