
# EVALUATION OF MULTI MODE TRANSPORTATION USING ANALYTIC HIERARCHY PROCESS: A UNILEVER CASE

By

LAPATRADA CHIMPIBUL

A Final Report of the Six-Credit Course
SCM 2202 Graduate Project

Submitted in Partial Fulfillment of the Requirements for the Degree of
MASTER OF SCIENCE IN SUPPLY CHAIN MANAGEMENT

Martin de Tours School of Management
Assumption University
Bangkok, Thailand

November, 2010

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Examination Committee:

1. Asst. Prof Brian Lawrence (Chair) .....
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Approved for Graduation on: November 12, 2010

Martin de Tours School of Management
Assumption University
Bangkok, Thailand

November 2010

**Assumption University**

**Martin de Tours School of Management**

**Master of Science in Supply Chain Management**

**Form signed by Proofreader of the Graduate Project**

I, Asst. Prof. Brian Lawrence, have proofread this Graduate Project entitled Evaluation of Multi Mode Transportation Using Analytic Hierarchy Process: A Unilever Case

Ms. Lapatrada Chimpibul

and hereby certify that the verbiage, spelling and format is commensurate with the quality of internationally acceptable writing standards for a master degree in supply chain management.

Signed

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Date: December 20

**Assumption University**
# Martin de Tours School of Management
**Master of Science in Supply Chain Management**

## Declaration of Authorship Form

I, Lapatrada Chimpibul declare that this project and the work presented in it are my own and have been generated by me as the result of my own original research.

**Evaluation of multi mode transportation using Analytic Hierarchy Process : A Unilever case**

I confirm that:

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3. Where I have consulted the published work of others, this is always clearly attributed;
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5. I have acknowledged all main sources of help;
6. Where the project is based on work done by myself jointly with others, I have made clear exactly what was done by others and what I have contributed myself;
7. Either none of this work has been published before submission, or parts of this work have been published.

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**Assumption University**
# Martin de Tours School of Management
**Master of Science in Supply Chain Management**

Student Name: Lapatrada Chimpibul
**ID:** 5129356

ADVISOR'S STATEMENT

I confirm that this thesis/project has been carried out under my supervision and it represents the original work of the candidate.

Signed:

_____

Dr. Athisan Wayuphab
Advisor

Date

_____December 21, ZOO___

# ABSTRACT

Transportation is one of the most important factors that affect the export of products from a company to its customers. This project focuses on the evaluation and selection of multi model transportation by selecting the best suitable transportation mode for exports to Malaysia

This project studies four transportation modes, road, sea, air and rail, by using five evaluation factors: routing, capability, loss and damage, freight rate, and transit time. After that the project sets up five scenarios to demonstrate the five factors and reveal the advantages and disadvantages of each transportation mode.

This project applies the Analytic Hierarchy Process, which is flexible and simple in the decision making process. There are calculations both in Excel and Expert Choice software for decision making. This process brings together the cross functional people to make a relative judgment by using a comparison with a 1-9 scale which is easy to understand, and commutates a consistency ratio for checking the answers.

This project attempts selection by comparing the highest scale from the Analytic Hierarchy Process to get the best solution of a new choice of transportation mode which could be applied in the company.

Moreover, the Analytic Hierarchy Process can be applied in the future to make decisions about other problem in the company, and the company could continue to benefit from this useful process.

# ACKNOWLEDGEMENTS

Firstly, I would like to thanks my advisor, Dr. Athisan Wayuparb, who was always there when I needed help, and who also sacrificed his valuable time to assist and guide me in many ways to complete this paper. Without his support, this paper could not have been completed.

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Thirdly, I would like to thank the Supply Chain Department in Unilever Thai Holding Ltd. for their support in providing useful information and for assistance in subsidizing my budget for every semester.

Finally, I would like to thank my family, my husband and my lovely two sons for their support and understanding, and for cheering me throughout the duration of my studies. Without their support, this paper would have not been possible at all. I really thank my family. I really love them.

Mrs. Lapatrada Chimpibul
Assumption University
November 2010

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# CHAPTER I

# GENERALITIES OF THE STUDY

In the present world, transportation is a necessary concomitant for the exchanging and evolving economy, and is indispensable to company growth. The role of transportation in supply chain development is expanding and becomes much more critical. It does not only a consideration in reducing cost of production but also helps in generating economic activities that yield place and time utility. The major purpose of transport is to carry commodities from one place to another. In the past, the role of transport was not as important as it is today, as production processes become much more complex due to technical progress. With the increasing complexity as well as development of production processes, transport costs will be dispersed and enter at various stages of the process, depending on the nature of the process, and therefore it can minimize the transport cost of production and distribution as well as expand the market at the same time. Most companies, in any stage or size, have by now realized that the development of suitable modes of transportation is a prerequisite for any company's growth.

Thailand was considered as the hub manufacturing point for many companies, with goods being transported from Thailand to many other locations including neighboring countries like Malaysia. Traditionally, transporting goods or services from Thailand to Malaysia is mostly by road, which is considered an important mode of transportation between the two countries. But due to the expansion of some constraints and increasing costs for road transportation, this leads to higher costs compared to other modes of transport. Nevertheless, a transportation mode will be considered more efficient than the others when it can minimize total costs. These costs should include infrastructure and equipment provision, plus terminal and transshipment operations. Therefore, all costs in the transportation process, either borne by the private or public sector, must be evaluated. The cost of transportation can be decomposed into four main items: operating cost, handling cost, time cost and facility provision cost. All these costs may not be explicit in the balance sheets of shippers or carriers, but it

should be borne in mind by a company in choosing the most efficient mode of transportation. Generally, financial costs which exist in the balance sheet of an enterprise comprise only operating cost and handling cost. Economic cost, which covers the total resources consumed on behalf of transportation activity, must include operating cost, handling cost, time cost, and facility provision cost.

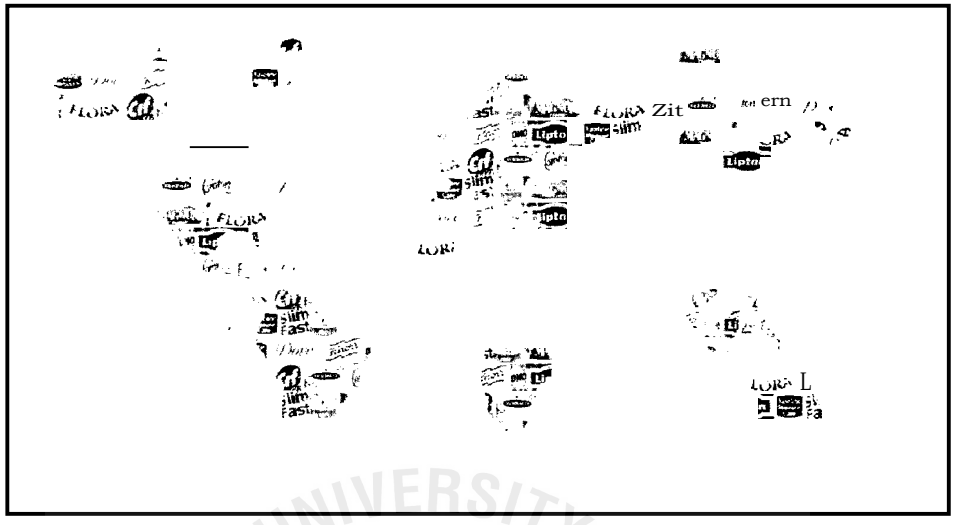
In practice, private shippers do not take all these costs into account. Rather, they compare the real charge or financial costs on each mode in order to select the cheapest one. This leads to the problem of promoting a transport mode, since it is misleading to ignore social costs, which do not enter into the normal transport market. Ignorance if social costs from the consideration often creates distortion in choosing a mode of transportation.

**Background of the Company**

**Unilever – Corporate**

Unilever was begun by the founder of the company, William Hesketh Lever, who had written his ideas about Sunlight Soap in the 1890s, his new and revolutionary product had helped to popularize hygiene and cleanliness in the Victorian England era. The product was 'to make hygiene and cleanliness become common; to reduce work for women; to care for health and contribute to personal attractiveness, so that life may become more rewarding and enjoyable for the people who use the products'. With a long and proud history that now spans three centuries, Unilever's success has been influenced by major events – economic boom, world wars, depression, changes in consumer lifestyles, and advances in technology. Throughout all these changes, Unilever had created products that help people to get more out of life – improving nutrition, cutting the time spent on household chores, enabling people to enjoy food and take care of their clothes, their homes, and themselves.

**Figure 1.1** Unilever sales geographic in 150 countries



Source : Company profile

**Unilever in Thailand**

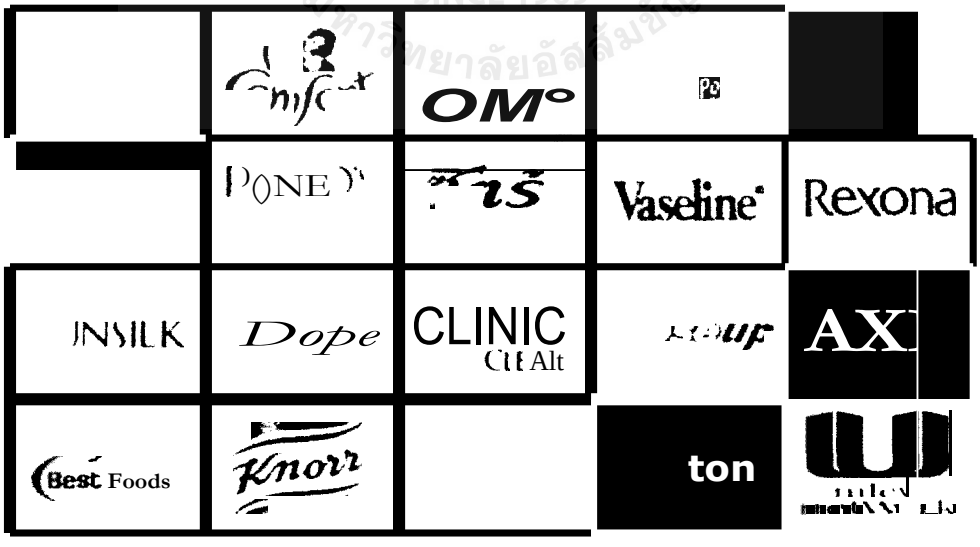
Unilever begins business in Thailand in 1932 as Siam Industries Co., Ltd., for the production of Lux soap, margarine, and vegetable oil. Then the Company changed its name to Unilever Thai Holdings Co., Ltd. in 1997, and was renamed Unilever Thai Trading Limited in 2005. The Unilever Thai Group of Companies is a subsidiary of Unilever, the world's largest branded consumer merchandise company. With headquarters in London and Rotterdam, Unilever enjoys a strong presence in over 150 countries worldwide, covering 400 leading products, maintaining 206,000 employees, and with annual total sales of Euro 40 billion. The Unilever Thai Group of Companies is located at SCB Park Plaza in Bangkok. In terms of sales it has been ranged in the top Unilever companies worldwide. It has two modern manufacturing sites situated at Ladkrabang Industrial Estate and Gateway Industrial Estate, producing and distributing 200,000 boxes of products to consumers every month. With over 3,000 employees, its core business activities are divided.

Unilever Group's mission is to add vitality to the life of the people who are using their products, for 150 million times at typical moments of their day. The everyday needs for hygiene, personal care and nutrition with brands that help a person to look well and get more out of life, are displayed in Figure 1-1.

**Product Brands**

| | | | |
|---|---|---|---|
| **Food** | Knorr | **Home Care** | Breeze |
| | Bestfoods | | Comfort |
| | Wall's | | Omo |
| | Lipton | | Vim |
| | Wall's | | Sunlight |
| **Personal Care** | Axe | **Skin Care** | Pond's |
| | Dove | | Citra |
| | Close-up | | Vaseline |
| | Clinic | | Lux |
| | Rexona | | |
| | Sunsilk | | |

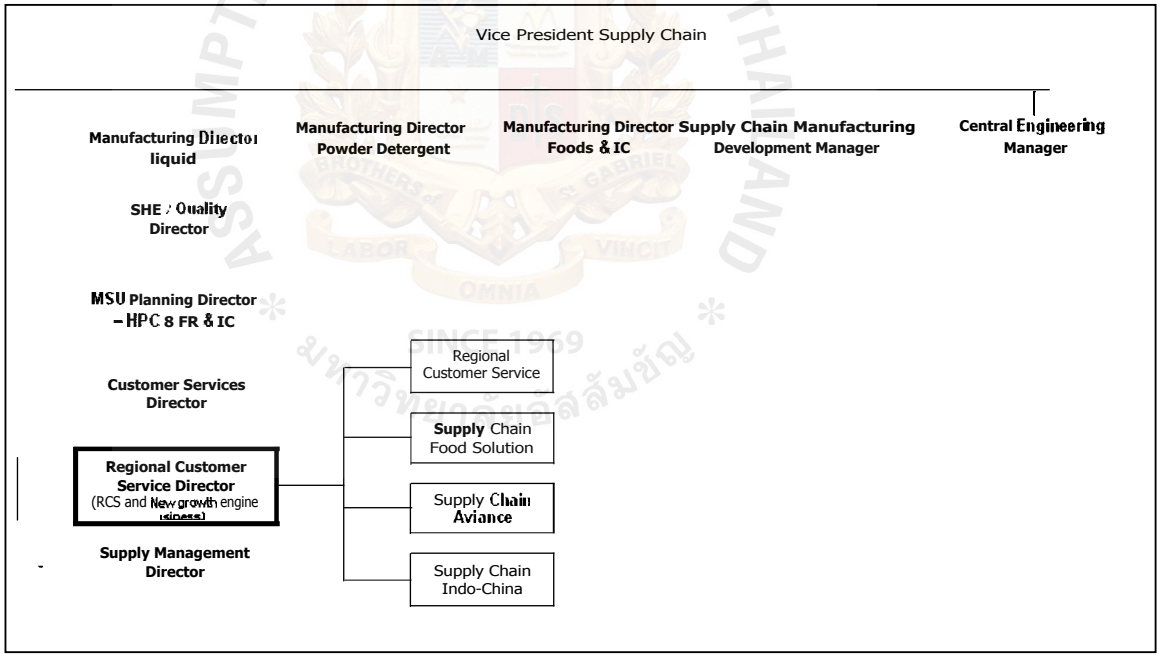
**Figure 1.2** Product Brand of Unilever Thai Trading Ltd.




Source : Company profile

The personal care and homecare products, such as conditioner and shampoo, are launched into the market with new innovations all the time, and distributed through various vending channels such as convenience stores or supermarkets. The development of new products is only in the preliminary stage and the company desires to expand and grow this particular product. But these products face high and fierce competition in the market compared to other brands, and Unilever needs to fight competitors to be successful in the market. This challenge means that Unilever should be more careful in its business opportunities, and thus more careful in strategic decisions such as investment cost or in operational decisions such as supply chain process design.

**Figure 1.3** Unilever organization




Source : Company profile

**Regional Customer Supply Chain Organization**

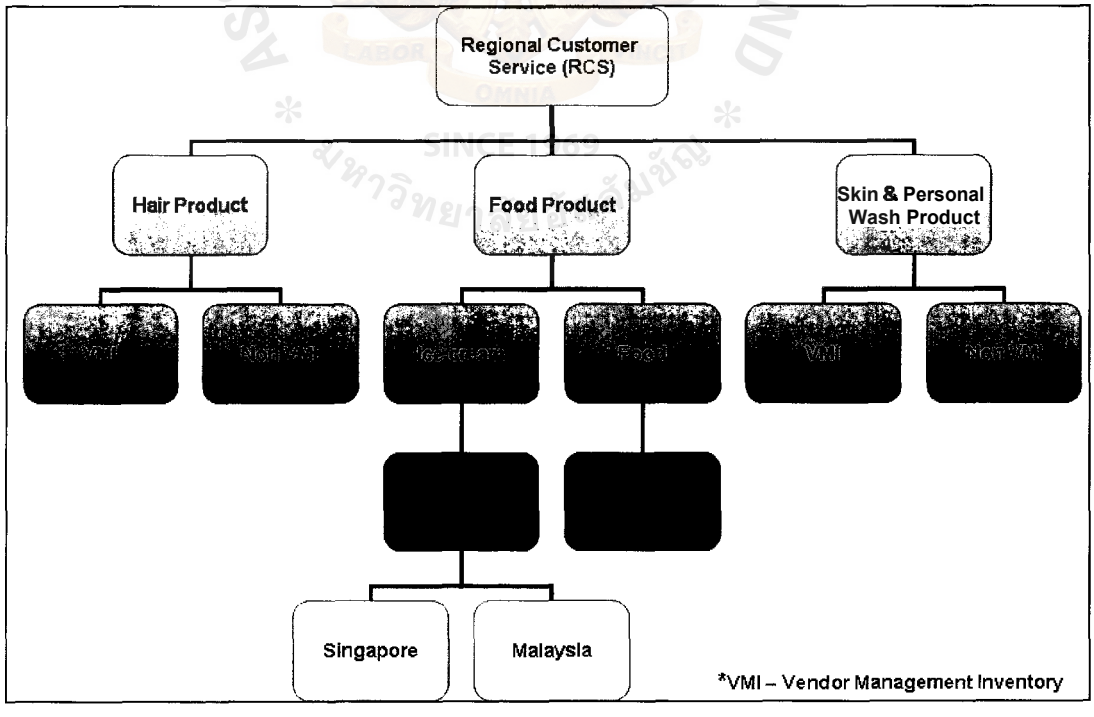
The supply chain of all Unilever products starts from sourcing in Thailand, and services to the related companies in neighboring countries. In-house manufacturing is divided into three parts, Liquid, Power Detergent, and Food and

Ice cream. The Regional Customer Service department plays an active role to balance demand from oversea customers and supply from in-house manufacturing and third-party manufacturing, and follows up the execution of production, delivery, and document process related to each transaction, according to the initial commitment. The illustrations below show the Regional Customer Service to Exporting Countries and a function chart of the oversea customer supply chain.

**Regional Customer Service Organization**

The Regional Customer Service department is divided into functions according to the product category and the ordering process, VMI (Vendor Management Inventory) and Non VMI. Basically, most regional customers are make-to-order. VMI customers are sent a yearly demand forecast, revised every quarter, fort inventory and are responsible for the inventory cost. Figure 1-4 below shows the function chart of regional customer service.

**Figure 1.4** Regional Customer Service Organizations




Source : Company profile

Table 1.1 shows, the net profit export by country. The highest percentage is for exports to Malaysia: 46 percent. This average volume is nearly that in every year.

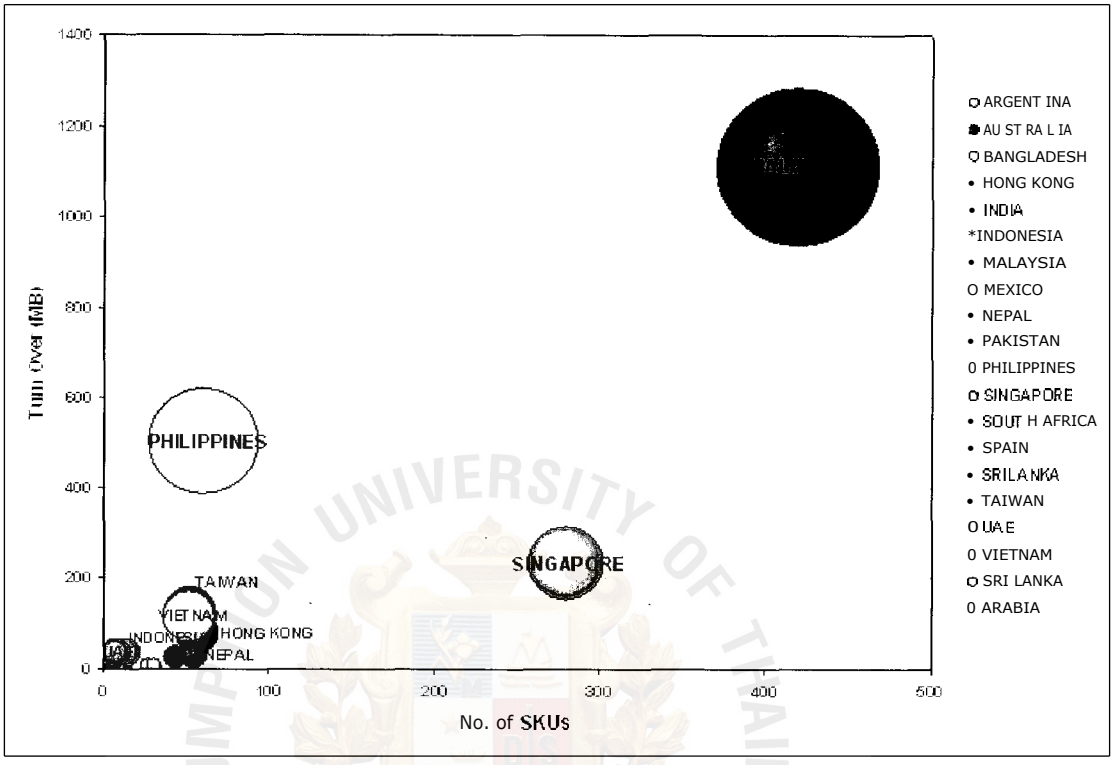
Table **1.1** Total net export profit for 2009: summaries by country

| Country | Sum of Net profit Year 2009 | % |
|---|---|---|
| Argentina | 1,628,172.00 | 0.07% |
| Australia | 34,707,050.79 | 1.43% |
| Bangladesh | 9,062,827.55 | 0.37% |
| Hongkon | 81,817,239.91 | 3.38% |
| India | 16,490,303.88 | 0.68% |
| Indonesia | 36,937,601.25 | 1.53% |
| **Malaysia** | **1,111,189,463.08** | **45.94%** |
| Mexico | 19,291,051.04 | . /0 |
| Nepal | 30,101,422.02 | 1.24% |
| Pakistan | 26,520,313.87 | 1.10% |
| Philippines | 505,179,153.03 | 20.88% |
| Singapore | 236,424,516.74 | 9.77% |
| South Africa | 5,665,435.79 | 0.23% |
| Spain | 3,629,092.11 | 0.15% |
| Sri Lanka | 9,015,536.15 | 0.37% |
| Sri Lanka – Asiana | 4,310,168.10 | 0.18% |
| Taiwan | 125,877,440.98 | 5.20% |
| UAE | 38,487,198.08 | 1.59% |
| Vietnam | 119,233,032.70 | 4.93% |
| Arabia | 1,461,401.82 | 0.06% |
| Afghanistan | 1,914,983.24 | 0.08% |
| Grand Total | 2,418,943,404.14 | 100.00% |

Source : Company profile

Details from the above Table are summarized in the graph in Figure 1.5, as Malaysia is the core country for consumer product exports.

**Figure 1.5** Regional Customer Service export countries, 2009




Source : Company profile

## 1.2 Statement of Problem

This project study is based on the company's enquiry into how to improve the transportation mode for exports to Malaysia. The Regional Customer Service department, a part of Unilever Thai Holding, Ltd., takes responsibility for exports of Fast Moving Consumer Goods to countries in Asia, including Malaysia, Singapore, Taiwan, Hongkong, Nepal, Pakistan, Srilanka, and India. In this research, it is the mode exporting to Malaysia which generates the highest volume and value for the department. Currently, exporting to Malaysia is by truck mode for which the transit time is four days, with a limit of container size being a 40 Foot container with FCL (Full container load) only, as well as a daily limitation of loading capacity. When the company has an NPD (New Product Development), Unilever Malaysia has to build up stocks which results in an insufficient number of trucks for loading to Malaysia. Moreover, the quality of truck does not reach the standard: for example there are

holes in a container, the container is dirty, with humidity and mess. Furthermore, it is an insufficient use of trucks which leads to a high logistics cost. Therefore, this project studies the trade off in each mode of transportation which consists of Road, Sea, Air, and Rail. This research will explain the advantages and disadvantages and scrutinize which is the best mode to optimize the company's logistics process and availability of stocks to arrive at customers on time.

### 1.3 Research Objectives

In order to justify a transportation mode and understand the advantages and disadvantages, the company has to understand the decision-making process for transportation,. Therefore, the three research objectives are:

(1) To select and evaluate a transportation mode in order to improve and manage the transportation cost and transportation management.

(2) To apply the AHP model in order to make decisions in selecting a transportation mode which is within the company's target.

(3) To explain collaboration in the supply chain with customers.

### 1.4 Scope of the Research

This project is concerned with optimizing the transportation cost and determining which transport mode is the most useable for export shipments from Unilever Thailand Ltd. to Unilever Malaysia Ltd.. It uses cost comparison and factors to make the decision, through comparative evaluation of each transportation mode. After calculations and evaluation, these will be compared,, with an expectation of a better result. Moreover, this project aims at the solution of improving the company's service level and also a better distribution center (if necessary).

### 1.5 Limitation of the Research

In the supply chain business, there are many ways to justify which transportation mode can provide customer satisfaction. However, this study focuses on the best way

for the company to improve, related to customer satisfaction. There are many unpredictables affecting customer satisfaction, some of which are not included in this study, which may cause errors and imperfection in the results. As each transporter has its own unique characteristics, the data obtained from the customer of only one transporter may not be able to represent the whole industry, and it might be inaccurate to generalize these results to other industries. The variation of customer satisfaction may not reflect reality, since only the factors of transportation efficiency are considered as the determinants of satisfaction.

### 1.6 Significance of the Study

After completing this project, the result should be useful to Unilever Thai Trading Limited in its delivery of exports, including the service level, from Thailand to Malaysia. The data, the analysis, and the result after implementing the solution, will help the company to save on delivery cost, reduce lead time, and gain a better quality of service, which should increase the company's sales volume in the near future.

### 1.7 Definition of Terms

***AHP** (Analytic Hierarchy Process):* is a pairwise comparison method designed to solve complex problems involving multi-criteria, and was developed as a reaction to the finding that there is a lack of common, easy to understand and easy to implement techniques.

***FTL** (Full Truck Load):* is the working term for that part of logistics which concerns itself with the transport of a complete load; an economic transportation quantity. The opposite is Less Than Truck load (LTL), a transportation quantity which constitutes an incomplete truck load and therefore is not economical.

*Multi modal transportation:* is the transportation of goods under a single contract but performed with at least two different means of transport.

***NPD (New Product Development):*** is the term used to describe the complete process of bringing a new product or service to market.

***Transportation mode:*** is a general term for the different kinds of transport facilities that are often used to transport people or cargo.

***VMI (Vendor Managed Inventory):*** is an inventory replenishment arrangement whereby the supplier either monitors the customer's inventory with its own employees or receives stock information from the customer. The vendor then refills the stock automatically, without the customer initiating purchase orders.

# CHAPTER II

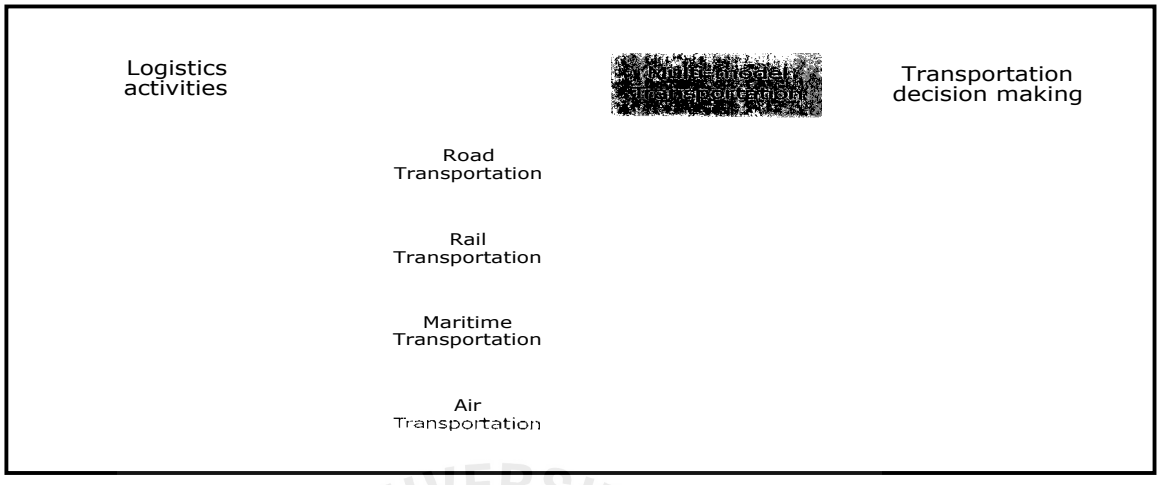
## REVIEW OF RELATED LITERATURE

This chapter present the literature review which demonstrates the theories and concepts of the study, mainly focusing on ideas to enhance supply chain performance for effectiveness and efficiency. This chapter explores previous research to find the best methodologies related to the main focus of the concept of transportation modes in order to arrange transportation modes from the source of the origin: manufacturing by Unilever Thai Holding ltd, to the destination of Unilever Malaysia Holding Ltd.

Logistics have existed since the beginning of mankind, long, long ago. Logistics are concerned with delivering the right product in the correct quantities with defined quality and condition, to the right location, on time, and of course to the right customer, at competitive costs. These are the basic functions of logistics which is about transportation and delivery of the product to the customer. Of course there are many concerns, such as sourcing, integration of suppliers, controlling the inventory pipeline, and so on.

To manage uncertainly, transportation needs to be the most effective and efficient, and apart from the mode of transportation, there is logistics infrastructures (e.g. highway system, ports, communication and information system) which play a major role. Other concerns are lead time, stock availability, and speed of service. Another approach, similar to cross docking, JIT also needs to take account either of the level of service or cost, as constraints. The relevant concepts related theories, and previous research, are shown in the following diagram.

**Figure 2.1** The relevant concepts and theories




Source : Adapted from Christopher (1998), Slater (2007) and Pichet (2007)

**2.1 Logistics Activities**

Logistics management was defined by Christopher (1998) as the process of strategically managing the procurement, movement and storage of material, finished and part inventory (and the related information flows) through the organization and its channels of marketing, in such a way that current and future profitability are maximized through the cost-effective fulfillment of orders. It is also about getting the right goods or services to the right place, at the right time and in the required condition, while making the greatest contribution to the firm. Lambert (1998) stated that logistics is the part of the supply chain that involves the activities of planning and effective implementation, effective flow and storage of goods, services, efficient control, and related information flow, from one point to another, from origin to the consumption point, are the requirements in order to provide customer satisfaction.

Taniguchi and Thomson (2003) explained that the growth of globalization has motivated an expansion in trade demand, and activities in logistics have become more important issues. At present, improvements in logistics have been the primary source of increased profits for companies, to allow them to maintain their competitive advantage. There is the same explanation from Slack (2001) who explained that

containerization has increasingly facilitated the transportation of products. By standardizing the dimensions of loads, the containers can be employed in the quality of cargo handling between transportation modes in terms of cost and speed. This improvement is an important and crucial condition for intermodal transportation, such as waterway and rail transportation in cooperation.

Lambert (1998) said that since logistics is a significant component of a country's economy, it is very important to define what the term means. In the past, the trade and academic press has given logistics a variety of names such as physical distribution, marketing logistics, business logistics, industrial logistics or even supply chain management. At one time or another, all of these terms have referred to what is essentially the same: the management of flow of goods from point-of-origin to point-of-consumption. But logistics management is the most widely accepted term among logistics professionals.

From what all these researchers have stated, in defining or naming the "logistics management" terms, they all give a similar definition to the process as "the flow" of goods or services, and they all agree on the importance of the logistic activities as part of economic, industrial, or company growth.

**2.2 Transportation Mode**

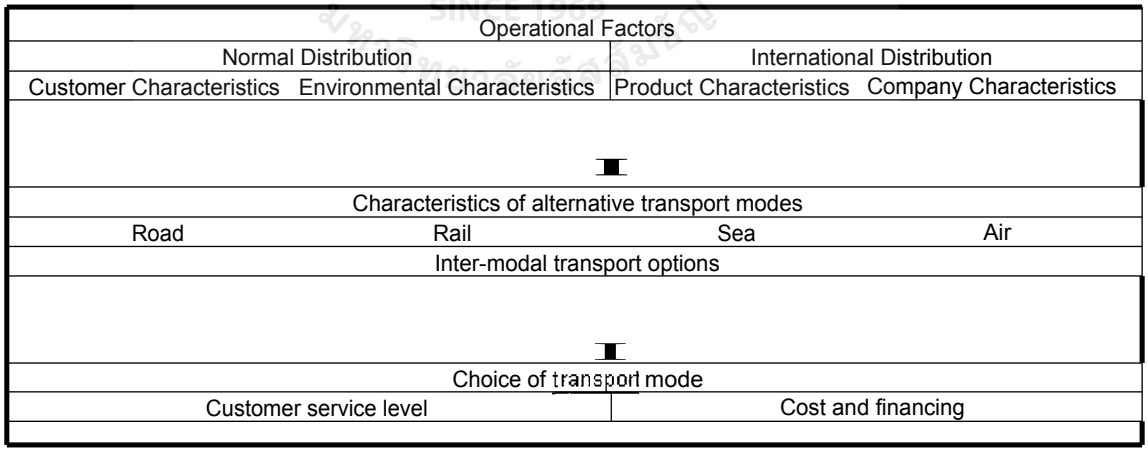
Common carriers have an obligation to move freight with reasonable dispatch and to do so using reasonable care in order to avoid loss and damage. Each of the fundamental transportation modes offers its services straightforwardly to users.

Slater (2007) explained that alternative transport modes are a fundamental part of distribution management which should be analyzed carefully because of the impact upon a company's operational efficiency. Failure to identify the most appropriate transport mode may incur higher costs than are necessary and may provide a lower customer service level than is potentially possible. Decisions on alternative transport modes are extremely difficult because of the vast volume of choice available in the

numerous methods of examination and evaluation of each choice. With the purpose of being able to recognize the best transport mode, it will be essential to:

**2.2.1 Identify the significant and collection of data** for all the varieties by determining the impact of transport on the distribution organization. It is necessary to be capable to determine the impact of transport upon the distribution system. Transport Costs depend upon the character of the product range and its market. However, the average transport cost ranges between 5 percent and 6 percent of the recommended retail price of the product. Transport is a cost which tends to be rising more rapidly than most, and it is therefore important that the correct operational method is adopted in order to avoid incurring high cost unnecessarily. The impact of reducing transport cost is shown by the profit leverage. Any reduction in transport costs would lead to an increase in profit. Moreover a distribution system is important in the movement process. The product will need to be monitored with documentation in order that its approximate location is known. Therefore the form or forms of transport used must be compatible, not only with the terminal systems at both ends, but also the operating environment through which the movement which take place.

**Figure 2.2** Factors of operations which determine the transport mode




Source : Adapted from Slater (2007)

**2.2.2 Identify the existing data and the factors** which determine the choice of the transportation mode. These factors could be divided mainly into three groups:

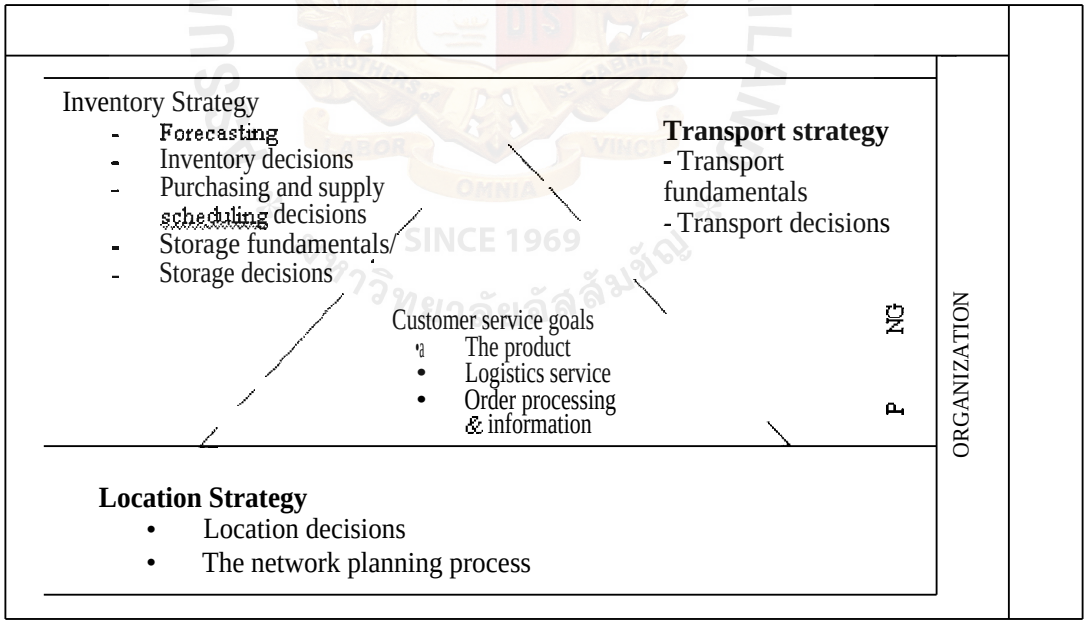
(1) Operational factors to covering the operating environment, the company, the product, and its customers. This process is shown in Figure 2-4. (2) Characteristics of alternative transport modes: it is important to define accurately the operating characteristics of each available transport mode, to establish whether it would match and be suitable to the important operating factors. (3) Channel Situation which covers the alternative approaches to the total distribution system. There are useful loads for physical capability and maximum load as a percentage of gross weight. The cargo densities (weight per cubic unit) are suitable. The fixed cost or overhead as a percentage of total cost is an indicator of risk for price increase and support for the requirements. Each mode of transport also has its own characteristics which affect the preparation of products before movement (for example packaging for sea freight must be more substantial than for air freight). These characteristics are of particular significance when considering inter-continental traffic by using more than one mode of transport.

**2.2.3 Identify key criteria and factors together with selection criteria** that are important keys and factors to consider when analyzing the transport requirement of each sector, such as financial standing, control ownership, information processing systems and security, the type of the movement of products for mechanical handling interfaces, stock level required at each terminal, packaging, capital, manpower, and product. The factors of marketing affect variations in service level requirements. Other factors are control risk factors for potential changes, inter-type competition, government influence and profit potential. The major influence upon the choice of transport mode may be the ability of the transport concern to match or adapt the requirements of the marketing channel to maximize the use of the transport offered. A further rule is that where possible, a trade-off analysis should be used to assess the impact of each transport mode upon other functions in the business system.

McGinnis (1990) and other writers explain that there are six variables which are the key to transport service choice: (1) reliability, (2) freight rate, (3) loss and damage, claims processing, and tracing (4) transit time, (5) carrier considerations, and (6) shipper market considerations.

**2.2.4 Subsequently evaluate and feedback that the choice is correct by the selection criteria.** There are four potential selection methods. The first is Judgment, in which the costs are not important because the decisions are made upon operational ability. The second is cost trade-off where the impact of transport is calculated in relation to its immediate terminal activities and the total cost of the distribution system optimized. The third consists of distribution models which identify and explain the inter-relationships between the components of the distribution system at various levels, daily/weekly/monthly, affecting the transport problem with the selection of the most important. The last is systematic selection which is based on analysis of all the factors affecting the transport problem with the selection of the most important.

**Figure 2.3** Transport planning strategy




Source : Adapted from McGinnis (1990)

Figure 2.3 shows strategies that are important elements in most firms. The movement of freight has been observes to absorb between one-third and two-thirds of the total logistics cost. Thus, a good understanding of transportation matters is needed for

logistics. There are transportation modes which show by capacity and usage which aret suitable for each shipper.

**Road transportation** Road infrastructures consume a large space with the lowest level of physical constraints among modes of transportation. However, the constraints of physiography are major in road construction, with a large amount of additional costs to overcome features such as rugged terrain, rivers etc. Road transportation has an average operational flexibility as vehicles can serve several purposes but are rarely able to move outside roads. Road transport systems have high costs in maintenance, both for the infrastructures and vehicles. They are mainly linked to light industries where fast movement of freight in small batches is common. Still, with containerization, road transportation has become a crucial link in freight distribution (http://people.hofstra.edu/geotrans/eng/ch3en/conc3en/ch3c1en.html).

**Rail transportation** Railways are composed of tracked paths on which are bound vehicles. The physical constraints are at an average leve, linked to the types of locomotive and the low slope required, especially for freight. Heavy industries are traditionally connected with rail transport systems, although containerization has improved rail's flexibility by connecting it with maritime and road modes. Rail is the land transportation mode with the highest capacity, a 23,000 tons fully loaded coal unit train being the heaviest load ever carried.

**Maritime transportation** Due to the physical properties of water conferring limited friction and buoyancy, maritime transportation is the most effective mode to transport or move large quantities of goods and cargo over long distances. Mostly maritime routes are composed of seas, oceans, coasts, rivers, lakes and channels. However, according to the location of economic activities, maritime circulation takes place in the specific parts of maritime space. The construction of locks and channels, and dredging, try to facilitate maritime circulation by reducing discontinuity. Maritime transportation has high terminal costs, since infrastructures in ports are among the most expensive to build, to maintain and to improve. High costs in inventory are also specific characteristics for maritime transportation. Compared to any other mode,

maritime transportation is linked to heavy industries, such as petrochemical facilities and steel near to port sites.

**Air transportation** The constraints of this type of transport are multidimensional and include the site (a commercial plane needs a runway of about 3,300 meters for landing as well as to take off), including the climate, fog or aerial currents. Air activities are importantly connected to finance and tourism industries, which deal with the long distance mobility of people. More recently, air transportation has been accommodating growing quantities of high value freight as well as playing a bigger role in global logistics.

**Intermodal transportation.** This concerns various modes of transportation, combining together so that the respective advantages of each mode are better used. Although intermodal transportation use for passenger movements, such as the usage of the different but interconnected modes of a public transit system, it is freight transportation that has the most significant impact. Containerization has been a powerful factor of intermodal integration, allowing transportation through land and maritime modes to become more effectively interconnected. The detail is explained in the next section.

### 2.3 Multi-model Transportation

Most multi-model transportation is new, and increasing due to its benefits, such as several firms and companies receive the benefits from using cross docking. Some of the benefits include: decrease in labor costs as goods no longer need to be picked up and stored in the warehouse, so it is a reduction in time from production to the customers, as well as helping to improve customer satisfaction. It is also reduce the need for warehouse spac, as there is no need to store the products.

Cross docking has several types with and cross docking scenarios are available to the warehouse management. Companies will choose the type of cross docking that is suitable to their product type that they are shipping. Types of Cross Docking are

- Manufacturing Cross Docking – This process involves the receiving of inbound and purchased goods that are intended for manufacturing. Warehouses may receive the products and then prepare sub-assemblies for the production orders.

- Distributor Cross Docking – This procedure focuses on having different vendors for inbound products on a mixed product pallet, which will be delivered to the customers when the final item is received. For example, distributors for computer parts can source their components from different vendors and combine them into a single shipment for the customer.

- Transportation Cross Docking – This procedure is for mixed shipments from several different carriers in less-than-truckload (LTL), and small package industries and eventually gains from economies of scale.

- Retail Cross Docking – This operation include product received from many vendors, and sorting them onto outbound trucks for a number of retail stores. This strategy was used by Wal-Mart in the 1980's. They would obtain two types of product, "staple stocks" which are goods that they sell each day of the year, and large amounts of products which are purchased once and sold and not usually stocked again. This second type of procurement is called direct freight, to minimize any warehouse costs, Wal-Mart use direct freight by using cross docking and keep the products in their warehouse for as little time as possible.

- Opportunistic Cross Docking – This can be used by any warehouses, transferring goods directly from the products receiving dock to the outbound shipping dock to meet a known demand (i.e. a customer sales order).

There are some goods more suitable for cross docking than others. Perishable products will require an immediate shipment, high quality products that do not need quality inspections during goods receipt, goods that are pre-tagged (bar coded, RFID), pre-ticketed, and ready for sale at the customers, staple retail products with a

continual demand or with low demand variance, promotional products and products that are being launched, pre-picked, and pre-packaged customer orders from another production plants or warehouses.

Marcus and Robert (1975) explained that in mixed-modal, several variations of a typical product are produced at the same time in mixed scenarios. Considering the work transport system is also a concern. Apart from manual work transport on the line, the mechanized work transport system is identified as synchronous (intermittent), continuous. The purpose is to design a line for smooth production, higher efficiency, less balance delay, optimized processing time, overall labor efficiency, just-in-time (JIT) production, cost effectiveness, and so on. The main point is to offer a line by exploiting the most efficient design methods which will deal in actual fact with user preferences.

There are a lot of factors touching individual modal choice due to different journey types. Variables can comprise the accessibility of transport skill, the workplace and the home relative to location, and the cost of diverse transport modes, routing, accessibility, personal preferences and convenience. Economic theory provides an appropriate framework for looking at people's purchasing performance An economist's model of alternative is based on the concept of usefulness. Hence, all the attributes including comfort, act simultaneously on the mind of commuters for mode choice behavior together with safety (www.nbmcw.com/articles/roads/5024-multi-modal-transportation-system-in-delhi-good-choice-for-better-mobility).

Multi-modal transportation planning is intricate because different modes function in different ways, including their speed, availability, costs, density, appropriate uses and limitations. They are not substitutes for each but only suitable for definite users and uses.

Also recommendations for multi-modal transportation reflect on a diversity of transportation development options, as well mobility management strategies such as pricing reforms and smart growth land use policies, and improvements to various modes. There are many combinations of these options of modes, for example public

transport improvement plus factors encouraging mobility in organization strategies. It would be impacts that cannot be quantified and monetized which should be described. Multi-modal comparisons should be marginal and comprehensive together with factors that out, such as transit organization scope and economies of scale. The person involved in transportation decision-making (planning professionals, community members and public officials) should try to survive without using a personal vehicle for at least two weeks each year that involve normal travel activities, with the aim of knowing how the non-automobile transportation system functions. (www.vtpi.org).

**2.4 Transportation Decision-Making**

Transportation managers and Logistics face an extremely challenging and unusual environment today than merely a few years ago. It is not amazing, then, that many have failed to fully adapt to the changing environment, resulting in performance shortcomings and zero opportunities. With the intention of meeting rising expectations, the essential job of transportation has changed from operationally assembling high services or low cost factors, to providing a planned edge by concurrently assembling higher service requirement and gradually more lower costs. When supply chain planning information is provided by transportation managers, it includes delivery requirements they can arrange shipment to take advantage of load/carrier considerations or routing efficiencies and resource availability.

Pichet (2007) stated that the transportation choice context in shippers and freight forwarders is mostly made of design networks. The possible intermodal transportation would rely on freight transportation decisions to continue connections in the chain of activities. Mostly decisions are made in some kind of environmental context and therefore rivet many factors ahead of the control of the decision creator. McGinnis (1990) summarized the transportation mode choice models, which are divide into four categories, differing essentially with respect to their supposition;. to start with, the model of classical economics believes that freight transportation is determined by cost (Friedlaender, 1969). Secondly, the inventory theoretic model supposes that gross revenue is impassive to transportation mode choice. The assortment on the optimum mode becomes a means of seeking the lowest cost alternative (Baumol and Vinod,

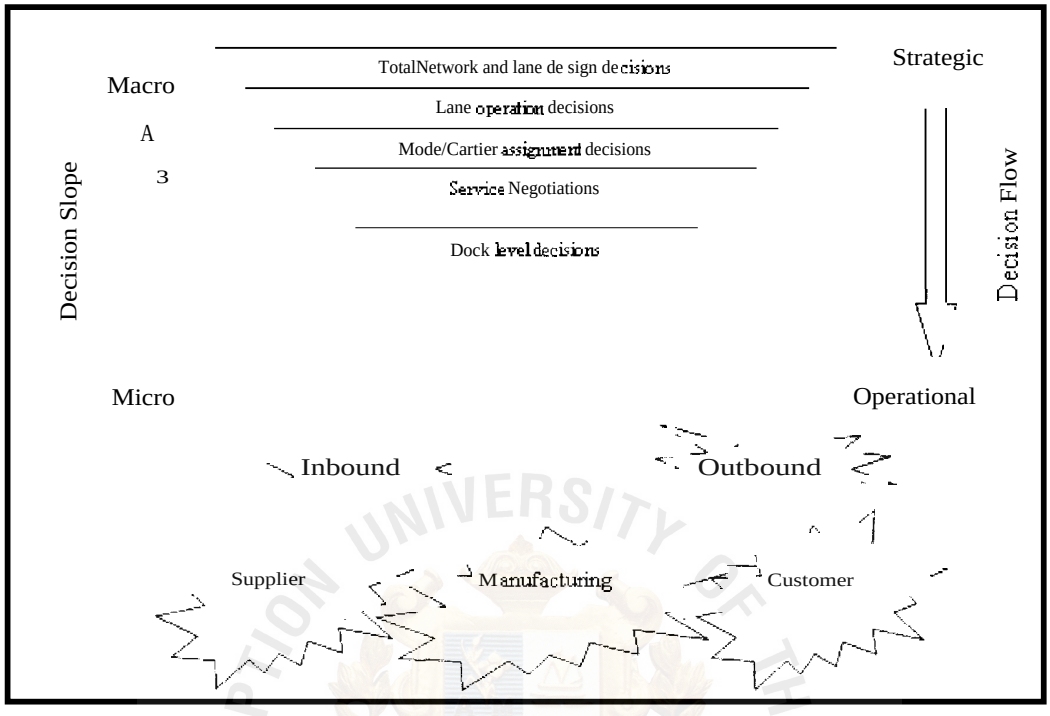
1970). The third sort is the trade-off model, which chooses the optimal mode by making a trade-off among variables until optimum logistics costs are obtained (Marcus and Robert, 1975). Lastly, there is the controlled optimization form. Transport costs are selected as the objective function, subject to several constraints (Lehmusvaara 1999).

Baumol and Vinod (1970) stated that logistics management is a key decision in the selection of the transportation mode and transporter to move the firm's inbound and outbound shipments. Managers normally believe in various factors when making this decision, but they usually concentrate on the major criteria of transit time and cost. In addition, the significance of personality factors is often unusual if compared business to business, company to company, and also within a company from one capability to the subsequent ones. After that, carrier selection and mode -is usually viewed as another way for inbound and outbound shipments, even though in the same position.

Vannieuwenhuyse, Gelders, and Pintelon (2003) stated that the consideration of environmental and safety bring forward to the problem of growing congestion. Freight transportation increase is an important issue in logistics in general, and particularly in the manufacturing business process. The choice of transportation mode is still often made in a rather incidental way. That research views the transportation modes which are the result of case studies to bring about the logistics decision user's perception. They determine and weight the different choice criteria. Even though there is control of the problems they summaries the freight flows and the transport and logistics activities by outsourcing. The choice of a suitable transportation mode is totally important for logistics users in a global supply chain industrial process. They also explained that the popular top five-ways criteria preferred by logistics providers and shipper refer to transportation mode cost, transportation time reliability, safety and flexibility.

Figure 2.4 shows initial transportation decisions as strategic, long-term decisions that focus on the overall supply chain transportation.

**Figure 2.4** Overall Transport decision making




Source : Adapted from Stank and Goldsby (2000)

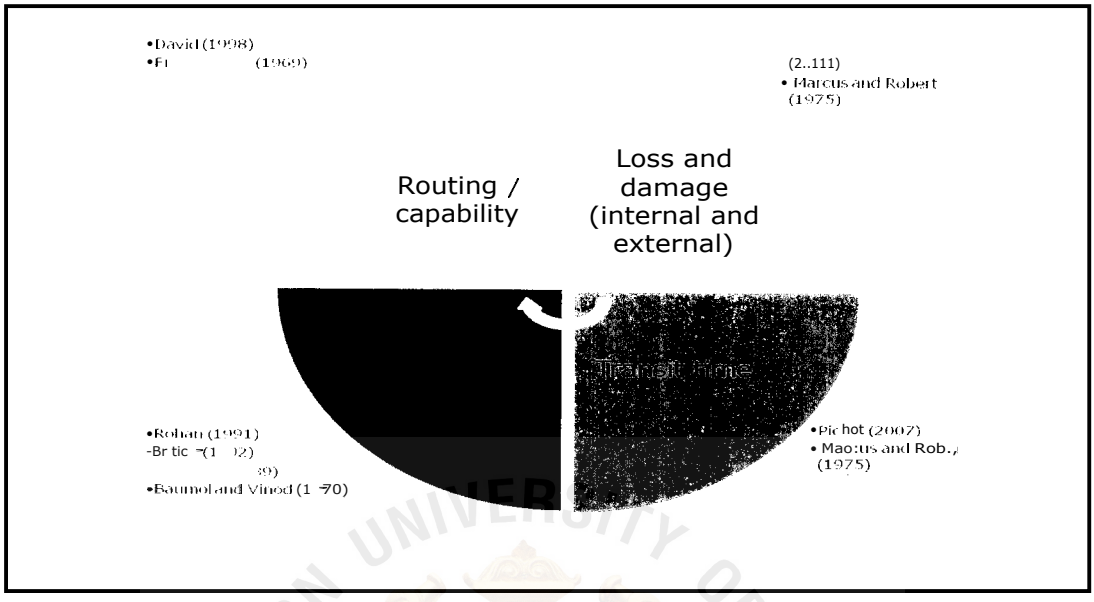
Friedlaender (1969) stated that the transport cost accounts for a main part of the total distribution cost for many companies. The primary factors influencing that cost is the quality of the transport mode decisions, as it influences not only total cost and transport cost, but also the levels of shipper-provided customer service. They also stated, as did David (1998), that most of the literature in the field of supply management and logistics is apprehensive of the role that should be taken by business behavior to add value for the customer and the shareholder. Concentrating on the issue underlying shareholder value management and planning, it proposed that the values of drivers are identified and examined in the context of both cost implication and value when related to the broader objectives of delivering shareholder value.

Pichet (2007) stated that the environment factor influences all elements and systems of the chain as well its subsidiary sites depending on the configuration and selection of the transport chain. For a long term decision making perspective it is necessary to seek significant modifications to the process. This could be achieved by considering a future analysis of infrastructures and technical and technological conditions and the

influences of various other factors on the resource consumption. A major degree of responsibility for tackling environmental problems is increasingly attributed not only to producers and industry but also to logistics providers (transporters). The determination of a deficiency within existing instruments and tools used in evaluation indicated the need to establish a tool supporting decision-making in relation to transportation in enterprises. Bruce (1972) explained that the greater is transportations' cost share and marketability influence on a company's products, the greater is its important, sophistication, and status as a managerial function. Different modes serve different needs. There is a trend to a total physical distribution systems approach to transportation decision making and the organization of a strong centralized traffic department with marketing and production executives' advisory or decision making input. The response provides definite evidence towards accepting the research sup-positions as heuristic guidelines for decision making by logistics managers in the manufacturing industry. If the research suppositions are extended to include logistics activities appropriate to the nearest two conversion points to that of the changed activity, then the empirical response supports these modified heuristics to an increase degree.

The many authors stated, show factors that support decision making in transportation as shown in Figure 2.5. There are routing, capacity, freight rate, transit time and loss and damage both internal and external.

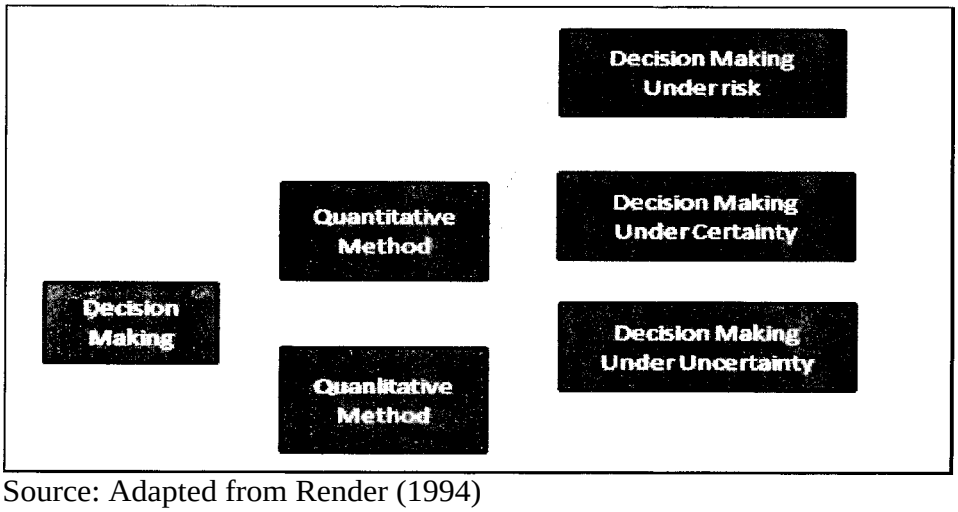
**Figure 2.5** Factors in transportation decision making




Source: Adapted from David (1998), Friedlaender (1969), Edeltraud and Vera (2010), Marcus and Robert (1975), Rohan (1991), Bruce (1992), McGinnis (1989), Baumol and Vinod (1970), Pichet (2007) and Marcus and Robert (1975)

There are many type of decision making which are not specific only to transportation, so this project will define a good decision as the one that is based on logic, considers all available data and possible alternatives, and applies the quantitative approach to be described in Figure 2.6.

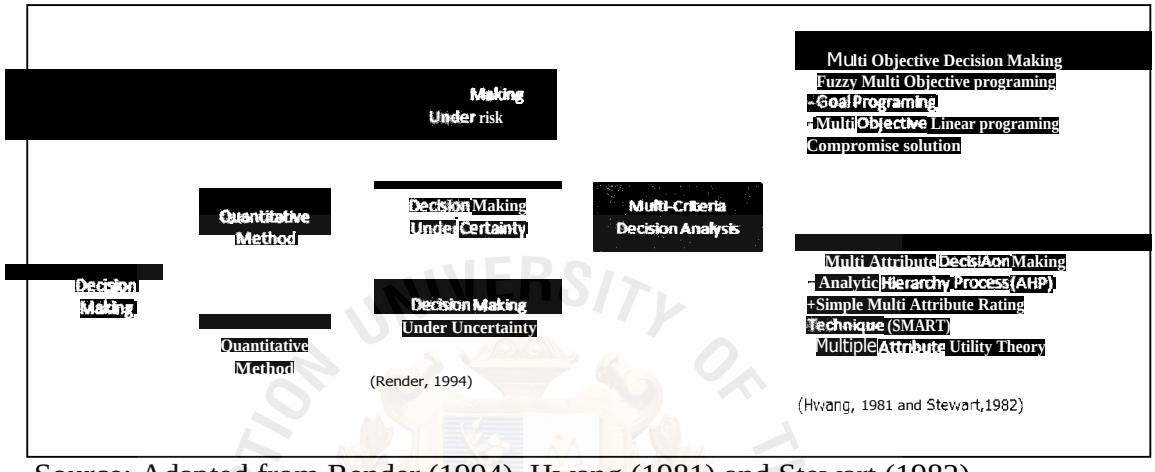
**Figure 2.6** The types of decision making




Source: Adapted from Render (1994)

In decision making under uncertainty, there are many possible outcomes of each alternative, and the decision maker cannot access the outcome probability with confidence, so Figure 2.7 explains more of the detail of decision under uncertainty.

**Figure 2.7** Decision making under uncertainty with multi criteria decision making




Source: Adapted from Render (1994), Hwang (1981) and Stewart (1982)

This project will analysis and concentrate only on Multi Attribute Decision Making.

**Table 2.1** Advantages and disadvantages of AHP, SMART and MAUT

| Author | Method | Advantage | Disadvantage |
|---|---|---|---|
| Yap (1992) | AHP | -Better clarifies the problem<br>-Better in eliciting goals and preferences<br>-More content in the result<br>-Handles both tangible and intangible<br>-Software package<br>-Uses pairwise comparison Use present for preference judgement<br>-Uses scale rating only1-9 | -Is more time consuming<br>-The number of computations required substantially complicated the method |
| | SMART | -Could be done manually without the aid of computer<br>-The tasks are more comprehensive<br>-Easily adapted where decision making is performed by the group | -Unreliable and unrepresentative of real preference<br>-Wide range score 0-100<br>-Requires no judgment of preference<br>-Bores untutored decision |

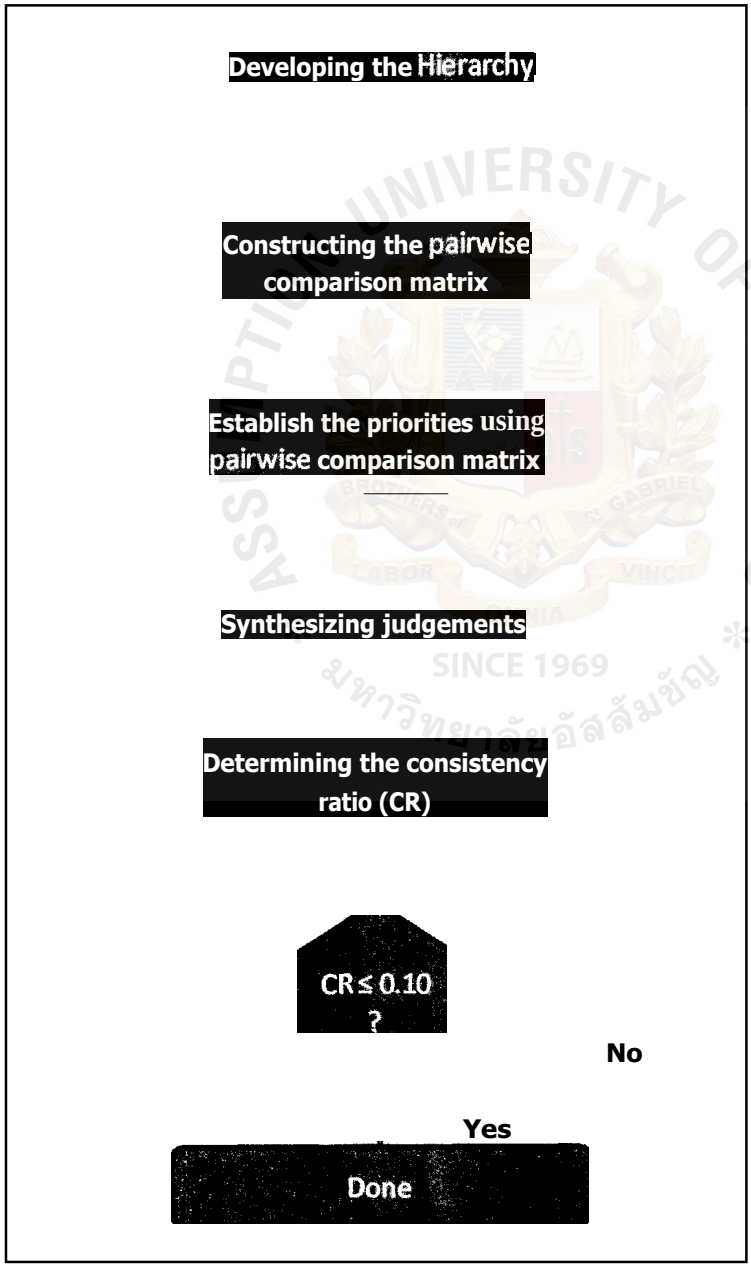
| | | | |
|---|---|---|---|
| | | -Simple method | makers into rejection of the process<br>-Evoking response for direct rating<br>-Not using preference judgment |
| Espen (2007) | AHP | -Encourages participation and brainstorming<br>-Reduces bias<br>-Uses pairwise comparison<br>-Incorporative of both quantitative and qualitative judgment<br>-Gives much greater differences in the rating than MAUT<br>-Software package<br>-Consistency ratio | -Time consuming<br>-The conversion from verbal to numerical judgment tends to overestimate preference differences |
| | MAUT | -Handles both quantitative and qualitative<br>-Can be applied in uncertainty or risk situation<br>-Direct rating | -Expected total utilities (0-1 scale) don't have any direct physical meaning<br>-Questions in MAUT seem to be ambiguous<br>-Complex and difficult preference elicitation procedure<br>-Expected total utilities might seem complex and fuzzy for decision maker |

The comparison found that AHP is a suitable methodology for decision and selection of transportation modes, both quantitative and qualitative factors. AHP also measure the consistency ratio to ensure the decision maker's answer is consistent and reasonable. This method use the analytical hierarchy that provides a structural model of the problem by imitating the way people normally approach complex problems and also provides a pairwise comparison base on a nine point scale.

### 2.4.1 The Analytic Hierarchy Process (AHP)

Thomas L. Saaty designed the Analytic Hierarchy Process for solve complex problem involving by multi criteria. The method requires the decision maker to convert the subjective assessments of relative importance to a set of overall scores or weights.

**Figure 2.8** The Analytical Hierarchy Process




Source: Adapted from Anderson (1941)

The method start from organizing the basis rationally by breaking down a problem into smaller constituent parts and then guides the decision maker through a series of pairwise comparisons to express that between the two alternative decision makers preferred and how much importance they find in the alternatives compared to the other. The fundamental scale is show in Table 2.2

**Table 2.2** The pairwise comparison for a nine point scale

| Intensity of Importance | Definition | Explanation |
|---|---|---|
| 1 | Equal importance | Two activities contribute equally to the objective |
| 3 | Weak importance of one over another | Experience and judgment slightly favor one activity over another |
| 5 | Essential or strong importance | Experience and judgment slightly strongly favor one activity over another |
| 7 | Very strong or demonstrated importance | An activity is favored very strongly over another; its dominance demonstrated in practice |
| 9 | Absolute importance | The evidence favoring one activity over another is of the highest possible order of affirmation |
| 2,4,6,8 | Intermediate value adjacent scale values | When compromise is needed |
| Reciprocals of above nonzero | If activities *i* have one of the above nonzero number assigned to ithen compared with activities *j,* then *j* has a reciprocal value when compared with *i* | A reasonable consumption |
| Rational | Ratios arising from the scale | If consistency were to be forced by obtaining n numerical values to span the matrix |

Source: Adapted from Saaty (1980)

The result from the comparison is put into matrices in which each alternative is compared with the others, such as if alternative A receives a score of 2 relative to alternative B, the alternative B should receive a score of V2 when compared with alternative A. For each comparison score given, the reciprocal is to the opposite

relationship. The priorities vector is calculated for each criterion using the geometric mean of each row in the matrix divided by the sum of the geometric mean of all the criteria. The method is repeated for the alternatives, comparing them one to another to determine their relative importance for each criterion. This method also provides a measure of the consistency of pairwise comparison judgment which is called consistency ratio. This ratio is obtained by comparing the C.I. with the appropriate one of the set of RI number show in Table 2.3

$$CI = \frac{\lambda \max - n}{n - 1} \qquad \text{Eq (2.1)}$$

Where CI = the sum of consistency vector

$\lambda Max$ = the largest or principle value of matrix

n = total number of alternatives

Therefore, $CR = \frac{CI}{RI}$

Where RI = the random index is a direct function of the number of alternatives

Table 2.3 Random Inconsistency for different size matrix

| n | RI |
|---|---|
| 2 | 0.00 |
| 3 | 0.58 |
| 4 | 0.90 |
| 5 | 1.12 |
| 6 | 1.24 |
| 7 | 1.32 |
| 8 | 1.41 |
| 9 | 1.45 |
| 10 | 1.49 |

Source: Adapted from Saaty (1980)

Generally, If CR < 0.10, the decision maker's answers are relatively consistent

If CR > 0.10, the decision makers have to seriously consider reevaluating their response during the pairwise comparison that was used to obtain the original matrix of pairwise comparisons.

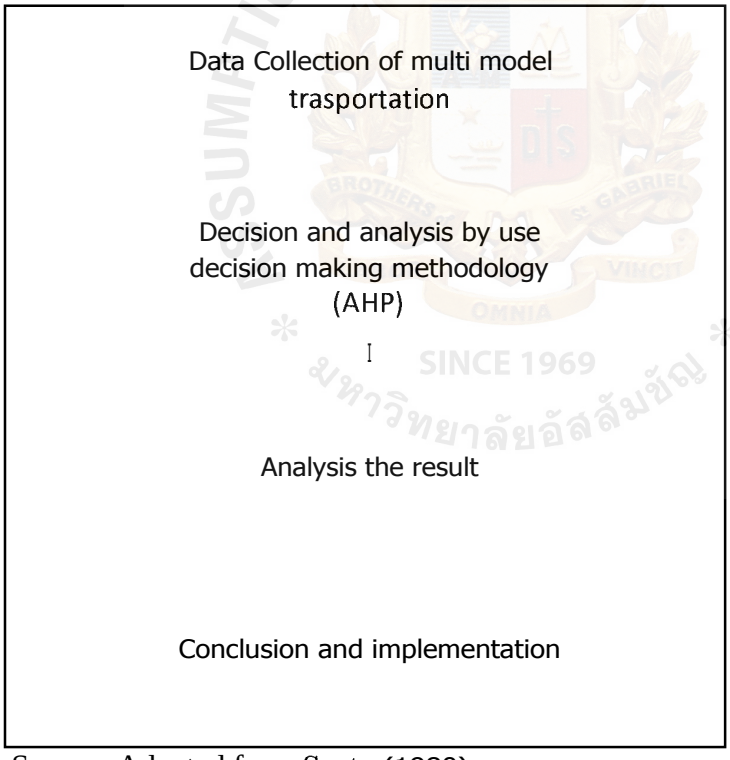
# CHAPTER III

# RESEARCH METHODOLOGY

In this chapter, the step by step method of conducting this project will be shown. In each step, the deep detail, data information, and the problems of the company will be reviewed once again in order to present the big picture of the whole process and the way to solve the problem.

The following Figure 3.1 presents the research framework which explains the main concept for each step of this project.

Figure 3.1 Research Framework and steps




Source: Adapted from Saaty (1980)

## 3.1 Data Collection

As shown in Table 3.1, the volume and value are both direct variations which will lead to the core country, and most volume came from Malaysia. Data of the actual

volume and value export to Malaysia in 2009 was collected from regional customer service department in terms of volume of exports to Malaysia and value spending from 2009, covering three product categories which are Food, Homecare and Ice cream. Moreover, the total numbers of stock keeping units (SKU) for collected data in 2009 are Food 11 SKU, Homecare 356 SKU and Ice cream 52 SKU.

**Table 3.1** Export volume to Malaysia in 2009

| Month | Foods | Homecare | Ice cream | Grand Total(carton) |
|---|---|---|---|---|
| Jan | 47,189,002 | 127,159,645 | 25,877,466 | 200,226,113 |
| Feb | 46,743,195 | 231,174,537 | 25,074,296 | 302,992,028 |
| Mar | 44,980,656 | 211,133,373 | 16,856,138 | 272,970,166 |
| Apr | 24,544,374 | 48,398,852 | 9,933,344 | 82,876,569 |
| May | 45,530,363 | 170,092,640 | 43,245,749 | 258,868,752 |
| Jun | 70,351,278 | 156;669,205 | 16,136,520 | 243,157,003 |
| Jul | 35,460,823 | 219,226,021 | 18,657,387 | 273,344,231 |
| Aug | 32,035,286 | 203,357,035 | 49,061,683 | 284,454,005 |
| Sep | 44,993,371 | 95,826,830 | 9,320,389 | 150,140,590 |
| Oct | 32,399,896 | 91,917,360 | 13,217,820 | 137,535,077 |
| Nov | 22,329,711 | 54,411,143 | 9,032,559 | 85,773,413 |
| Dec | 45,940,083 | 60,834,119 | 19,831,255 | 126,605,457 |
| Total | 492,498,037 | 1,670,200,761 | 256,244,607 | 2,418,943,404 |

Source: Company profile

Due to many products, with varying numbers of cartons per pallet, the way to analysis using the same unit measurement is by basing freight cost between each mode divided into full containers (forty foots size container). One shipment can deliver more than one container, depending on the volume of Malaysia customers.

Shown in Table 3.4 are the summaries of total trucks for 2009. Due to the volume being constant all the year, because the products of the company are FMCG (Fast Moving Consumer Goods), so all categories always launch their new projects in the Malaysia market which makes a supply pipeline volume to them all the year long.

**Table 3.2** Total transportation cost of exports to Malaysia by truck, 2009

| Month Year 2009 | Total pallet delivered | No. of container made by truck | Transport cost per trip **(Baht)** | Total transport cost **(Baht)** |
|---|---|---|---|---|
| Jan | 7,786 | 389 | 55,000 | 21,412,246 |
| Feb | 10,605 | 530 | 55,000 | 29,163,671 |
| Mar | 8,733 | 437 | 55,000 | 24,016,575 |
| Apr | 3,263 | 163 | 55,000 | 8,972,346 |
| May | 11,304 | 565 | 55,000 | 31,084,664 |
| Jun | 8,703 | 435 | 55,000 | 23,933,211 |
| Jul | 9,025 | 451 | 55,000 | 24,819,418 |
| Aug | 13,383 | 669 | 55,000 | 36,802,896 |
| Sep | 5,540 | 277 | 55,000 | 15,235,982 |
| Oct | 6,373 | 319 | 55,000 | 17,526,771 |
| Nov | 3,904 | 195 | 55,000 | 10,734,939 |
| Dec | 6,278 | 314 | 55,000 | 17,264,814 |
| Total | 94,897 | 4,745 | | 260,967,536 |

Source **:** Company profile

Remarks: a The data on total pallets delivered was gathered from the company records

ᵇ No. of container made by truck by (a) / 20 pallets

Transportation cost per container (in Baht) was gathered from the company records

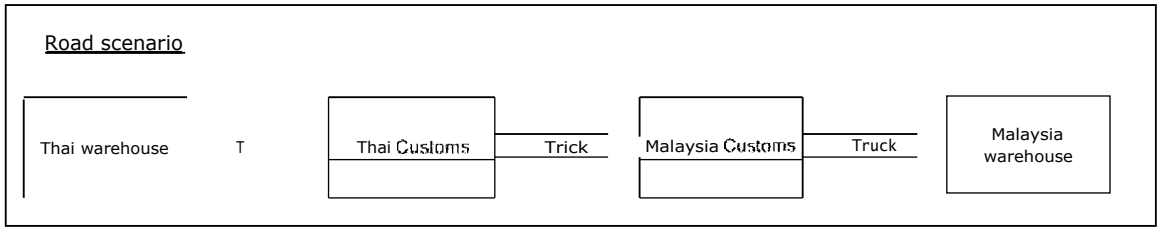
ᵈ Total transportation cost (in Baht) is calculated by (b) * (c)

### 3.2 Analysis and identifying key criteria

The objective of this project is to identify which transportation modes are the most suitable for export products to Malaysia, so this project shown four scenarios between each transportation modes. The first is the current process which is delivering the product by truck or road transportation. The other three scenarios are sea, air and rail transportation.

#### 1 Road transportation mode - Overview of the current process

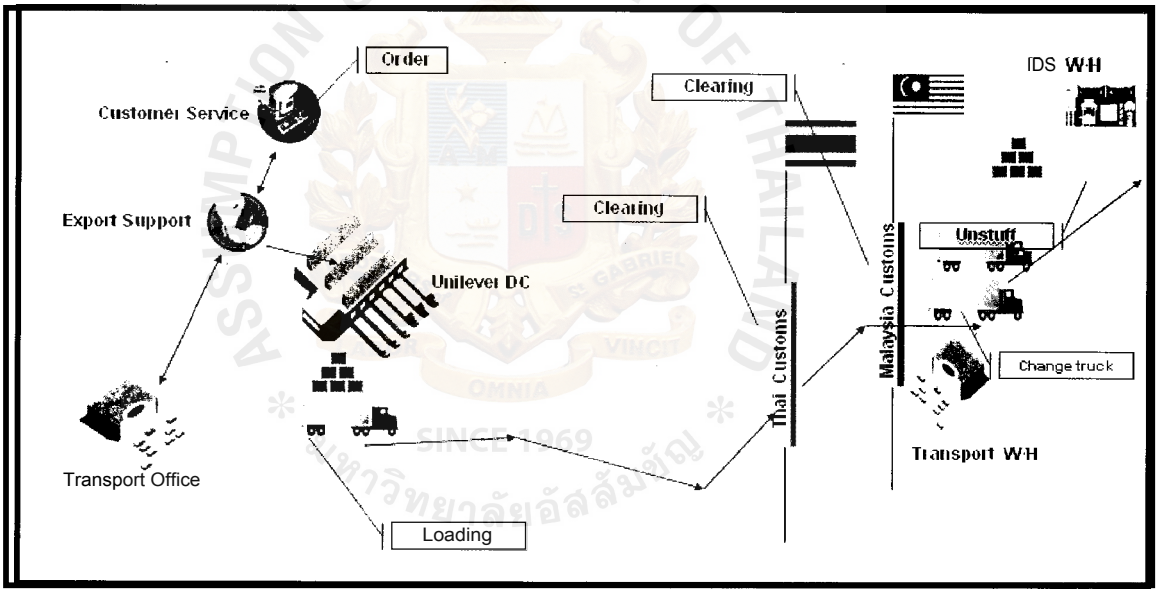
**Figure3.2** Road routing



### 3.2.1.1 Determine current routing

Currently the shipment of exports to Malaysia is delivery by truck mode only. The mode had shown that the shipment flows forward from Thailand to Malaysia, starting from a customer input order by using APO SAP to generate net requirement for production. Then the export department provides export documents and books trucks per volume output from production. On the loading date, trucks will be provided following the Unilever standard. The clear Thai customs and Malaysia customs, and then the trucks are unstuffed to trucks on the Malaysia side, and then arrive at the IDS warehouse.

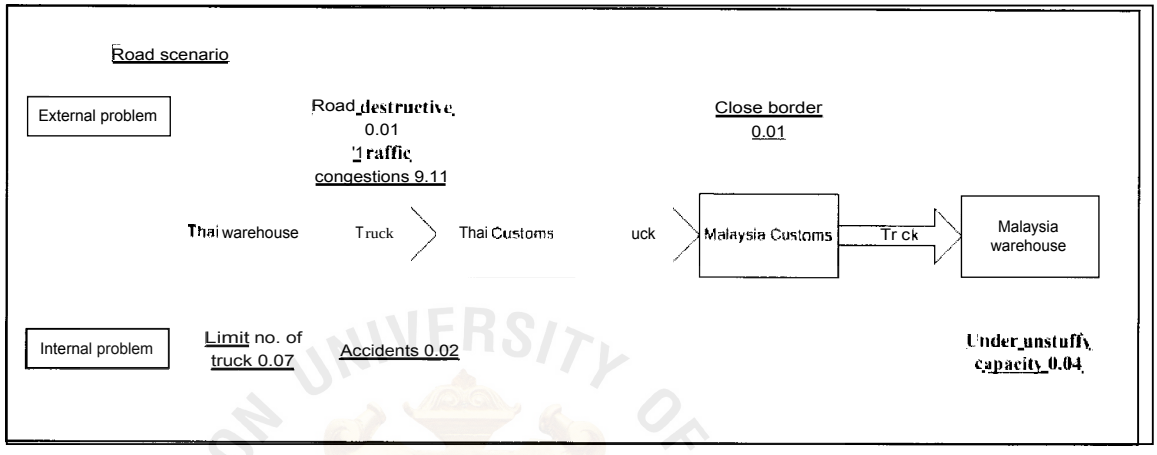
**Figure 3.3** Truck flow forward to Malaysia




After trucks are unstuffed at Malaysia customs, they will return back to Thailand, as in Figure 3.3 in empty containers, or sometimes a truck will load other products back to Bangkok to increase the company volume. All routes use only truck delivery.

### 3.2.1.3 Determine internal and external factors, and cost of loss and damage by road mode

**Figure 3.5** Loss and damage probability by road mode




In the in-depth interview with the truck transporter supervisor, he explained the problems which affect the delivery truck mode, which occur every working day, as shown in the list below, which are both internal and external problems.

**Internal problems**

- Limited number of trucks - due to some period the products are launched at the same time which means not enough trucks to load in the same day. This problem links to the Malaysia side for the second problem.
- Under unstuffed capacity - this problem is the effect of launching products at the same time.
- Accidents – Unpredictable problems which mean delay in customer requirements.

**External problems**

- Road destruction – This problem creates accidents and delays in customer requirements.
- Traffic congestion – Sometime there is a loading period delay, especially because of traffic jams during rush hours.

- Closed border – On the Malaysia holiday, the borders are closed, which will cause delays in customer requirements, and inventory stock at the Thai warehouse.

From the above problems, can be summarized the occurrence percentage and impact on damage and loss:

Table 3.3 Total loss and damage cost per year, 2009, by road mode

| Problem | Number of occur per year (a) | Loss and damage probability (b) | Cost of freight per pallet (c) | Cost of loss and damage per pallet (d) | Total cost of loss and damage per pallet year 2009 (e) | Impact | Damage |
|---|---|---|---|---|---|---|---|
| Limit number of truck | 25 | 0.07 | 2,750 | 188.36 | 893,750.00 | Delay delivery | Pay Penalty cost and have to find new mode |
| Under unstuffy capacity | 16 | 0.04 | 2,750 | 120.55 | 572,000.00 | No truck return back to load at Thai warehouse | Pay inventory management |
| Accidents | 6 | 0.02 | 2,750 | 45.21 | 214,500.00 | Product damage | Pay Penalty cost, and reduce reliability |
| Road destructive | 5 | 0.01 | 2,750 | 37.67 | 178,750.00 | Delay delivery | Pay Penalty cost, and reduce reliability |
| Traffic congestion | 40 | 0.11 | 2,750 | 301.37 | 1,430,000.00 | Delay delivery | Pay Penalty cost, and reduce reliability |
| Close border | 3 | 0.01 | 2,750 | 22.60 | 107,250.00 | Delay delivery | Have to find new mode |
| Total | 95 | 0.26 | 16,500 | 715.75 | 3,396,250.00 | | |

Source **:** Transporter profile

Remarks: [a] The quantity of loss and damage occur during 2009, from the transporter records

[b] Number of occurrences / 365 days

Total freight cost / 20 pallets

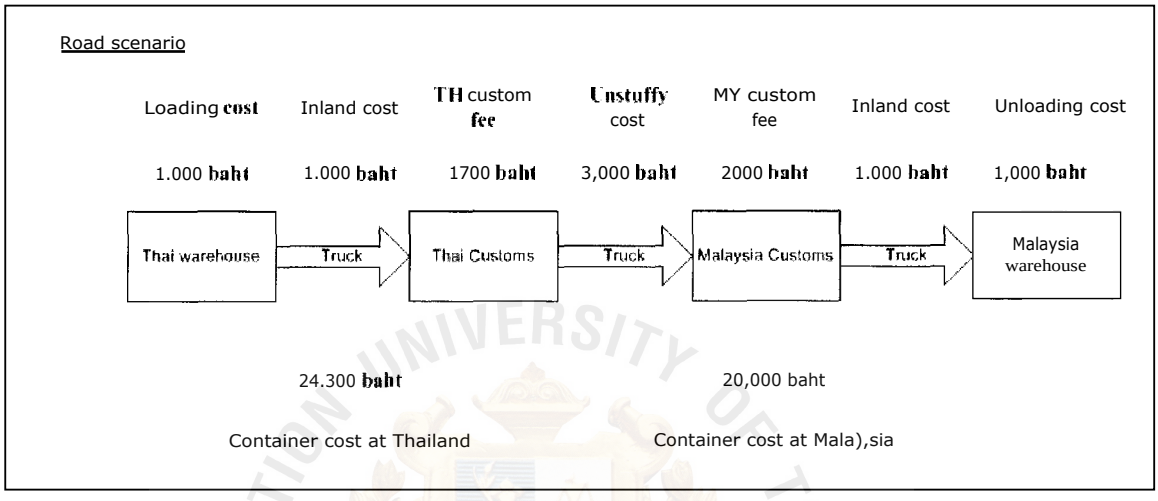
[d] Loss and damage probability (b) x cost of freight per pallet (c)

[e] Total of pallets delivered in 2009 (4,745 pallets) x cost of loss and damage per pallet

3.2.1.4 Freight rate by road is the rate charged for the movement of goods between two points (Unilever Thai and Unilever Malaysia). As shown in Figure 3.6, there are separate costs by stop point. All cost are fixed except the container rate which will

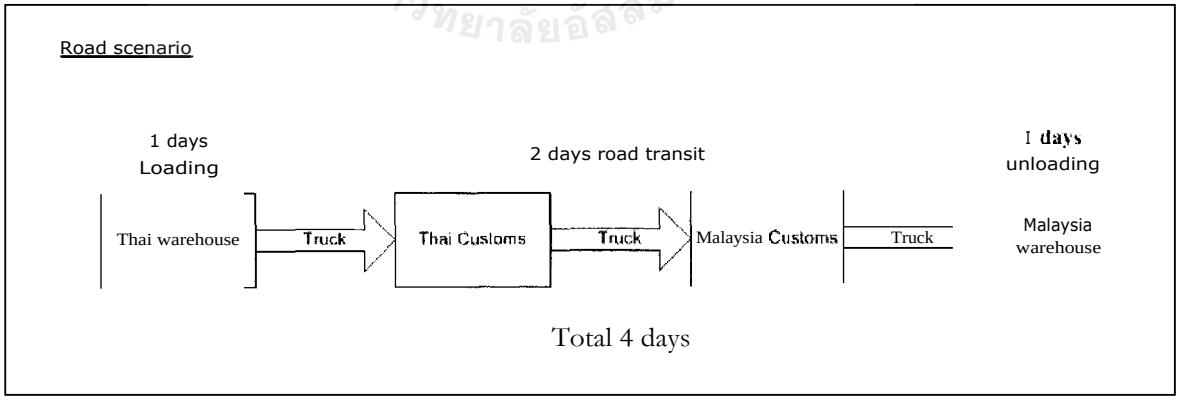
vary depending on the oil price, which the transporter shows in four ranges: 21.00 — 23.99 baht, 24.00-26.99 baht, 27.00-29.99 baht, and 30.00-32.00 baht.

Figure 3.6 Total freight cost by road mode per one container



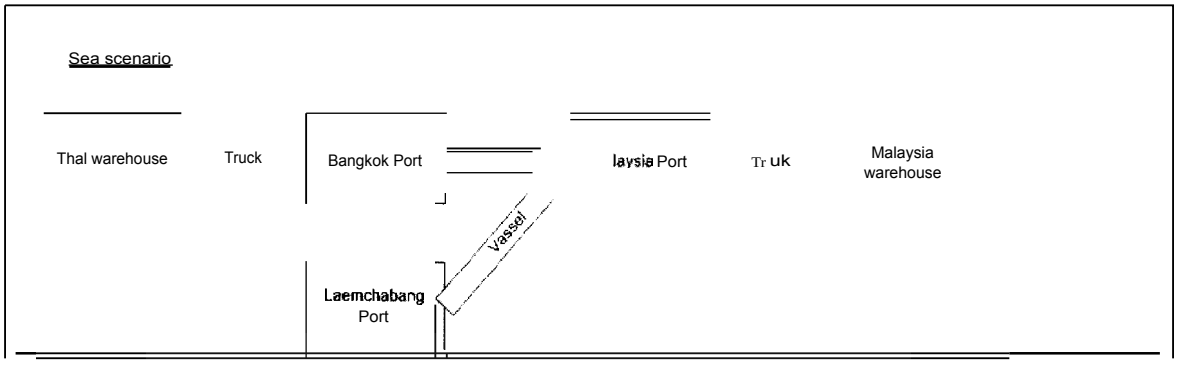

3.2.1.5 Transit times by road are short, as shown in Figure 3.7. The start is from loading 1 day, after that road transit will take 2 days(1 day in Thailand and the rest in Malaysia). Then arrival at the Malaysia warehouse that includes unloading 1 day, so the total is 4 days. Sometimes delays have already stated, and loss and damage.

Figure 3.7 Total lead time by road mode



### 3.2.2 Scenario 2: Sea transportation mode

**Figure 3.8** Sea routing




**3.2.2.1 Determine sea routing** This scenario shows the export shipment to the same destination but changing the transportation mode from truck to sea. This mode's starting point is the Thai warehouse, then loading, and delivery to the port. Normally when exporting to other countries such as Singapore, Taiwan and Australia, the export department will use both Bangkok and Laemchabang ports, so two pointsare set up in this scenario to evaluate results. After arrival at Klang port in Malaysia, trucks are used in Malaysia to deliver product to the Malaysia warehouse.

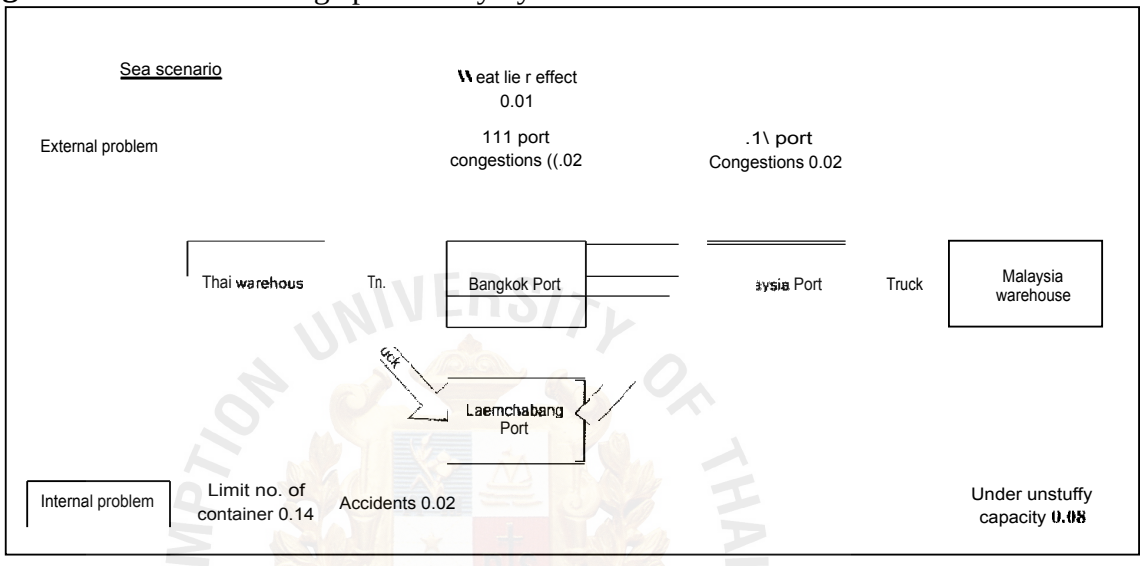
**3.2.2.2 Determine sea mode capability**

Following company practice, every year Unilever Thailand sends a forecast to the center at Singapore for shipping line bidding for the freight for the year. After the bidding result is known, the sea shipments will be the delivery mode based on bidders from the first choice until the third choice. Concerning the volume and the capacity of the sea mode, this does not make problems to find space or capacity issues.

The container sizes are the same as the truck load, which can contain twenty pallets for forty foots container. But this mode is better when the volume is not a full container load, so that they can load the products in 20' containers which contain ten pallets.

### 3.2.2.3 Determine internal and external factors and cost of loss and damage by sea mode

**Figure 3.9** Loss and damage probability by sea mode




In an in-depth interview with a shipping line sale executive, she explained the problems which affect the sea mode delivery, and the quantities occurring from past records. They occur in every working day, as show in the list below for both internal and external problems.

**Internal problems**

- Limited number of containers – during peak periods, as in prior to new year, or Chinese new year, customers need to keep the stock during the long holiday.
- Under unstuffed capacity - this problem affects customers during seasonal periods.
- Accidents – Unpredictable problem which delay customer requirement, which is because the product cannot be loaded at the port on time; each port and shipping line always set a closing time before the vessel departs.

**External problems**

- Thai port congestion – Usually occurs when nearly closing time, as the transporters hurry to unload their products. There are major differences between Bangkok port and Laemchabang port as most shipping lines prefer to

unload containers at Laemchabang port as the Bangkok port area is smaller than Laemchabang port. But Laemchabang port has a higher in-land cost which is part of the freight rate.

- Malaysia port congestion – It occurs during long holidays.
- Weather effect – As vessels can be used only when sufficient water is available. In the open sea, if freighters get into a storm, it becomes difficult to rescue them.

From the above problems, can be summarized the occurrence percentage and impact for damage and loss.

**Table 3.4** Total loss and damage cost for 2009, by sea mode

| Problem | Number of occur per year (a) | Loss and damage probability (b) | Cost of freight per pallet (c) | Cost of loss and damage per pallet (d) | Total cost of loss and damage per pallet year 2009 (e) | Impact | Damage |
|---|---|---|---|---|---|---|---|
| Limit number of container | 50 | 0.14 | 2,525 | 345.82 | 1,640,925.00 | Delay delivery | Pay Penalty cost and have to find new shipping line or new mode |
| Under unstuffy capacity | 30 | 0.08 | 2,525 | 207.49 | 984,555.00 | No impact at Unilever Thai | Pay inventory management |
| Accidents | 9 | 0.02 | 2,525 | 62.25 | 295,366.50 | Product damage | Pay Penalty cost, and reduce reliability |
| Thai Port congestion | 6 | 0.02 | 2,525 | 41.50 | 196,911.00 | Delay delivery | Pay Penalty cost |
| Malaysia Port congestion | 6 | 0.02 | 2,525 | 41.50 | 196,911.00 | Delay delivery | No damage at Unilever Thai |
| Weather effect | 2 | 0.01 | 2,525 | 13.83 | 65,637.00 | Delay delivery, product damage | waste time for claim insurance and loss sale at Unilver Malaysia |
| Total | 103 | 0.28 | | 712.39 | 3,380,305.50 | | |

Source : Transporter profile

Remarks: a The quantity of loss and damage occurring during 2009 from the transporter records

[b] Number of occurrences / 365 days

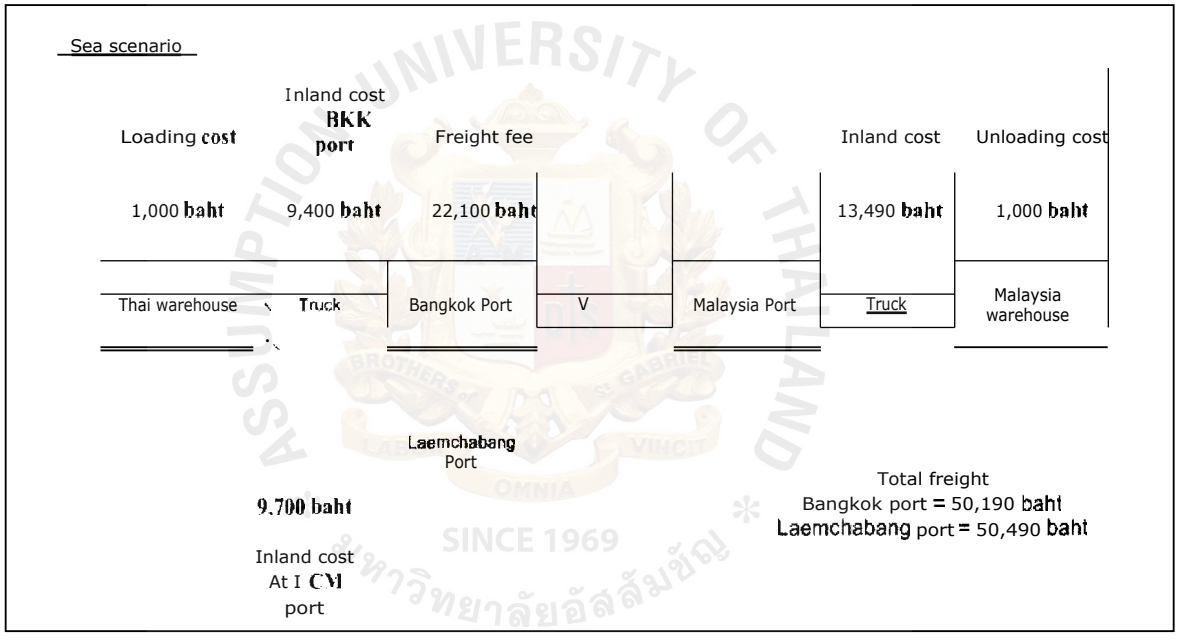
Total freight cost / 20 pallets

[d] Loss and damage probability (b) x cost of freight per pallet (c)

[e] Total of pallet delivered in 2009 (4,745 pallets) x cost of loss and damage per pallet

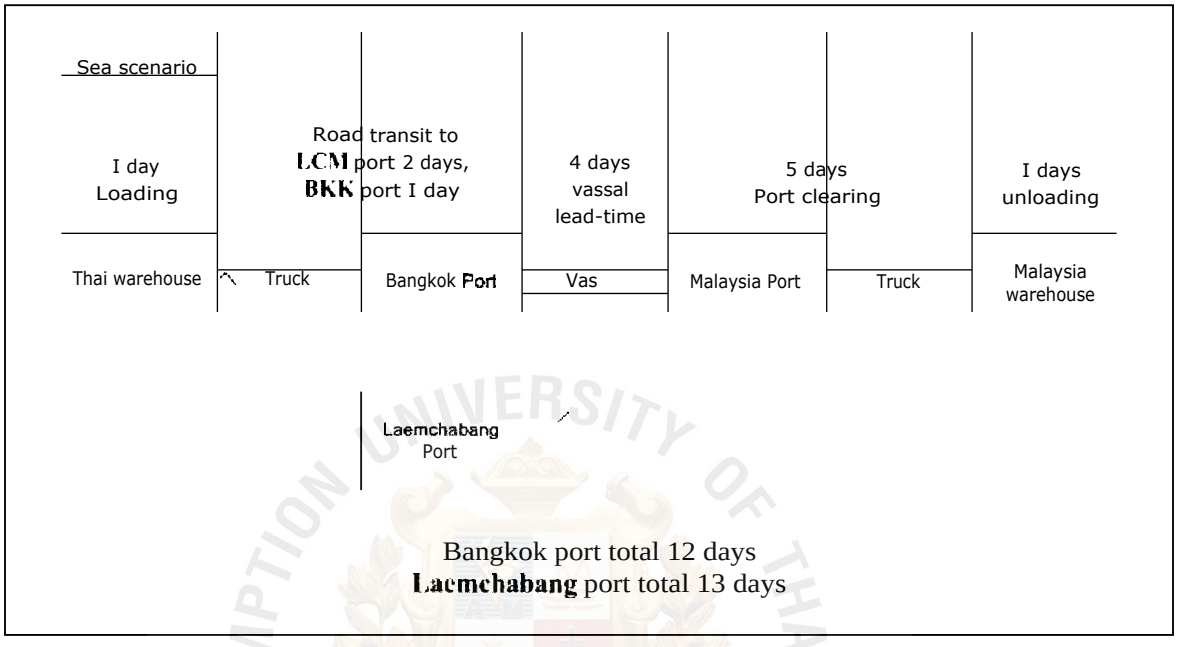
3.2.2.4 Freight rate by sea is the rate which includes a loading cost, inland cost, freight rate and inland cost, and an unloading cost in Malaysia, as shown in Figure 3.10: there are separate costs for stop points. Most costs are fixed except the inland cost rate with will vary depending on the oil price, which a transporter will update and send a new quotation every year. It not much different between the inland cost to Bangkok port and Lamchabang port, by an amount of 300 baht if compared with other factors.

Figure 3.10 Total freight cost by sea mode per one container



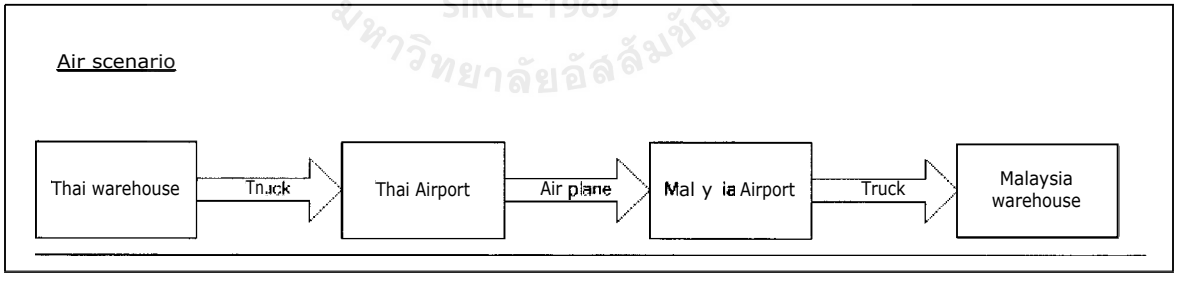

3.2.2.5 transit times by sea have the longest lead time, as shown in Figure 3.11 It will start from loading 1 day; after that the road transit will take 2 days which is the maximum days if loading at Laemchabang port. For Bangkok port the road transit is 1 day. The products are kept 4 days on the vessel before arriving at the Malaysia port. At the Malaysia port, it will take a maximum of 5 days in clearing the products. Then inland to Malaysia takes 1 day for unloading.

**Figure 3.11** Total lead time by sea mode




### 3.2.3 Scenario 3 Air transportation mode

**Figure 3.12** Air routing




**3.2.3.1 Determine Air routing** This scenario shows the shipment of exports by air mode to Malaysia. This mode had its starting point at the Thai warehouse, then loading and delivery to Suvannabhumi airport. As normally products by air mode are only for urgent use, in small quantities, they are delivered in cartons and pallets. There are freight forwarder who provide a service, to check flight schedules, freight rates, capacity, and provide export documents. On loading day the transporter will come to the Thai warehouse to pick up the product, normally using four wheel or six

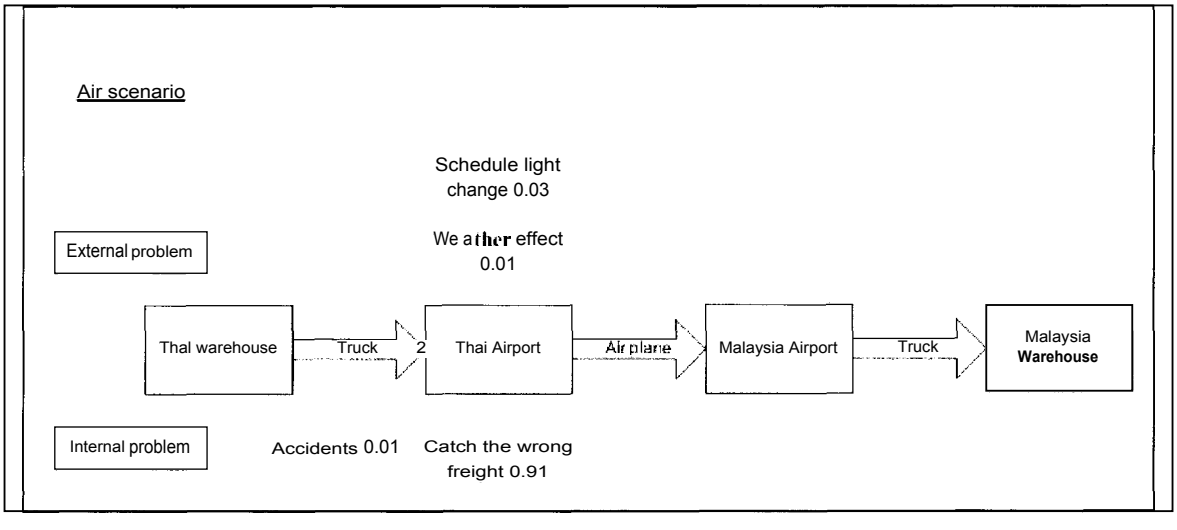
wheel cars. They will stuff the product at the airport. After that, the cargo plane departs and arrive on the same schedule as passenger air planes. Arriving at the Malaysia airport, truck will deliver products to the Malaysia warehouse.

**3.2.3.2 Determine air mode capability** Due to the high freight cost but fastest lead time, this mode will be the option that customers need for urgent products urgently. If the company needs to deliver a normal shipment to Malaysia, the volume in 2009 is shown in Table 3.1. There, a huge volume cannot be loaded onto pallets and into the container, but have to be loaded in pallet that fit with unit loads of different sizes in cargo airplanes.

In this project, full pallets are used as the smallest unit measurement, so the cost of air freight is rounded up from the cost of pallet multiplied by twenty pallets for delivery in full containers, and other modes are able to be compared. Air transportation has the advantage of being a mode which can deliver by cartons, but as it can deliver smaller quantities these are broken into cartons which other modes can hardly manage. So this project will deal only with full container (twenty pallets) measurements.

**3.2.3.3 Determine factors of internal, external and cost of loss and damage by air mode**

**Figure 3.13** Loss and damage probability by air mode



From deep interviews with the freight forwarder managers of two companies, they gave information about the problems which affect delivery by air mode, and the quantities occurring from past records: the occurrences during operation days are show in the list below, in which both internal and external problems are shown..

**Internal problems**

- Accidents – These occur in inland transport, which causes delays in freight schedules, as the products cannot be loaded at the airport on time and the products may be damage due to these accidents.
- Catch the wrong flight – This occurs when products from the same company but to different destinations, may be delivered to the wrong customer. It will take time to return the product to the right customer, which will cause delays in customer requirements.

**External problems**

- Schedule flight change – It occur because of effect of delays from the other flight, but delays are not more than a day as there are many flights from many airlines
- Weather effect – As volcanoes affected many airports in Europe, with planes not allowed to land or take off Due to this delay, the bullwhip effect operates until the manufacturer can run production due to no raw material coming infrom another country.

From the above problems, can be summarized the occurrence percentage and impact for damage and loss.

**Table 3.5** Total loss and damage cost for 2009 by air mode

| Problem | Number of occur per year (a) | Loss and damage probability (b) | Cost of freight per pallet (c) | Cost of loss and damage per pallet (d) | Total cost of loss and damage per pallet year 2009 (e) | Impact | Damage |
|---|---|---|---|---|---|---|---|
| Accidents | 5 | 0.01 | 33,553 | 459.62 | 2,180,912.50 | Product damage and delay shipment | Pay Penalty cost |
| Catch the wrong flight | 3 | 0.01 | 33,553 | 275.77 | 1,308,547.50 | Delay delivery | Reduce reliability |
| Fight delays | 10 | 0.03 | 33,553 | 919.25 | 4,361,825.00 | Delay delivery | Reduce reliability |
| Weather effect | 5 | 0.01 | 33,553 | 459.62 | 2,180,912.50 | Delay delivery | Pay Penalty cost, do not have product sale in the local Malaysia market |
| Total | 23 | 0.06 | | 2114.27 | 10,032,197.50 | | |

Source **:** Transporter profile

Remarks: [a] the quantity of loss and damage occurred during 2009 from the transporter records

b Number of occurrences / 365 days

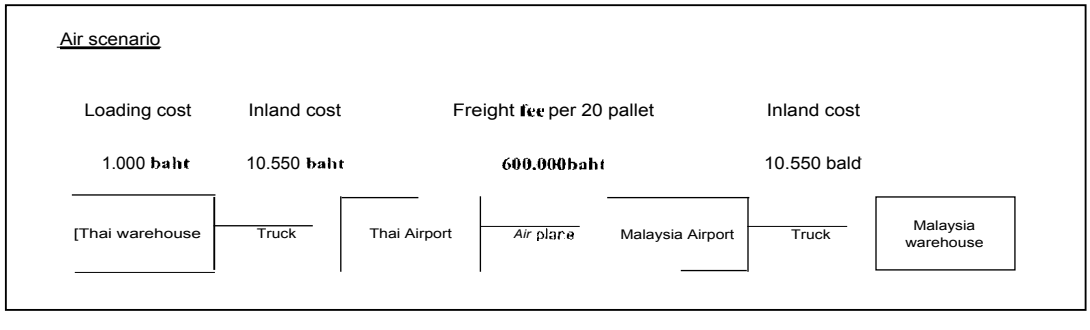
total freight cost / 20 pallets

d Loss and damage probability (b) x cost of freight per pallet (c)

[e] total of pallet delivered year 2009 (4,745 pallets) x cost of loss and damage per pallet

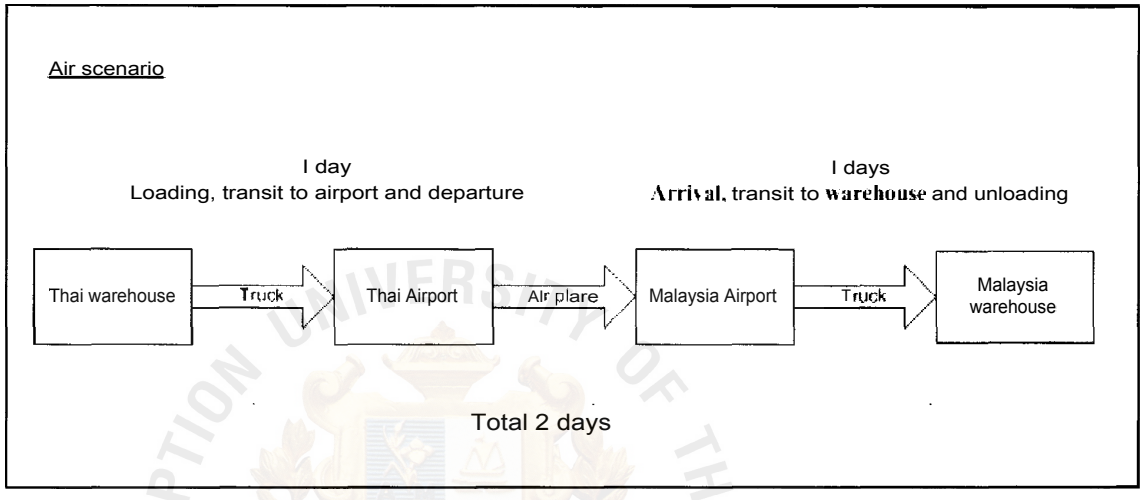
**3.2.3.4 Freight rate by air** is the rate for loading cost, inland cost, freight rate, inland cost and unloading cost at Malaysia, as shown in Figure 3.14. There are separate costs at each stop point. Due to the main concern and important information being the weight of the product, so the freight rate is the highest cost by comparison with other modes. Most costs are dependent on product weight which is a fixed cost rate in each airline. Oil price is the factor that causes air freight increases.

**Figure 3.14** Total freight cost by air mode per one container



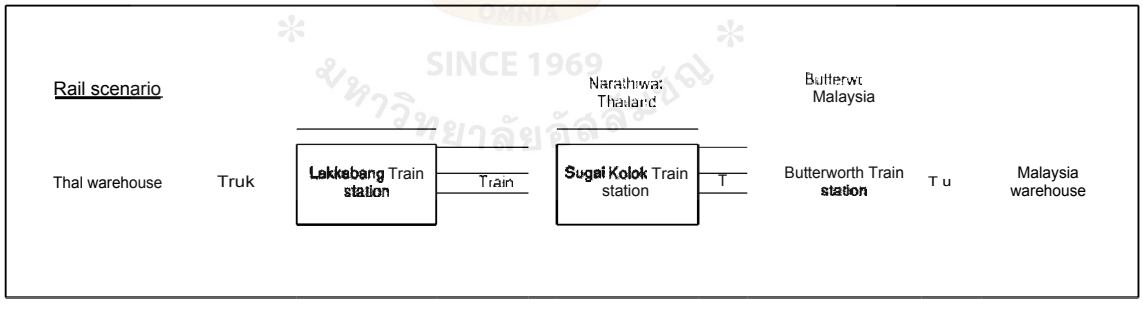
**3.2.3.5 Transit times by air** is the shortest lead time, as shown in Figure 3.15. It will start from loading, transit to airport, load to airplane and departure within 1 day. After arrival the product will be delivered to the warehouse within 1 day as well.

**Figure 3.15** Total lead time by air mode




### 3.2.4 Scenario 4: Rail transportation mode

**Figure 3.16** Rail routing

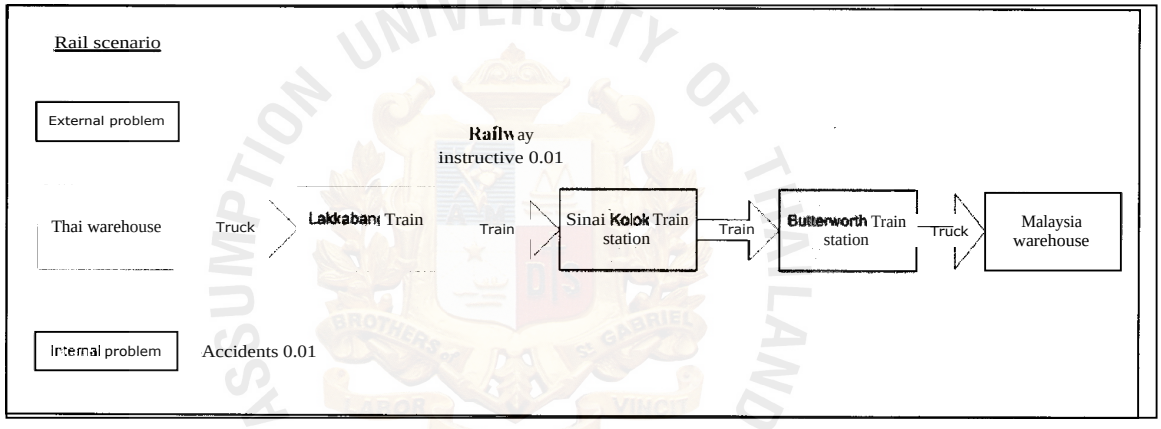



**3.2.4.1 Determine rail routing** This scenario shows the shipment of exports by rail mode to Malaysia. At present, import and exports are convenience by train between the Thai and Malaysia borders. The mode's starting point is the Thai warehouse, then loading onto trucks and delivered to Ladkabang train station. Then delivery to Sugai Kolok train station in Narathiwat province. Then change trains to the train destined for Butterworth train station in Malaysia. After that, the truck will deliver the product to the Malaysia warehouse.

**3.2.4.2 Determine rail mode capability** This rail mode can load a full container (twenty pallets) and currently the train station can load the container onto the train immediately without transferring the product between containers. The Freight forwarder manager found that the capacity per day of one train is ten containers, so compared with the volume of exports in 2009, it take time to deliver the product.

**3.2.4.3 Determine factors of internal, external and cost of loss and damage by rail mode**

**Figure 3.17** Loss and damage probability by rail mode




From a deep interview with the freight forwarder manager, he explained the problems which affect delivery by rail mode, and the quantity occurring from past records. The occurrences during operation day are show in the list below, for both internal and external problems.

**Internal problems**

- Accidents – These occur in inland transport and cause delay in shipment schedules, as the products cannot catch the train as the product cannot be loaded at the train station on time, and the product may be damaged due to this accident.

**External problems**

- Railway construction – This occurs during maintenance periods at the train station. This problem causes delay in delivery to customer requirements.

From the above problems, can be summarized the occurrence percentage and impact of the damage and loss.

**Table 3.6** Total loss and damage cost per year 2009 by rail mode

| Problem | Number of occur per year (a) | Loss and damage probability (b) | Cost of freight per pallet (c) | Cost of loss and damage per pallet (d) | Total cost of loss and damage per pallet year 2009 (e) | Impact | Damage |
|---|---|---|---|---|---|---|---|
| Accidents | 5 | 0.01 | 2,691 | 36.86 | 174,889.00 | Product damage and delay shipment | Pay Penalty cost. Reduce in reliability |
| Railway instructive | 3 | 0.01 | 2,691 | 22.11 | 104,933.40 | Delay delivery | Reduce in reliability, have to find new mode for delivery |
| Total | 8 | 0.02 | | 58.97 | 279,822.40 | | |

Source **:** Transporter profile

Remarks: a The quantity of loss and damage during 2009 from the transporter records

b Number of occurrences / 365 days

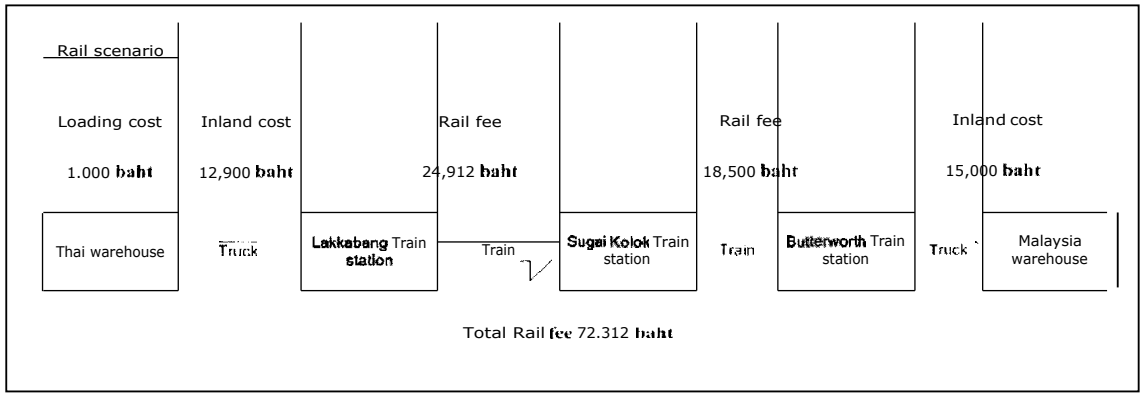
Total freight cost / 20 pallets

[d] Loss and damage probability (b) x cost of freight per pallet (c)

[e] Total of pallet delivered year 2009 (4,745 pallets) x cost of loss and damage per pallet

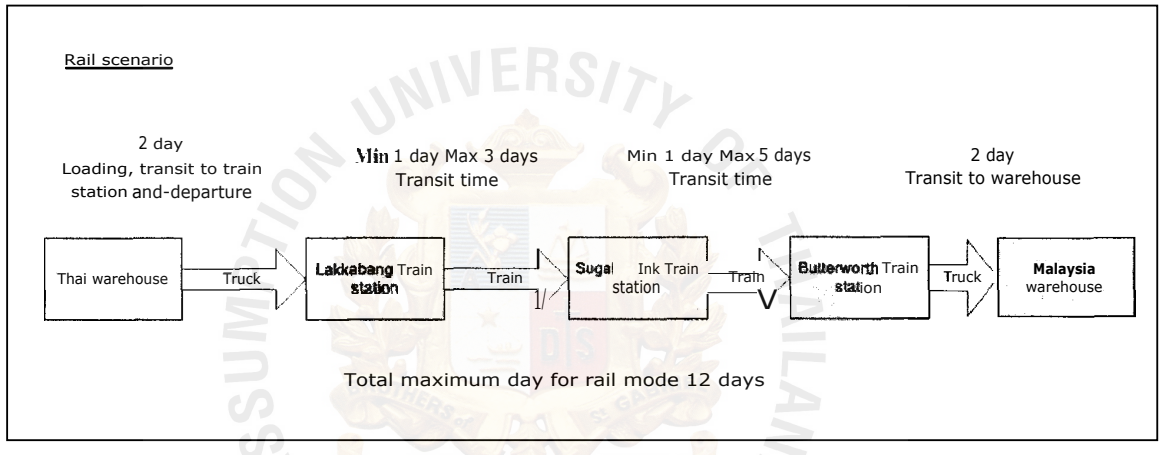
**3.2.4.4 Freight rate by rail** is the rate includingloading cost, inland cost, rail fee at Ladkabang train station, and rail fee again at Sugui Kolok train station. Then the trucks will deliver the product to the Malaysia warehouse. As shown in Figure 3.18 due to many stopping points during the rail transit mode, the rail cost are higher if compared with other mode's freight cost.

**Figure 3.18** Total freight cost by rail mode per one container



3.2.4.5 **transit time by rail** has a long lead time, as shown in Figure 3.19 It will start from loading, transit to train station by truck, load onto train, but as informed in the earlier paragraph that depends on when there is full capacity per trip, because then the train will depart, so actually the schedule departure is everyday but can be delayed by three days at Ladkabang port and 5 days at Sugui Kolok train station. So the longest lead times for rail mode are twelve days.

**Figure 3.19** Total lead time by rail mode

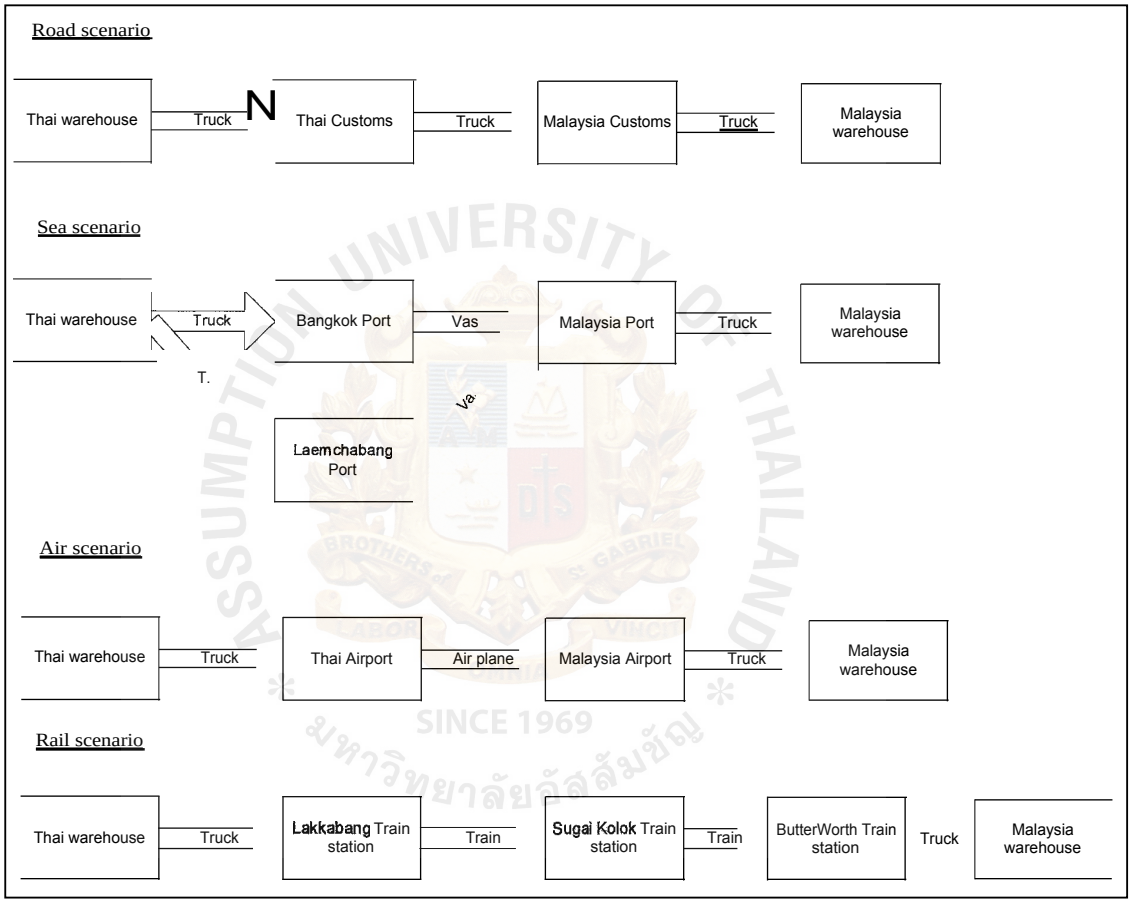


## 3.3 Summary of data collection

### 3.3.1 Routing

There routing comparison is shown for each transportation mode in Figure 3.20

**Figure 3.20** Transportation mode scenarios




There are main stopping points, as shown in Table 3.7, in which road, sea and air modes have three stop points, but rail has four stop points. The stop point will link with the lead time per mode.

**Table 3.7** Stop point for each transportation modes

| Transportation mode | Stop point | No. of stop point |
|---|---|---|
| Road | Thai customs-> Malaysia customs-> Malaysia warehouse | 3 |
| Sea | Bangkok port-> Malaysia port-> Malaysia warehouse | 3 |
| | Laemchabang port-> Malaysia port-> Malaysia warehouse | 3 |
| Air | Thai airport-> Malaysia airport-> Malaysia warehouse | 3 |
| Rail | Ladkabang train station->Sugai Kolok train station -> Butterworth train station-> Malaysia warehouse | 0 |

### 3.3.2 Capability

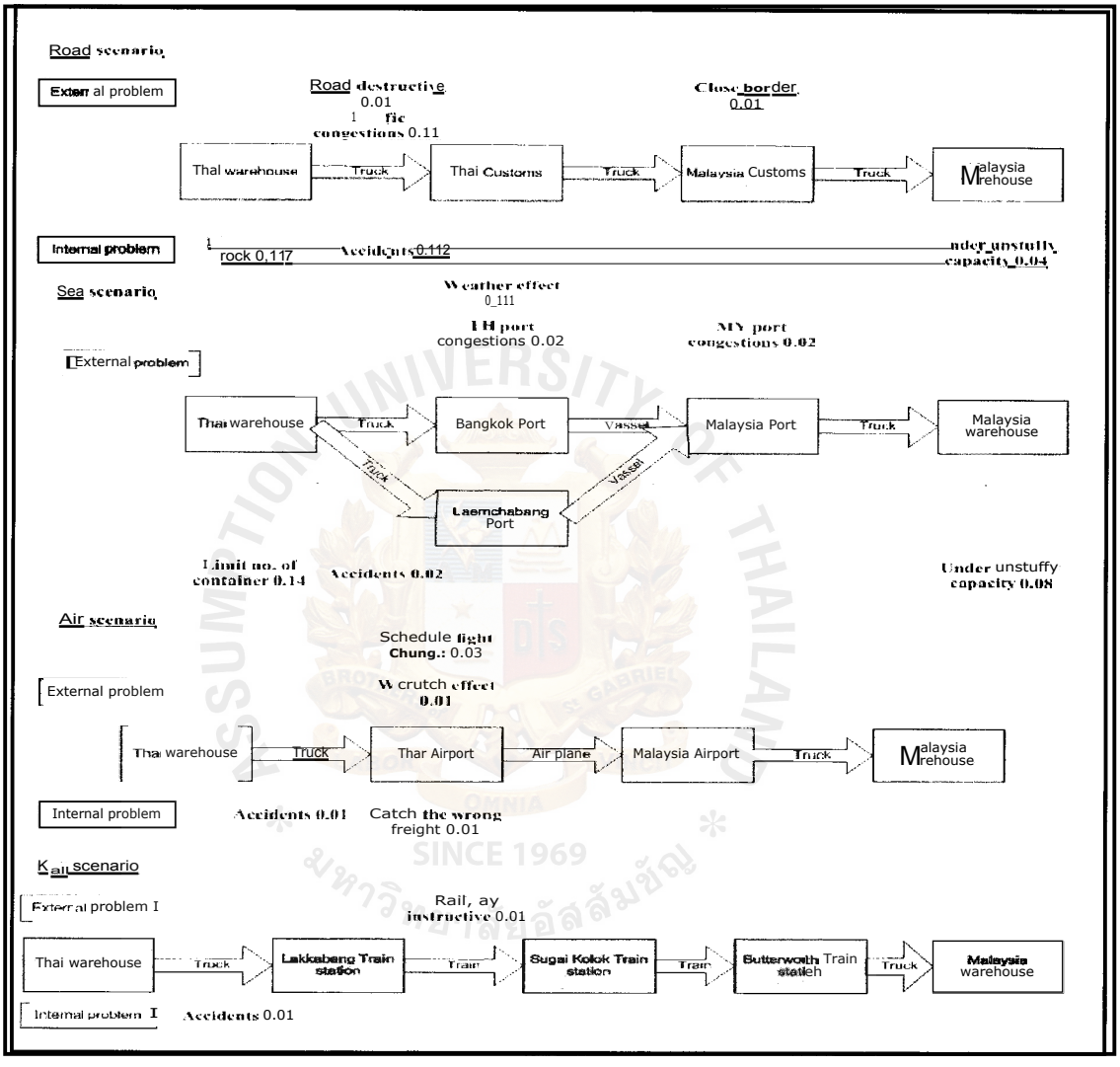
Due to capacity of road, sea and rail being based on full container load (forty foots container) with a total of twenty pallets, air mode will use only 6-wheel trucks for loading the product to the airport. After calculating the number of pallet per day, air mode can load only sixty pallets per day but other modes can load two hundred pallets per day.

**Table 3.8** Transportation mode capacity per day

| Transportation mode | Maximum capacity Container 40 FCL (Pallet) | Maximum capacity per day (container) | **Total pallet** per day |
|---|---|---|---|
| Road | 20 | 10 | 200 |
| Sea | 20 | 10 | 200 |
| Rail | 20 | 10 | 200 |
| | Truck (6 wheels) | Truck (6 wheels) | |
| Air | 6 | 10 | 60 |

### 3.3.3 Loss and damage

**Figure 3.21** Loss and damage for transportation mode




Even though loss and damage probability are not much different, as shown in Table 3.9, cost of loss and damage are totally different in air freight. This result leads from the highest freight cost of air freight.

**Table 3.9** Loss and damage percentage

| Transportation mode | Total Loss and damage probability | Total cost of loss and damage year 2009 | Percentage of loss and damage front total freight cost year 2009 |
|---|---|---|---|
| **Road** | 0.26 | 3,396,250 00 | 1.30% |
| **Sea** | 0.28 | 3,380,305.50 | 1.41% |
| **Rail** | 0.06 | 10,032,197.50 | 0.32% |
| **Air** | 0.02 | 279,822.40 | 0.08% |

**Table 3.10** Cost base activities of loss and damage

| Tranportation mode | Stop point | Activities | Loss and damage | | Solution | Cost |
|---|---|---|---|---|---|---|
| | | | External | Internal | | |
| Road | Thai warehouse | Packing | Limit number of loader | | Increase number of resource | 600 baht per container |
| | | Loading | | Limit number of truck | Booking another truck company | 1,000 baht per container |
| | | Delivery | Road destructive | | Change to sea mode | 27,000 baht per container |
| | | | Traffic congestion | | Avoid this period by loading within keine | - |
| | | | | Accidents | Re loading stock | 55,000 baht per container |
| | Thai customs | Clear export entry | Close border | | Change to sea mode advance loading | 27,000 baht per container |
| | | | Inspection and prohibited | | - | 3,000 baht per day per container |
| | Malaysia customs | Clear export entry | Close border | | Change to sea mode advance loading | 27,000 baht per container |
| | | | Inspection and prohibited | | | 3,000 baht per day per container |
| | | Change to Malaysia truck | | Damage stock during change truck | Delivery stock in next shipment | 200 baht per case |
| | | Delivery | Road destructive | | Change to sea mode | 27,000 baht per container |
| | | | Traffic congestion | | Avoid by loading within timeline | - |
| | | | Accidents | | Re loading stock | 55,000 baht per container |
| | Malaysia warehouse | Unloading | | Limit resource for unstuff | Increase number of resource | 770 baht per container |
| Sea | Thai warehouse | Packing | Limit number of loader | | Increase number of resource | 600 baht per container |
| | | Loading | | Limit number of Hualage | Booking another truck company | 500 baht per container |
| | | Delivery | Road destructive | | Change to truck mode | |
| | | | Traffic congestion | | Avoid by loading within timeline | |
| | | | | Accidents | Re loading stock | 50,490 baht per container |
| | Bangkok port | Loading | Port congestion | | Change to other port | 300 baht per container |
| | Laemchabang port | | Accidents | | Re loading stock | 50,490 baht per container |
| | Malaysia port | Unloading | Port congestion | | Change to other port | 3,000 baht per day per container |
| | | | Accidents | | Re loading stock | 50,490 baht per container |
| | | Delivery | Road destructive | | Avoid and change route | 3,000 baht per day per container |
| | | | Traffic congestion | | Avoid by loading within timeline | - |
| | | | Accidents | | Re loading stock | 50,490 baht per container |
| | Malaysia warehouse | Unloading | | Limit resource for unstuff | Increase number of resource | 770 baht per container |
| Air | Thai warehouse | Packing | Limit number of loader | | Increase number of resource | 600 baht per container |
| | | Delivery | Road destructive | | Change to truck mode | - |
| | | | Traffic congestion | | Avoid by loading within timeline | |
| | | | | Accidents | Re loading stock | 622,100 baht per container |
| | Thai Airport | Loading | Schedule flight change | | Find new flight schedule | 3,000 baht per day per container |
| | | | Weather effect | | Change to truck mode | 3,000 baht per day per container |
| | | | | Catch the wrong flight | Return stock back | 1,244,200 baht per container |
| | Malaysia Airport | Delivery | Road destructive | | Avoid and change route | 3,000 baht per day per container |
| | | | Traffic congestion | | Change to truck mode | |
| | | | Accidents | | Avoid by loading within timeline | |
| | Malaysia warehouse | Unloading | | Limit resource for unstuff | Increase number of resource | 770 baht per container |
| Rail | Thai warehouse | Packing | Limit number of loader | | Increase number of resource | 600 baht per container |
| | | Loading | | Limit number of Hualage | Booking another truck company | 1,000 baht per container |
| | | Delivery | Road destructive | | Change to truck mode | |
| | | | Traffic congestion | | Avoid by loading within timeline | |
| | | | | Accidents | Re loading stock | 622,100 baht per container |
| | Lakkabang train station | Loading | Capacity not reach | | Change to truck mode | |
| | | | Schedule flight change | | Change to truck mode | - |
| | | Delivery | Railway destructive | | Change to truck mode | - |
| | Sugai Kolok train statio | Loading | Capacity not reach | | Wait until reach train capacity | 3,000 baht per day per container |
| | | | Schedule flight change | | Wait until reach train capacity | 3,000 baht per day per container |
| | | Delivery | Railway destructive | | Wait until reach train capacity | 3,000 baht per day per container |
| | Butterworth train station | Loading | Capacity not reach | | Wait until reach train capacity | 3,000 baht per day per container |
| | | | Schedule flight change | | Wait until reach train capacity | 3,000 baht per day per container |
| | | Delivery | Railway destructive | | Change to truck mode | - |
| | Malaysia warehouse | Unloading | | Limit resource for unstuff | Increase number of resource | 770 baht per container |

Source: Company and transporter profile

Table 3.10 explains loss and damage by activities that occur at each stop point which will have a cost or not, and the way to solve the loss and damage issue from each transporter.

### 3.3.4 Freight rate

**Figure 3.22** Freight rate for transportation mode

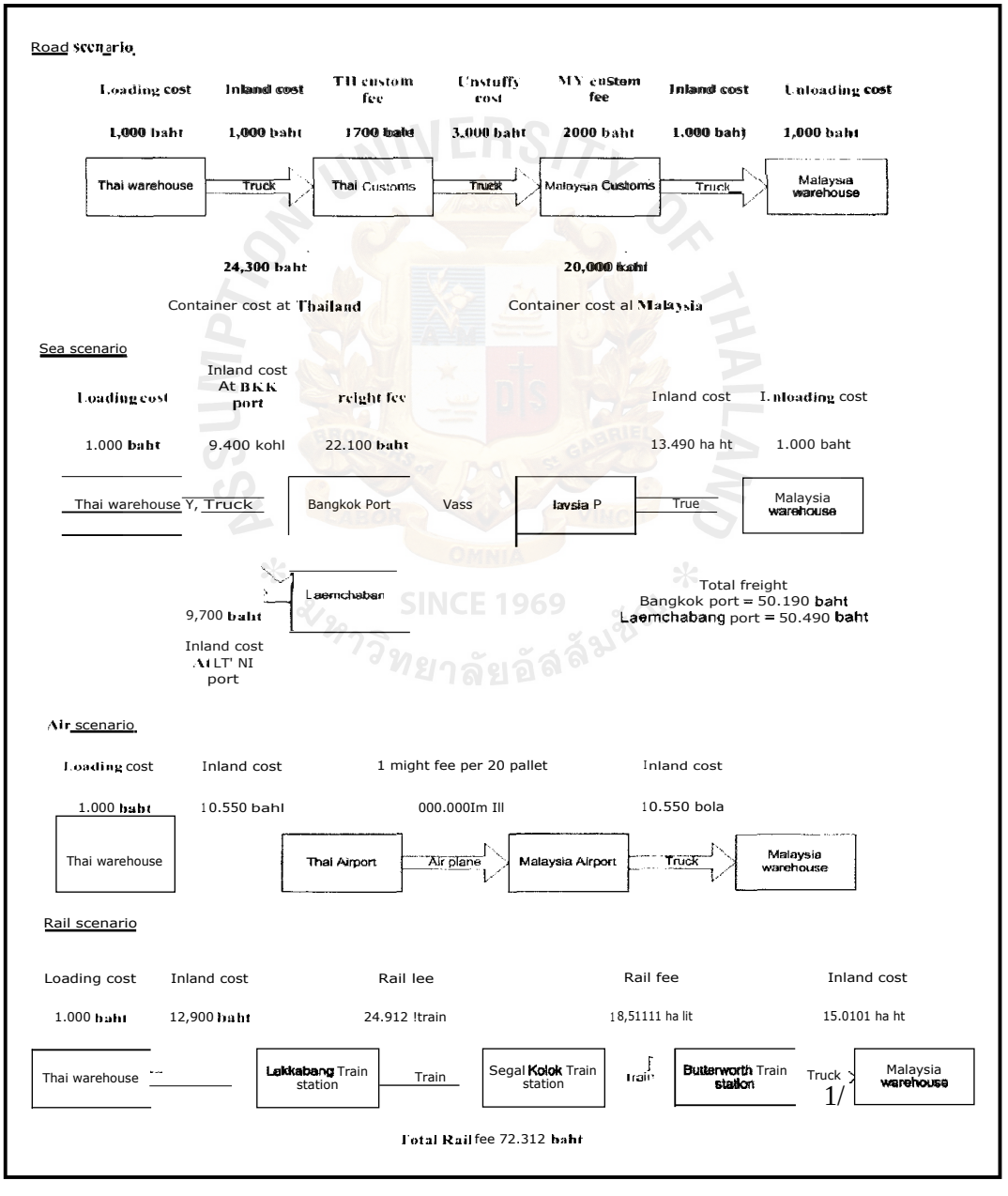


Table 3.11 indicates that road, sea, rail are significantly at the same level, but air mode is very high but this is accompanied by the shortest lead time.

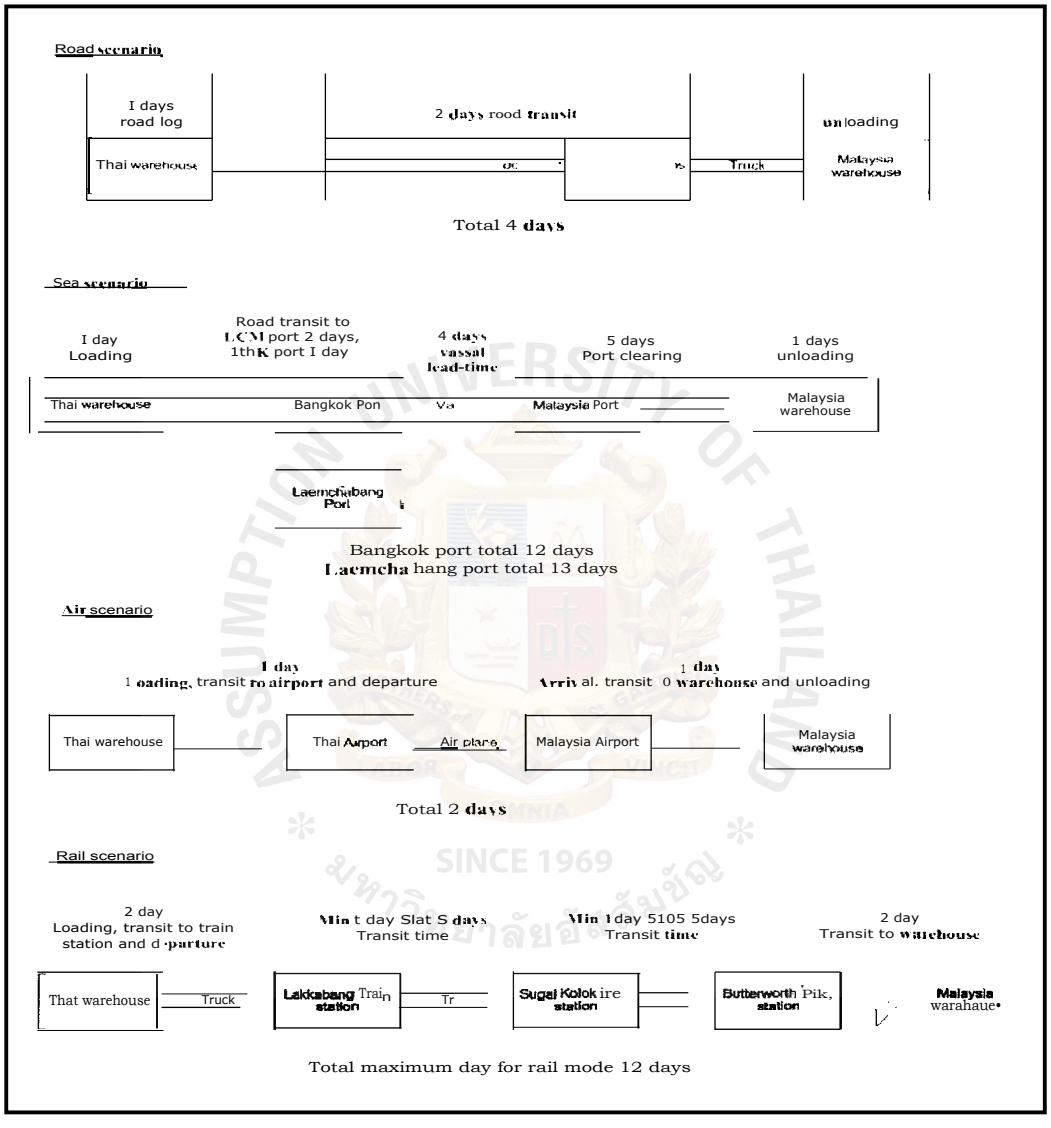
**Table 3.11** Total transportation cost

| Description | Road | Sea | Air | Rail |
|---|---|---|---|---|
| Container 20 pallets* | | | | |
| | | | | |
| Loading cost | 1,000 | 1,000 | 1,000 | 1,000 |
| In land cost - warehouse to port | 1,000 | (Bangkok port) 9,400 | 10,550 | 12,900 |
| | | (Laemchabang port) 9,700 | | |
| shipping expense | | 3,200 | | |
| TH customs fee | 1,700 | | | |
| Unstuffy cost at MY customs | 3,000 | | | |
| MY customs fee | 2,000 | | | |
| In land cost - port to warehouse | 1,000 | 13,490 | 10,550 | 15,000 |
| Unloading cost | 1,000 | 1,000 | | |
| Freight cost at Thailand | 24,300 | 22,100 | 600,000 | 24,912 |
| Freight cost at Malaysia | 20,000 | | | 18,500 |
| | | | | |
| **Total** freight rate | 55.000 | 50,490 | 02.100 | 72.312 |

Source : Transporter profile

### 3.3.5 Freight time

**Figure 3.23** Freight time for transportation modes




As lead times for all transportation modes are concerned with other factors above. Air mode lead time is only 2 days which can meet urgent requirements form customers. Even though sea and rail lead time are the same levels, this comparison found that trucks have a reasonable cost together with a better lead time, close to air mode.

**Table 3.12** Lead time per transportation mode

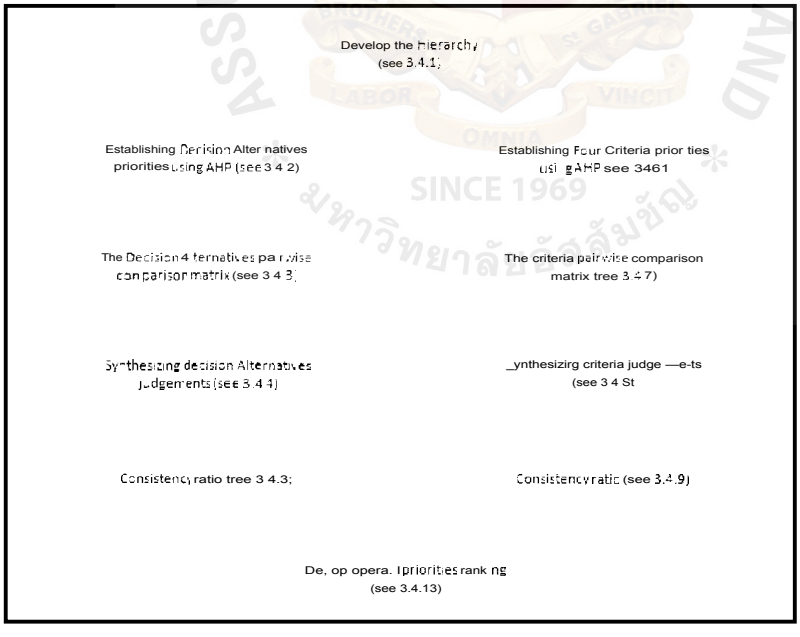
| Transportation mode | Total leadtime (day) |
|---|---|
| Road | 4 |
| Sea - bangkok port | 12 |
| Sea - Laemchabang port | 13 |
| Rail | 12 |
| Air | 2 |

The data collection above is still not sufficient to make decisions about transportation modes, so this project applies AHP decision making to choose a mode of transportation of exports to Malaysia.

### 3.4 AHP methodology step by step

Figure 3.24 is the step by step plan. for AHP, to better understand what happens at each step.

**Figure 3.24** AHP computation process

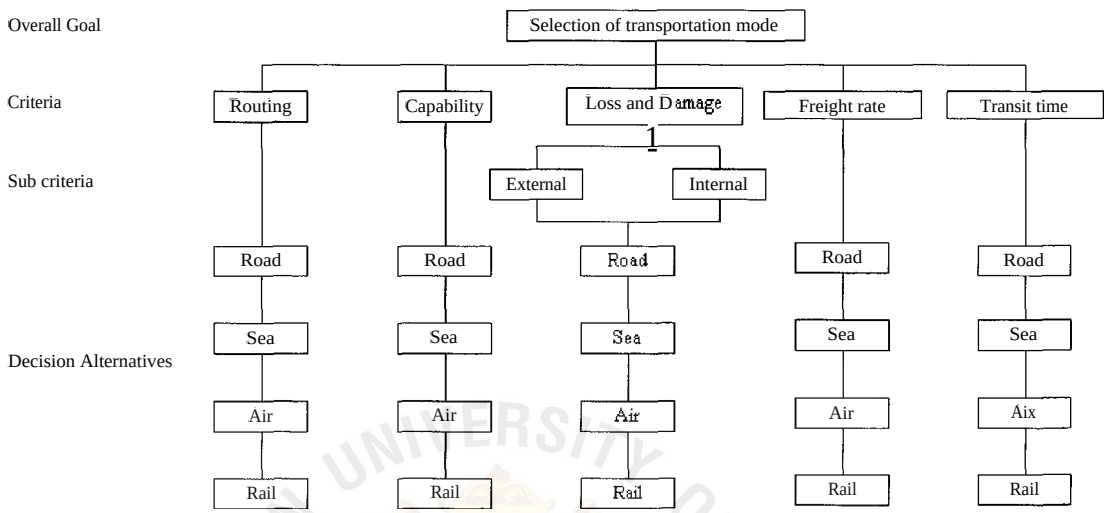



Source : Adapted from Anderson (1941)

#### 3.4.1 Developing the Hierarchy

Provide a hierarchy for Overall goal, Criteria, Sub criteria, Decision Alternatives, in which each level contributes to the upper level, as shown in Figure 3.25

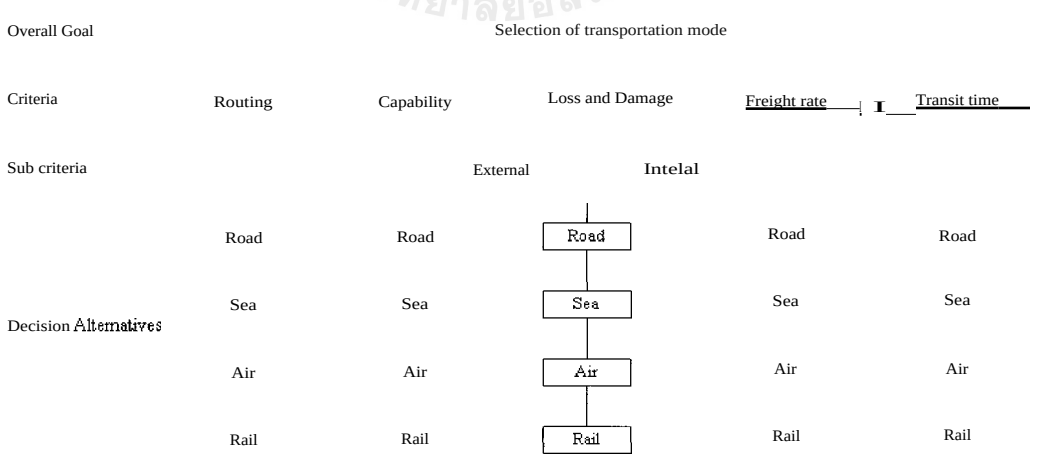
**Figure 3.25** Hierarchy level of decision making for using AHP




### 3.4.2 Establish Decision Alternative Priorities Using AHP

Choose one criteria to compute a decision alternatives pairwise comparison matrix, synthesizing decision alternatives until the computation of the consistency ratio. When computed until the consistency ratio, then compute for other criteria for comparison, as shown in Figure 3.26

**Figure 3.26** Priorities of transportation under routing criteria



3.4.3 Decision Alternatives **Pairwise** Comparison Matrix

Table 3.13 Transportation mode alternatives pairwise comparison matrix with respect to routing criteria

| Routing | Road | Sea | Air | Rail |
|---|---|---|---|---|
| Road | 1 | 3 | 2 | 4 |
| Sea | 113 | 1 | 2 | 4 |
| Air | 1/2 | 1/2 | 1 | 4 |
| Rail | 1/4 | 1/4 | 1/4 | 1 |

As shown in Table 3.13, to priorities transportation mode, matrices are prepared for each transportation mode is and compared against other. This scale came from brainstorming and the rating between official having transportation responsibilities. If road mode is moderately important compared to sea mode (i.e. a value of "3"), then sea mode has a value of 1/3 compared to road mode. So for each comparative score given, the reciprocal is awarded to the opposite relationship. Normally the comparison will start from the upper left corner to the lower right corner.

3.4.4 Synthesizing Decision Alternatives Judgments

Step 1 Sum the value in each column of pairwise comparison matrix

| Routing | Road | Sea | Air | Rail |
|---|---|---|---|---|
| Road | 1.0000 | 3.0000 | 2.0000 | 4.0000 |
| Sea | 0.3333 | 1.0000 | 2.0000 | 4.0000 |
| Air | 0.5000 | 0.5000 | 1.0000 | 4.0000 |
| Rail | 0.2500 | 0.2500 | 0.2500 | 1.0000 |
| Total | **2.0833** | **4.7500** | **52500** | **13.0000** |

Step 2 Divide each criteria in the pairwise comparison matrix to total equal to one.

| Routing | Road | Sea | Air | Rail |
|---|---|---|---|---|
| Road | 0.4500 | 0.6316 | 0.3810 | 0.3077 |
| Sea | 0.1600 | 0.2105 | 0.3810 | 0.3077 |
| Air | 0.2400 | 0.1053 | 0.1905 | 0.3077 |
| Rail | 0.1200 | 0.0526 | 0.0476 | 0.0769 |
| Total | **1.0000** | **1.0000** | **1.0000** | **1.0000** |

Step 3 To compute the average of the elements in each row of the normalized matrix. This average is an estimate of the relative priorities of the elements being compared. The highest total score is the preferred alternative.

| Routing | Road | Sea | Air | Rail | Row average |
|---|---|---|---|---|---|
| Road | 0.4800 | 0.6316 | 0.3810 | 0.3077 | **0A501** |
| Sea | 0.1600 | 0.2105 | 0.3810 | 0.3077 | **0.2648** |
| Air | 0.2400 | 0.1053 | 0.1905 | 0.3077 | **0.2109** |
| Rail | 0.1200 | 0.0526 | 0.0476 | 0.0769 | **0.0743** |
| Total | 1.0000 | 1.0000 | 1.0000 | 1.0000 | **1.0000** |

The Priority vector is the normalized principal Eigen Vector which shows the relative weights among criteria that are compared.

From the average row it can be found that the most preferred transportation mode is road mode (45.01%) followed by sea mode (26.48%), air mode (21.09%) and rail mode (7.43%).

### 3.4.5 Consistency Ratio for Decision Alternatives

There is unperfected consistency achieved in the set of pairwise comparisons. To handle this issue, AHP helps in measuring the pairwise judgments by establishing priorities. If the degree of consistency is acceptable then the decision can continue. On the other hand, if unacceptable, the decision makers have to reconsider and revise the pairwise comparison before proceeding to analyze.

There are 5 steps for providing the consistency ratio

Step 1 Multiply each element of pairwise comparison matrix with priority vector of each element. Sum the values across the rows to obtain a vector of values labeled weighted sum.

$$0.4501\begin{vmatrix}1.0000\\0.3333\\0.5000\\0.2500\end{vmatrix}+0.2648\begin{vmatrix}3.0000\\1.0000\\0.5000\\0.2500\end{vmatrix}+0.210\begin{vmatrix}2.0000\\2.0000\\1.0000\\0.2500\end{vmatrix}+0.0743\begin{vmatrix}4.0000\\4.0000\\4.0000\\1.0000\end{vmatrix}$$

$$\begin{vmatrix} 0.4501 \\ 0.1500 \\ 0.2250 \\ 0.1125 \end{vmatrix} \quad \begin{vmatrix} 0.7944 \\ 0.2648 \\ 0.1324 \\ 0.0662 \end{vmatrix} \quad \begin{vmatrix} 0.4217 \\ 0.4217 \\ 0.2109 \\ 0.0527 \end{vmatrix} \quad \begin{vmatrix} 0.2972 \\ 0.2972 \\ 0.2972 \\ 0.0743 \end{vmatrix} \quad \begin{vmatrix} 1.9633 \\ 1.1337 \\ 0.8655 \\ 0.3057 \end{vmatrix}$$

Step 2 Divide the elements from the weight sum from step 1 by priorities vectors

$$\begin{bmatrix} 1.9633 \\ \overline{0.4501} \end{bmatrix} = 4.3624$$

$$\begin{bmatrix} 1.1337 \\ \overline{0.2648} \end{bmatrix} = 4.2815$$

$$\begin{bmatrix} 0.8655 \\ \overline{0.2109} \end{bmatrix} = 4.1045$$

$$\begin{bmatrix} 0.3057 \\ \overline{0.0743} \end{bmatrix} = 4.1150$$

Step 3 Compute the average of the values

$$\lambda_{max} = \frac{4.3624 + 4.2815 + 4.1045 + 4.1150}{4} = 4.2158$$

Step 4 Compute the consistency index (CI), which is defined as

$$CI = \frac{\lambda_{max} - n}{n - 1} \qquad \text{----------Eq. (3.1)}$$

Where $n$= number of items being compared

$$CI = \frac{4.2158 - 4}{3} = 0.0719$$

Step 5 Compute the consistency ratio (CR), which is defined as

$$CR = \frac{CI}{RI} \qquad \text{----------Eq. (3.2)}$$

Due to RI being the random index which is the consistency index of a randomly generated pairwise comparison matrix referred to in Table 2.3, so for transportation mode selection with $n = 4$ and RI = 0.90, the consistency ratio will be:

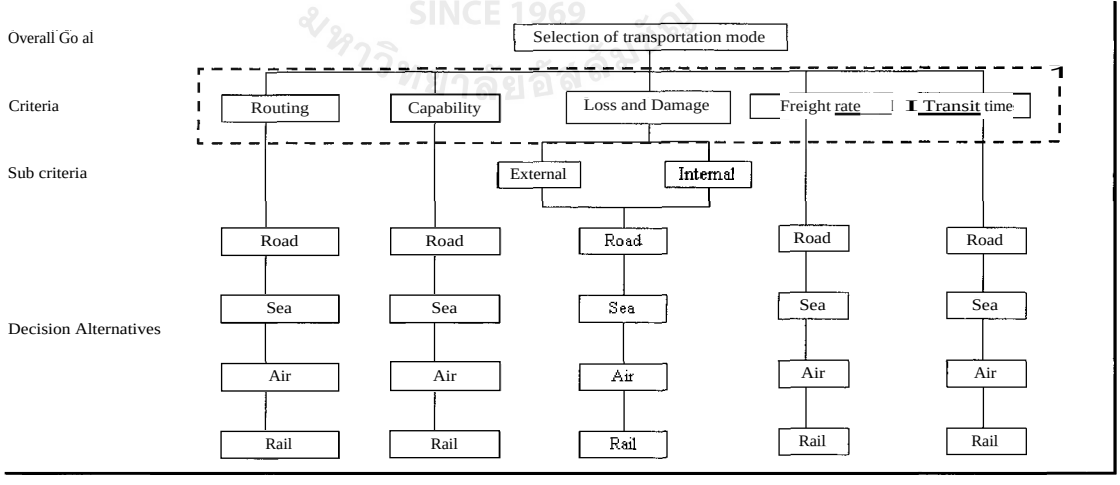
$$CR - \frac{0.0719}{0.9000} = 0.0799$$

A consistency ratio of 0.1 or less is considered acceptable. The project here shows a consistency ratio of 0.0799, therefore the degree of consistency in the pairwise matrix for routing criteria is acceptable.

Continue following the same synthesis and consistency ratio step that was used for routing criteria of transportation mode selection, to determine transportation mode with respect to capability, loss and damage, freight rate and transit time criteria.

### 3.4.6 Establishing four criteria priorities using AHP

**Figure 3.27** Priorities routing, capability, loss and damage, freight rate and transit time




Provide the same synthesizing process and consistency ratio step for four criteria in terms of importance of routing, capability, loss and damage, freight rate and transit time for contributing to the overall goal of selection of a transportation mode.

### 3.4.7 The criteria pairwise comparison matrix

**Table 3.14** Criteria pairwise comparison matrix

| Criteria | Routing | Capability | Loss and Damage | Freight rate | Transit time |
|---|---|---|---|---|---|
| Routing | [illegible] | 1/2 | 1/4 | 1/4 | 1/3 |
| Cap ability | 2 | 1 | 1/4 | 1/4 | 1/3 |
| Loss and Damage | 4 | 4 | 1 | 1/3 | 1/2 |
| Freight rate | 4 | 4 | 3 | 1 | 1 |
| Transit time | 3 | 3 | 2 | 1 | 1 |

### 3.4.8 Synthesizing criteria judgments

Step 1 Sum the values in each column of pairwise comparison matrix

| Routing | Routing | Capability | Loss and Damage | Freight rate | Transit time |
|---|---|---|---|---|---|
| Routing | 1.0000 | 0.5000 | 0.2500 | 0.2500 | 0.3333 |
| Capability | 2.0000 | 1.0000 | 0.2500 | 0.2500 | 0.3333 |
| Loss and Damage | 4.0000 | 4.0000 | 1.0000 | 0.3333 | 0.5000 |
| Freight rate | 4.0000 | 4.0000 | 3.0000 | 1.0000 | 1.0000 |
| Transit time | 3.0000 | 3.0000 | 2.0000 | 1.0000 | 1.0000 |
| Total | **14.0000** | **125000** | **65000** | **2.8333** | **3.1667** |

Step 2 Divide each criteria in the pairwise comparison matrix to total equal to one.

| Routing | Routing | Capability | Loss and Damage | Freight rate | Transit time |
|---|---|---|---|---|---|
| Routing | 0.0714 | 0.0400 | 0.0385 | 0.0882 | 0.1053 |
| Cap ability | 0.1429 | 0.0800 | 0.0385 | 0.0882 | 0.1053 |
| Loss and Damage | 0.2857 | 0.3200 | 0.1538 | 0.1176 | 0.1579 |
| Freight rate | 0.2857 | 0.3200 | 0.4615 | 0.3529 | 0.3158 |
| Transit time | 0.2143 | 0.2400 | 0.3077 | 0.3529 | 0.3158 |
| Total | **1.0000** | **1.0000** | **1.0000** | **1.0000** | **1.0000** |

Step 3 To compute the average of the elements in each row of the normalized matrix. This average is for estimating the relative priorities of the elements being compared. The highest total score is the preferred criterion.

| Routing | Routing | Capability | Loss and Damage | Freight rate | Transit time | Row average |
|---|---|---|---|---|---|---|
| Routing | 0.0714 | 0.0400 | 0.0305 | 0.0882 | 0.1053 | 0.0687 |
| Capability | 0.1429 | 0.0800 | 0.0385 | 0.0882 | 0.1053 | 0.0910 |
| Loss and Damage | 0.2857 | 0.3200 | 0.1538 | 0.1176 | 0.1579 | 02070 |
| Freight rate | 0.2857 | 03200 | 0.4615 | 03529 | 0.3158 | 03472 |
| Transit time | 0.2143 | 02400 | 03077 | 03529 | 0.3158 | 0.2861 |
| Total | 111000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 |

The Priority vector is the normalized principal which shows the relative weights among criteria that are compared

The average row found that the most preferred transportation mode is Freight rate (34.72%) followed by Transit time (28.61%), Loss and damage (20.70%), capability (9.10%) and Routing (6.87%).

### 3.4.9 Consistency ratio for criteria

There are 5 steps to provide consistency ratio

Step 1 Multiply each element of pairwise comparison matrix with priority vector of each element. Sum the values across the rows to obtain a vector of values labeled weighted sum.

$$0.0687\begin{vmatrix}1.0000\\2.0000\\4.0000\\4.0000\\3.0000\end{vmatrix}\quad 0.0910\begin{vmatrix}0.5000\\1.0000\\4.0000\\4.0000\\3.0000\end{vmatrix}\quad 0.2070\begin{vmatrix}0.2500\\0.2500\\1.0000\\3.0000\\2.0000\end{vmatrix}\quad 0.3472\begin{vmatrix}0.2500\\0.2500\\0.3333\\1.0000\\1.0000\end{vmatrix}\quad 0.2861\begin{vmatrix}0.3333\\0.3333\\0.5000\\1.0000\\1.0000\end{vmatrix}$$

$$\begin{vmatrix}0.0687\\0.1374\\0.2747\\0.2747\\0.2060\end{vmatrix}\quad\begin{vmatrix}0.0455\\0.0910\\0.3639\\0.3639\\0.2729\end{vmatrix}\quad\begin{vmatrix}0.0518\\0.0518\\0.2070\\0.6211\\0.4140\end{vmatrix}\quad\begin{vmatrix}0.0868\\0.0868\\0.1157\\0.3472\\0.3472\end{vmatrix}\quad\begin{vmatrix}0.0954\\0.0954\\0.1431\\0.2861\\0.2861\end{vmatrix}\quad\begin{vmatrix}0.3481\\0.4623\\1.1044\\1.8930\\1.5263\end{vmatrix}$$

Step 2 Divide the elements from weight sum from step 1 by priorities vectors

$$\left[\frac{0.3481}{0.0687}\right] = 5.0685$$

$$\left|\frac{0.4623}{0.0910}\right| = 5.0818$$

$$\left|\frac{1.1044}{0.2070}\right| = 5.3347$$

$$\left[\frac{1.8930}{0.3472}\right] = 5.4521$$

$$\left[\frac{1.5263}{0.2861}\right] = 5.3341$$

Step 3 Compute the average of the values

$$\lambda_{max} = \frac{5.0685 + 5.0818 + 5.3347 + 5.4521 + 5.3341}{5} = 5.2542$$

Step 4 Compute the consistency index (CI), which is defined as

$$CI = \frac{\lambda_{max} - n}{n-1} \quad \text{----------Eq. (3.1)}$$

Where $n$ = number of items being compared

$$CI = \frac{5.2542 - 5}{4} = 0.0635$$

Step 5 Compute the consistency ratio (CR), which is defined as

$$CR = \frac{CI}{RI} \quad \text{----------Eq. (3.2)}$$

Due to RI being the random index, which is the consistency index of a randomly generated pairwise comparison matrix referred to in Table 2.3, so transportation mode selection with $n$ = 5 and RI = 1.12, the consistency ratio will be:

$$CR = \frac{0.0635}{1.1200} = 0.0567$$

A consistency ratio of 0.1 or less is considered acceptable. The project here shows a consistency ratio of 0.0567, therefore the degree of consistency in the pairwise matrix for routing criteria is acceptable.

### 3.4.10 Develop overall priority ranking

This Step will show how to combine the priorities of each decision alternative criteria priorities to develop an overall priority ranking of decision alternatives. The overall

priority of each decision alternative is obtained by summing the criterion priority and decision alternative.

Therefore,

Overall Road mode priority

= 0.3481(0.4501) + 0.4623(Road mode with respect to Capability) + 1.1044(Road mode with respect to Loss and damage) + 1.8930(Road mode with respect to Freight rate) + 1.5263(Road mode with respect to Transit time)

Overall Sea mode priority

= 0.3481(0.2648) + 0.4623(Sea mode with respect to Capability) + 1.1044(Sea mode with respect to Loss and damage) + 1.8930(Sea mode with respect to Freight rate) + 1.5263(Sea mode with respect to Transit time)

Overall Air mode priority

= 0.3481(0.2109) + 0.4623(Air mode with respect to Capability) + 1.1044(Air mode with respect to Loss and damage) + 1.8930(Air mode with respect to Freight rate) + 1.5263(Air mode with respect to Transit time)

Overall Rail mode priority

= 0.3481(0.0743) + 0.4623(Rail mode with respect to Capability) + 1.1044(Rail mode with respect to Loss and damage) + 1.8930(Rail mode with respect to Freight rate) + 1.5263(Rail mode with respect to Transit time)

The highest priority ranking values is the best alternative based on AHP analysis.

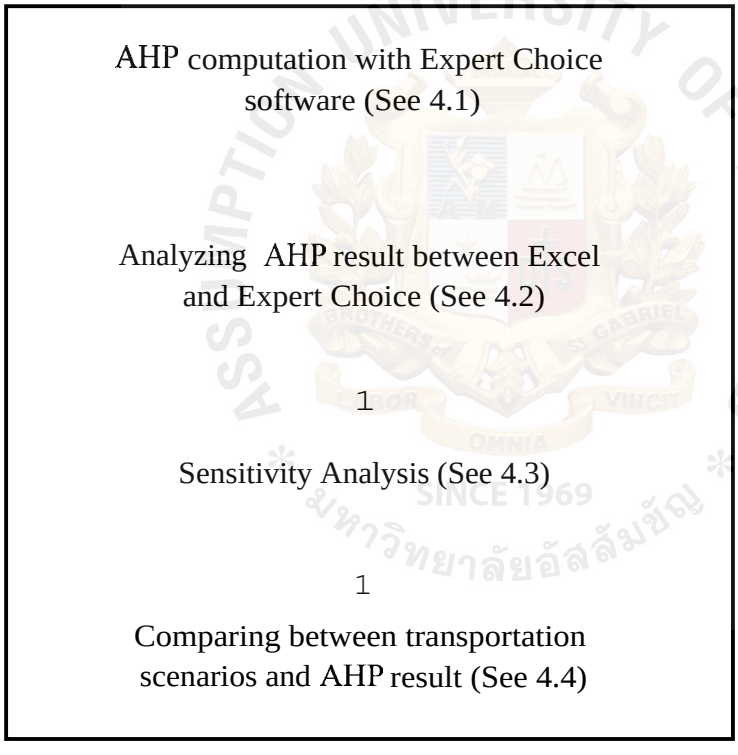
# CHAPTER IV

## PRESENTATION OF DATA AND CRITICAL DISCUSSION OF RESULTS

In this chapter we will go through the steps used to select the right transportation mode. We also analyze the criteria which will affect the decision making for exporting consumer products to Malaysia.

The following Figure 4.1 presents the steps to identify the result and analysis.

**Figure 4.1** Results and Analysis Process

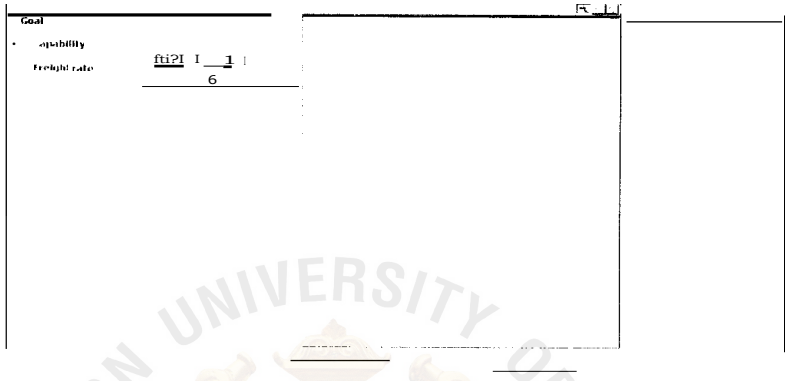



### 4.1 AHP computation with Expert Choice software

As shown in Chapter 3, these are the steps in Microsoft Excel for calculating the AHP process as the way to make comparisons. Checking the correction of the result, by the use of AHP software which is called "Expert Choice" that has been utilized to support the decision making issue within a short period.

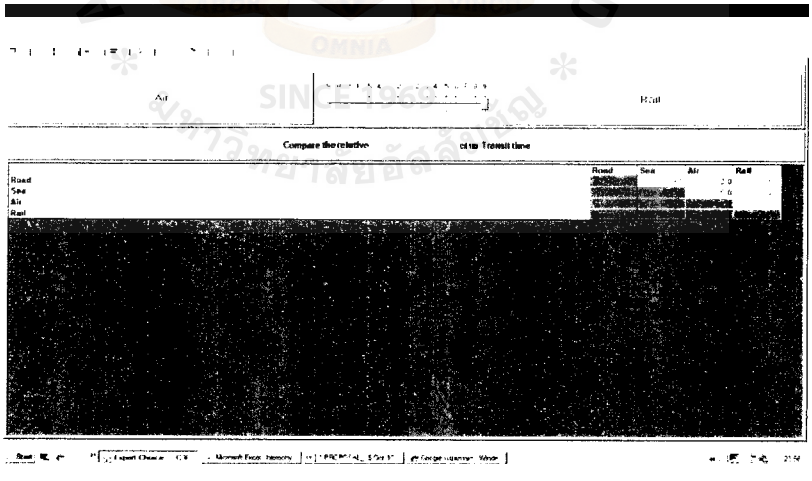
Step **1** Input goal and all criteria (routing, capability, loss and damage, freight rate and transit time) in transportation mode selection, as shown in Figure 4.2.

**Figure 4.2** Input goal and all criteria



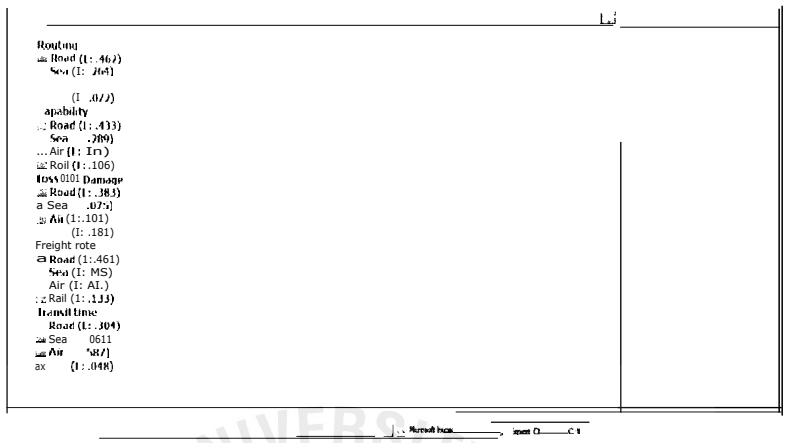

**Step 2** Use the data of transportation mode alternatives pairwise comparison matrix in Chapter 3 with respect to every criterion. Move the circle to the number that the number in black integer number, but the number in red is a friction number.

**Figure 4.3** Compare the relative importance with respect to criteria



**Step 3** Expert Choice software will calculate the result of transportation mode selection under each criterion.

**Figure 4.4** The result in every criterion of transportation mode selection




## 4.2 Analyzing AHP result between Excel and Expert Choice

The result of transportation selection under every criterion is shown in Tables 4.1, 4.2, 4.3, 4.4

**Table 4.1** Summary of the result of transportation mode selection under routing

| **Routing** | Road | Sea | Air | Rail |
|---|---|---|---|---|
| Excel | 0.4501 | 0.2648 | 0.2109 | 0.0743 |
| Expert Choice | 0.4620 | 0.2640 | 0.2030 | 0.0720 |

**Table 4.2** Summary of the result of transportation mode selection under capability

| **Capability** | Road | Sea | Air | Rail |
|---|---|---|---|---|
| Excel | 0.4314 | 0.2807 | 0.1776 | 0.1102 |
| Expert Choice | 0.4330 | 0.2890 | 0.1720 | 0.1060 |

**Table 4.3** Summary of the result of transportation mode selection under loss and damage

| **Loss and Damage** | Road | Sea | Air | Rail |
|---|---|---|---|---|
| Excel | 0.3744 | 0.0788 | 0.1643 | 0.3825 |
| Expert Choice | 0.3883 | 0.0750 | 0.1610 | 0.3810 |

**Table 4.4** Summary of the result of transportation mode selection under freight rate

| **Freight rate** | Road | Sea | Air | Rail |
|---|---|---|---|---|
| Excel | 0.4619 | 0.3545 | 0.0418 | 0.1418 |
| Expert Choice | 0.4620 | 0.3650 | 0.0400 | 0.1330 |

**Table 4.5** Summary of the result of transportation mode selection under transit time

| **Transit time** | Road | Sea | Air | Rail |
|---|---|---|---|---|
| Excel | 0.3005 | 0.0665 | 0.5824 | 0.0506 |
| Expert Choice | 0.3040 | 0.0610 | 0.5870 | 0.0480 |

From the result of transportation mode selection under each criterion, since all transportation modes meet all criteria, and the results between Excel and Expert Choice are slightly different, the trends of the results for all criteria are positive in both processes. The road mode has the highest score in routing, capability and freight rate, as shown in Tables 4.1, 4.2 and 4.4, but for loss and damage and transit time criteria, the highest scores are rail and air mode. It can be implied and suggested that the company should use road mode as the current transportation mode and also still be the best practices of transportation modes, and the company should not change to other modes even though using road mode has the problems stated in the problem statement in Chapter 1. But the result comparison based on every criterion as routing, capability and freight rate is slightly different from the same result of loss and damage criteria, such that the results are not much different between rail and road mode. Air mode has the highest result in transit time criterion which is the consequence of the highest cost for freight rate. Although road mode outranks the others, it is still inferior in the area of transit time and loss and damage, although some or all the inferior points can be improved. That can be done by control of loss and damage, manage the number of truck to fit with customer requirements, exchange and share information on things such as capacity, change according to customer requirements the production plan, delivery date and anything else that impacts the company's export activities. Improvement will help in developing the road transportation mode in quality of trucks, control of availability of tucks to fit customer requirements, control and always check delivery cycle and routing to protect against road destruction, and avoid limits on the number of trucks.

**Table 4.6** Summary of the result of overall priority for each transportation mode

| **Overall Priority** | Road | Sea | Air | Rail |
|---|---|---|---|---|
| Excel | 0.3940 | 0.2022 | 0.2458 | 0.1580 |
| Expert Choice | 0.3910 | 0.1890 | 0.2430 | 0.1770 |

**Table 4.7** Summary of the result of criteria priority

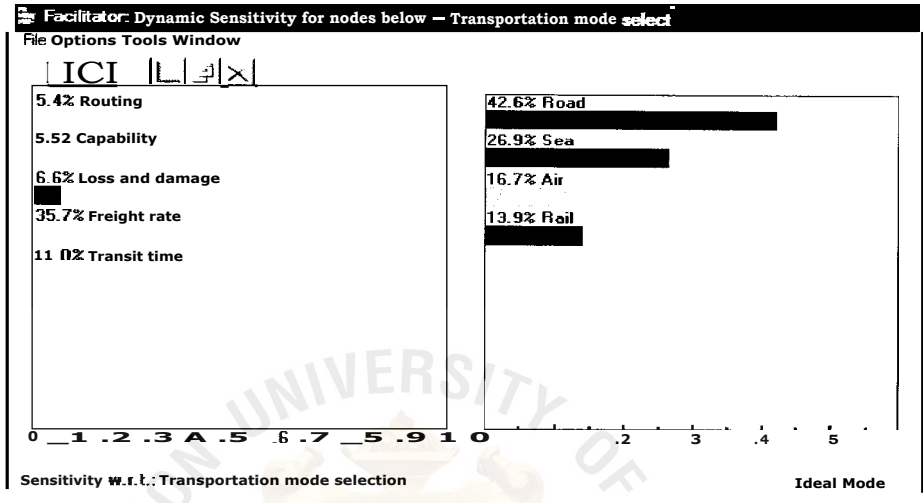
| Criteria Priority | Routing | Capability | Loss and Damage | Freight rate | Transit time |
|---|---|---|---|---|---|
| Excel | 0.0687 | 0.0910 | 0.2070 | 0.3472 | 0.2861 |
| Expert Choice | 0.0660 | 0.0860 | 0.2050 | 0.3550 | 0.2870 |

As shown in Table 4.6, road mode gains the highest overall priority among all transportation modes, followed by air mode, sea mode and rail mode with scores of 0.3910, 0.2430, 0.1890 and 0.1770 respectively. In Table 4.7,the result of criteria priority show that freight rate factors scores are the highest among all factors, followed by transit time, loss and damage, capability and sourcing. The results between Excel and Expert Choice are slightly different due Expert Choice having the computation in the synthesization procedure which is not available in Excel, so that gives Expert Choice a more precise result than Excel can. But if the Microsoft Excel is set up in the formula in all steps, then if ranking criteria are changed, the decision making can change only the alternatives pairwise comparison matrix table. After that, the formula will calculate until the result appears. So both Microsoft Excel and Expert Choice are easy to adapt when the situation is changed.

### 4.3 Sensitivity Analysis

The sensitivity analysis demonstrates a "what if' analysis that is the result from Expert Choice, as shown in Figure 4.2, that freight rate is more important than transit time, loss and damage, capability and routing. The right box in Figure 4.2 shows in scores of alternatives that the result shown is the same as in Microsoft Excel.

**Figure 4.5** Dynamic Sensitivity of overall alternatives focusing only on freight rate criteria

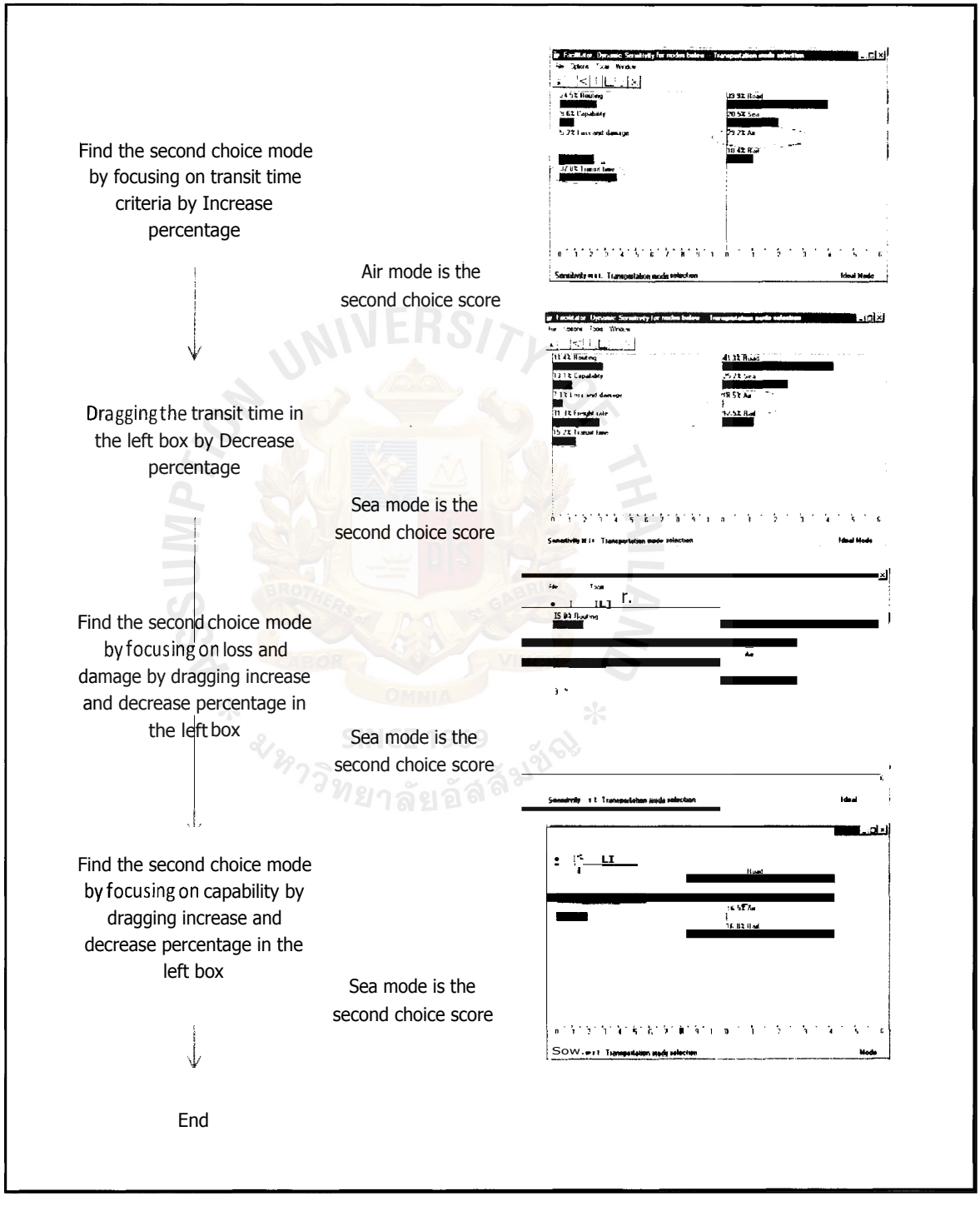



As shown in Table 4.7, freight rate is the highest score, so the project needs more study to find which the second choice of transportation mode is by using sensitivity analysis.

To find the second choice of transportation mode, shown in Figure 4.6 is the flowchart step by step, starting from dragging the transit time criterion, that is the second most important criterion, back and forth (increase and decrease percentage) in the left box. Then the priorities of the alternative transportation selection modes are not instantly changed in the right column. After changing the criteria from transit time to loss and damage and capability, the result after dragging back and forth shows instantly that it is sea mode.

Even though the most important is road mode, in road mode are limitations, such as a limited number of trucks or even closing the Thai/Malaysia border. The second choice as shown in this project should be sea mode transportation. Most sea mode scores are second from road mode in routing, capability and freight rate. So sea mode can be the first back-up plan when road mode is not available.

**Figure 4.6** Flowchart of finding second choice transportation mode by using Dynamic sensitivity analysis



### 4.4 Comparing between transportation scenarios and AHP results

Figure 3.20 for transportation scenarios shows the flow of export consumer products from the Thai warehouse until arrived at the Malaysia warehouse. Also shown are five factors include routing, capability, loss and damage, freight rate and transit time. Each factor has pros and cons, as shown in Table 4.8

**Table 4.8** Appropriate transportation mode from transportation scenarios

| Factors | Appropriate transportation mode scenarios | | | |
|---|---|---|---|---|
| | **Road** | **Sea** | **Air** | **Rail** |
| Routing | x | x | x | |
| Capability | x | x | | x |
| Loss and damage | | | x | |
| Freight rate | | x | | |
| Transit time | | | x | |

From all transportation modes, there are no matches with all factors, so the scenario cannot identify which transportation modes are the most appropiate for exports to Malaysia. The scenarios are difficult in decision making so the scenarios of transportation modes are useful for support information of AHP analysis only. Due to transportation mode scenarios not having a method for transportation decision making, if AHP analysis lacks this data, it will impact wrong participation in brainstoming within the group in using this data during pairwise comparison. Even though sea and air mode match three from five factors, when using AHP, road mode has the highest score ranking instead. As stated in Table 4.9, we are clearer in making a decision due to a numerical judgment which incorporates both quantitative and qualitative judgments, which are different from transportation scenarios and the factors may be suitable for more than one mode.

**Table 4.9** Appropriate transportation mode from AHP analysis

| Factors | Appropriate transportation mode from AHP analysis | | | |
|---|---|---|---|---|
| | **Road** | **Sea** | **Air** | **Rail** |
| Routing | x | | | |
| Capability | x | | | |
| Loss and damage | | | | x |
| Freight rate | x | | | |
| Transit time | | | x | |

AHP analysis, brainstorming, and encouranging participation from the functional team, can assist judgments to achieve suitable results for the company. AHP analysis also helps the company in making decisions for choosing the current mode, the road mode for exports to Malaysia, but when road mode is not available, the second choice that should be selected is sea mode followied by rail and air modes. Moreover, AHP can re-run, which provides flexibility to re-run the result when the criteria are changed Therefore, the company can adapt it for selection of in house transporters to transport consumer products from the Thai warehouse to the Thai port.

# CHAPTER V

# SUMMARY FINDINGS, CONCLUSION AND RECOMMENDATIONS

## 5.1 Conclusion

The objective of this project is to select and evaluate transportation modes in order to improve and manage the transportation cost and transportation management. As the company faces the situation of the current road transportation mode, this project can support the company in selecting the best transportation mode to export consumer products to customers in Malaysia. The decision is complicated but this project could produce a very important and significant benefit to the company.

As this project is concerned with transportation, the literature review explained the relevant concepts and theories that deal with the main parts of logistics activities, the transportation mode, multi model transportation, and transportation decision making. All parts support the company's selection. But the most important part in decision making is methodology, so the AHP analysis process is used, which is a process that is flexible and simple in decision making. The cross functional personnel can make relative judgments and use a 1 – 9 scales which easy to understand and commutates a consistency ratio in checking the answer.

Before starting the AHP analysis process, this project presents transportation mode scenarios by showing five factors, which are routing, capability, loss and damage, freight rate and transit time. All five factors affect road, sea, air, rail transportation modes, as follows:

1. Routing factors explain the stop points for each mode, its effect on other factors that occur, and issues of cost when there are changes in transportation mode in the same routing. There are three stop points for road, sea and air mode, except that the rail mode has four stop points

2. Capability factors explain the capability per day for each transportation mode. The maximum capacities of road, sea and rail mode are two hundred pallets per day, while air mode has only sixty pallets per day.
3. Loss and damage factors explain the probabilities of each transportation mode facing loss and damage during delivery, based on total cost of transportation, leading to the percentage of loss and damage for air mode being the lowest compared with other transportation modes.
4. Freight rate factors explain cost based activities that occur at each stop point. The unit of measurement for this project is one container (twenty pallets). The lowest total cost is sea mode, followed by road, rail and air modes .
5. Transit time factors explain the number of delivery days taken by each transportation mode to deliver the products to customers. Air mode is the fastest mode of delivery, followed by road, sea and rail modes.

The five scenarios are support information for applying the AHP process. The relevant criteria are the five factors of the scenarios and are cross-functional, discussed by a cross-functional team. Then they are composed into the hierarchy to represent goal, criteria, sub-criteria and alternatives. When the hierarchy is set, the prioritization is developed to determine the relative importance of the elements at each level. Comparisons are synthesized to rank the transportation mode alternatives. The output of AHP is a priorities ranking of the transportation mode alternative, based on overall preferences expressed by the company.

The result of the overall priorities is that the company should continue using the road transportation mode to export consumer products to Malaysia. This is due to the road mode having a score higher than sea, rail and air transportation modes. Freight rate criterion is the most important criterion, followed by transit time, loss and damage, capability and routing.

Sea mode is the second choice in case the company cannot use the road mode. To switch modes would increase the operation cost, and the operation process would be changed. Staffs at each stop point would need to be changed. If we control all factors

of the current road mode, to ensure good conditions, unexpected costs will not occur. The oil price is the factor that brings freight rate increase, but the price is linked to all transportation modes and therefore does not affect the decision making. If some factors change(for example transit time), the company should review the pairwise comparison alternatives again.

### 5.2 Managerial Implication

As this project is of direct concern to the company as mentioned earlier in the objectives, it is not only local distribution that matters but the Unilever Thailand Global Supply Chain is also considered as a very critical function for the company as it is considered as the main hub for producing and distributing consumer products to several other countries. Therefore this project would be of great use tor the company.

From a business point-of-view, the factor that affects decision making for several companies is "cost". Therefore, the research in this project has shown that the second choice, the sea mode, has the lowest cost among all other options. So if the company decides on a change in which mode to use, in deciding to use the sea mode, this project will help because it has comparison factors, so that easier and more efficient decision making can be made. The company can foresee in what direction they are heading, and prepare managerial and operational work as well as resources.

Moreover the project can create choices and solutions in solving the company's existing problems, as well as bringing new knowledge and idea to the company. As this project focuses on the existing problems, it will need a real practical solution which is what this project can offer. This project also applies, improves and extends the company's knowledge with real practical action to test the efficiency of the solution.

### 5.3 Recommendations for further study

For further research, the company should apply the AHP analysis process in selection of land transporters, as it now has only a single transporter which sometimes does not have sufficient capability to serve the company. If in the future, there are changes in some criteria which reflect direct factors, this may affect the decision making result to change. Moreover the company can explore collaboration in the supply chain, using other transportation modes, and can share the information with each transportation company for accurate capacity and forecast production.

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# APPENDICES

# APPENDIX A

## Total Truck freight rate

| | | Exclusive of Thai | | | | Inclusive of Thai Malaysia Custom Clear an | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Maylobe** | Size | 21.00 -23.99 | 24.00 -26.99 | 27.00 - 29.99 | 30.00 - 32.99 | 21.00 -23.99 | 24.00 -26.99 | 27.00 29.99 | 30.00 -3299 | |
| Container Rate | 40ft | 44,300 | 45300 | 46,300 | 47,300 | 48,000 | 49,000 | 50,000 | 51,000 | |
| TH Custom | | 1700 | 1 700 | 1 700 | 1,700 | - | - | - | - | |
| MY Custom | | 2000 | 2,000 | 2,000 | 2,000 | - | - | - | - | |
| Total Cost | | 18,000 | 49.000 | 50.000 | 51.000 | 48,000 | 49.000 | 50,000 | 51.000 | |
| Additional cost if appliable | | | | | | | | | | |
| Form D | | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 | |
| Overnight | | 2,000 | 2,000 | 2,000 | 2,300 | 2,000 | 2 000 | 2,000 | 2,0012 | |
| Cancel charge | | 2,000 | 2,000 | 2,000 | 2,000 | 2,000 | 2,032 | 2,000 | 2,000 | |
| **Cost To Unilever** | | | | | | | | | | |
| Container Rate | | 44300 | 45300 | 46,300 | 47,300 | 48,000 | 49,000 | 50,000 | 51,000 | |
| Management Fee | 5.26% | 2,330.18 | 2,382.78 | 2,435.38 | 2,487 98 | 2,524 80 | 2577 40 | 2,630 00 | 2,682 60 | |
| Total Container rate | | **46,630** | **47.683** | **48,735** | **49,788** | **50.525** | **51,577** | **52,630** | **53,683** | 3,894.62 |
| TH Custom | 1,943 | 1,700 | 1,705 | 1,700 | 1,700 | | | | | |
| MY Custom | 2,286 | 2,000 | 2,000 | 2,000 | 2,000 | | | | | |
| Management Fee | 14.29% | 528.73 | 520.73 | 528.73 | 528 73 | | | | | |
| Total Custom Cost | | 4,228.73 | 4,228.73 | 4228.73 | **4,228.73** | | | | | 4,228.73 |
| **G.Total** Cost 40ft | | 50.858.91 | 51,911.51 | 52.964.11 | 54,016.71 | 50.524.80 | 51,577.40 | 52.630.00 | 53.682.60 | 334.11 |
| Form **D** include Mgt. fee | | 228.58 | 228.58 | 228.58 | 228.58 | 228.58 | 228.58 | 228.58 | 228.58 | |
| Overnight Include Moth e | | 2.105.20 | 2,105.20 | 2.105.20 | 2,105.20 | 2.105.20 | 2.105.20 | 2.105.20 | 2.105.20 | |
| Cancel charge Include **Mgt.fee** | | 2.105.20 | 2.105.20 | 2.105.20 | 2.105.20 | 2.105.20 | 2.105.20 | 2.105.20 | 2,105.20 | |

| | | Exclusive of Thai · Malaysia C stom Clearance | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| LAI Transport | Size | 21.00 - 23.99 | 24.00 - 26.99 | 27.00 - 29.99 | 30.00 - 32.99 | 21.00 - 23.99 | 24.00 - 26.99 | 27.00 - 29.99 | 30.00 - 32.99 | |
| Container Rate | 405 | 45000 | 46,000 | 47,000 | 48,000 | 48,500 | 49,500 | 50,500 | 51,500 | |
| Container Rate | 205 | 36,500 | 37,500 | 38,500 | 39,500 | 40,000 | 41.000 | 42,000 | 43,000 | |
| TH Custom | | 2,000 | 2,000 | 2,000 | 2,000 | | | | | |
| MY Custom | | 1,500 | 1,500 | 1,500 | 1,500 | | | | | |
| Total Cost 40 ft | | 48.500 | 49.500 | 50.500 | 51.500 | -18,500 | 49.500 | 50.500 | 51.500 | |
| Total Cost 20 ft | | 40.000 | 41.000 | 42.000 | 43.000 | 40,000 | 41.000 | 42.000 | 43.000 | |
| **Additional** cost If appliable | | | | | | | | | | |
| Form D | | 300 | 300 | 300 | 300 | 300 | 300 | 300 | 300 | |
| Overnight | | 2,000 | 2.000 | 2,000 | 2,300 | 2,000 | 2 000 | 2000 | 2 000 | |
| Cancel charge | | 2,000 | 2000 | 2,000 | 2,000 | 2,000 | 2 000 | 2,000 | 2 000 | |
| **Cost To Unilever** | | | | | | | | | | |
| Container Rate | 400 | 45,000 | 46,000 | 47,000 | 48000 | 48500 | 49.570 | 50.500 | 51,500 | |
| Management Fee | 5.26% | 2,367.00 | 2.419 60 | 2,472 20 | 2,524 80 | 2,551 10 | 2,603 70 | 2,656 30 | 2708 90 | |
| Total Container rate 400 | | 47,367 | 48,420 | 49,472 | **50.525** | **51,051** | **52.104** | **53.156** | **54.209** | 3,684 10 |
| Container Rate | 205 | 36,500 | 37,500 | 38,500 | 39,500 | 40 000 OD | 41.000 32 | 42 000 00 | 43,000 00 | |
| Management Fee | 5.25% | 1,919.90 | 1,972 50 | 2,025.10 | 207770 | 2,104 00 | 2,155 60 | 2 209 20 | 2,2618 0 | |
| Total Container rate 20ft | | 38.420 | 39.473 | **40,525** | **41.578** | **42,104** | **43.157** | **44.209** | **45.262** | 3684.10 |
| TH Custom | 2,266 | 2,000 | 2,000 | ,000 | 2,000 | | | | | |
| MY Custom | 1,714 | 1,503 | 1,500 | 1.500 | 1 500 | | | | | |
| Management Fee | 14.29% | 500.15 | 500.15 | 500.15 | 500 15 | | | | | |
| **Total Custom** Cost | | **4,000.15** | **4.000.15** | **4.000.15** | **4.000.15** | - | | - | | 4,000.15 |
| **G.Total** Cost 40ft | | 51,367.15 | 52.419.75 | 53.472.35 | 54.524.95 | **51.051.10** | **52.103.70** | **53.156.30** | **54.208.90** | 316.05 |
| **G.Total** Cost 201t | | 42,420.05 | 43,472.65 | 44.525.25 | 45.577.85 | **42.104.00** | **43.156.60** | **44.209.20** | **45.261.80** | 316.05 |
| **Forts D** Include Mgt fee | | 342.87 | 342.87 | 342.87 | 342.87 | **342.87** | **342.87** | **3.12.87** | **342.87** | |
| Overnight Include **Mgt.fee** | | 2.105.20 | 2.105.20 | 2.105.20 | 2.105.20 | **2.105.20** | **2.105.20** | **2,105.20** | **2.105.20** | |
| Cancel **charge** Include **Mgt.fee** | | 2.105.20 | 2,105.20 | 2.105.20 | 2.105.20 | **2.105.20** | **2.105.20** | **2.105.20** | **2.105.20** | |

# APPENDIX B

## Total Sea freight rate

Pre-Quotation

Dare : June 3C :D I 8
Subject : Sea Freight Export Quotation FCL by Sea from BEN to Port Mang

*Dear Khun hit,*

Pursuant o our tele-conversation, this letter it erved to introduce LEO Cabal Logistic Ltd at the lee freight consolidator and full container specialist between Thailand and the 5 :a:C.D.S:E. We have a proven track record in dealing with many large accounts like , ir oranization and more importantly, lip have the infrastructure in place and the expertise :a bar e both your du mid tee. shipments in me international standard practice which you specially require.

| Commodity : Consumer Pro-duct | | | | | | |
|---|---|---|---|---|---|---|
| Destination | ETD | IT (Days) | Liner | Ocean Freight (USD) | | |
| | | | | 20'DC | 40'DC | 40'HC |
| Port Klang | PAT 5.m | 3 | ZanLine | | | |

Local Charge at Bangkok

| | | |
|---|---|---|
| B L | TH | |
| Surrender B L (from) | TH | |
| THC | TH | 2 D |
| | TH | 40'Dc |
| | TH | --) BC :As per carrier tariff) |
| SCF | TI- | arrier |
| Customs Clearance | TH | 20 ,40' |
| | TH | ar |
| Transportation Charge | TH | 20 (LSSB - ?AT: |
| | TH | 0 (LSSB - ?AT: |
| Other charge | As p | 11 receipt: |

**Local Charge at Port Klang**

| | | |
|---|---|---|
| D O | | |
| Manifest Submission Fee | | |
| | | 4C-[C :As per carrier tariff) |
| Docum nt Fee | | |
| Customs Clearance | | lupment |
| Delivery Charge | | |
| | | 0'DC, 40 HC |
| Other charge | As per ctual receipt: | |

Remark: The above rates subjected to VAT as per governing law.

This rate valid unnl July 31. 201:

# APPENDIX C

## Total Air freight cost

Pioneer Air Cargo Co., Ltd.
47 Soi Sukjai Sukhumvit 42 Prakanong Bangkok Thailand
Tel (662)392-1960, Fax (662)381-1513, 381-2878
Email : sales@pioneer.co.th homepage : www.pioneer.co.th

To : Unilever Thai Holding Co.,Ltd. From : Sales Department
Ref: NK11062007 Date : June 11,2007
Attention : Khun Cindy /K.Nat Tel : 02- 554-2251
Subject: Pioneer Air Freight Quotation. (Revised May 27,08) Fax : 02-512-1211

Thank you for your kind consideration in our service , we are pleased to submit our quotation for export handling shipment as follow details:-

**1. Export customs clearance and delivery service charges a s follows :**

| | |
|---|---|
| **H**andling charge | Baht. |
| Terminal charge | Baht. |
| **Cartage charge** : | |
| *Pick up at Bangna (Milot) | |
| - 4 wheels truck | Baht./truck /trip |
| - 6 wheels truck | Baht. struck /trip |
| *Pick **up** at Chacheongsao (CCS) | |
| - 4 wheels truck | Baht./truck /trip |
| - 6 wheels truck | Baht. truck /trip |
| *Pick up at **M**inburi (MFDS) | |
| - 4 wheels truck | Baht./truck /trip |
| - 6 wheels truck | Baht. /truck /trip |
| Packing with Fumigation per CBM | Baht/cbm |
| Packing with Fumigation per pallet | Baht/pallet |
| Excluding | |
| Customs Overtime | aht. (If any) |
| Form A or Form C/O of Origin | aht. (If any) |
| Other receipt (at cost) (If any) | |
| Vat 7% | |

We hope above quotation will meet your requirement. Should there be any inquiry, please do not hesitate to contact us immediately.

Yours sincerely,
Pioneer Air Cargo Co., Ltd.

Katekangk S./Sales Co-Ordinator Ext. 259
CC : Jairung D./Sales Representative E )1.257
Anurak U. I Sales Manager. E A. 255 1.07