Master of Logistics

A STUDY ON INTERMODAL FREIGHT TRANSPORT MODELS IN VIETNAM

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Abstract

Freight transportation is a potential component of the logistics system, which absorbs between one - third and two - thirds of the total logistics costs. In the transport field, transportation companies try to search the best operating ways or alternatives which could help them compete with others, so there are competitions among different transport modes (*road, rail, air, and water modes*). Instead of finding the better alternative for such competition, this paper has considered to build the freight transport networks based on the coordination among modes, which makes the transport systems operate more effectively. This concept is called intermodal freight transport or intermodalism model. Depending on different conditions, the best suitable intermodalism models will be proposed. Author will study, construct, analyze, evaluate, and apply the intermodal freight transport models that suit for the special conditions in Vietnam.

Besides, constructing the optimum transportation networks, which are used for collecting or distributing freight to/from depot centers from/to customer zones, is a challenge of logicians. In this paper, author will present one of the general ways to do it. Transportation model is built, in which objective and constraint functions are formulated. An experience method to solve this problem is proposed, where it follows three phases. The first one is that a possible set of tours is generated. An optimum alternative, then, is determined in phase 2 by using optimization program, Lingo software. Finally, suitable fleets are assigned to response it. To illustrate the method, an example transportation problem is presented.

Chapter 1: Introduction

1.1 Introduction

Freight transportation is a vital component of the national economy. It supports production, trade, and consumption of goods by ensuring that commodities and/or materials are always available. Transportation expense is considered as one of the most cost-consumed elements of the total production costs, and occupies a vital amount of the national expenditures. The objective that freight transport industry aims to reach is to achieve the "high performance levels" in terms of both economic efficiency and quality of service.

Each transportation mode (road, rail, air, and water) has its own characteristics, including both advantages and disadvantages. Using advantages of different types of cargo transportation in combination, the most efficient variant can be developed to deliver the cargo from/to every part in the world. Some of the factors are used to evaluate the performance level or efficiency of transportation networks are transportation capacity, flexibility, safety, transportation costs, environment effects, and et cetera.

Intermodal freight transport, or intermodalism, is such effective method that combines advantages of two or more modes together with the development of technology which vitally affects to transportation modes. Each mode plays an important role in transportation chains. Intermodalism model has been used widely in the world. Recently, it plays a vital role in the global logistics systems. Relative to this model, many pieces of research have been done and applied successfully in many countries. However, in Vietnam, this type of transportation model has not been considered approximately. Therefore, it is essential to investigate the current conditions as well as situation of Vietnam to know that whether intermodalism is applicable and can help to boost the national economy. In the case that it is helpful and applicable, which intermodal transportation models should be applied? How to evaluate these models is then another question. In other words, which criteria and factors should be used to evaluate intermodal models? In addition, there are many factors affecting to the success of the application of intermodalism.

With the above mentioned purposes, author will consider characteristics of the intermodalism and relative researches. Then, Vietnam's conditions are carried out which include economy, geographic, infrastructure, and transportation conditions.

Based on them, some suitable intermodal transport models will be proposed. Evaluating criteria and factors and market segmentations will be considered; consequently, the offering models will be presented and evaluated along with suggesting factors. Some suggestions for the successfulness of intermodalism application also presented.

Besides, at each market segment, collecting and delivering freight are important parts of transportation systems. Therefore, constructing an optimum transportation network with minimizing total transportation costs or time is expected. It has to meet customers' demand under limitations of suppliers' capacities. Furthermore, there are many constraints affecting to determination of transportation network. In this case, author suggested an experience way to construct and solve the transportation problem to find the best alternative for consolidating freight.

Finally, some conclusions are concluded. In addition, future studies relative to this one are suggested.

1.2 Objectives

This thesis aims to:

- Study intermodalism or intermodal freight transport
- Investigate Vietnam's market conditions
- Apply, analyze, and evaluate suitable intermodal freight transport models concerning Vietnam's conditions.
- Propose an experience way to construct and solve the transport network problem.

1.3 Scale and scope

- In this study, intermodalism models are proposed concerning Vietnam's conditions such as geography, infrastructure, and so on. Therefore, just some suitable combinations between transportation modes are considered.
- Intermodalism models are analyzed and evaluated based on some suggested factors such as transportation costs, its performance, flexibility, infrastructure appropriation, and expanded capacity.
- AHP is applied to rank model based on certain circumstances, which are derived from decision makers. An example is carried out for illustration purpose.

- At each market, freight collection and delivery are very important issues, so an experience way is presented to construct and solve transportation network problems.
- Data used in study are collected and compiled from many sources. However, they are varied and some are missing, so these data are for illustration purpose only.
- Case study mentioned to illustrate the usages of AHP is just assumed one.

1.4 Structure of thesis

This thesis will consist of seven chapters.

Chapter 1 – Introduction: this chapter presents the background of study, objectives, scale and scope, as well as the structure of thesis.

Chapter 2 – Literature review: in this chapter, a systematic literature review which relates to intermodalism, problem modeling and solving will be considered. The nature of both supply of transport services and the demand of those services will be studied and presented.

Chapter 3 – A briefly introduction of Vietnam: Vietnamese conditions such as geography, topography, economic, political, social, as well as superstructure and infrastructure will be stated clearly and concisely.

Chapter 4 – Methodology: methodology and main techniques are presented in this chapter.

Chapter 5 – Modeling and evaluation: intermodal freight transport models are proposed and evaluated in this chapter.

Chapter 6 – An experience way is proposed to construct and solve transportation network problems, which is useful and should be applied to find best routes for freight consolidating at each market.

Chapter 7 – Conclusions and suggestions: Conclusions, limitations, and suggestions will be mentioned in this chapter.

Chapter 2: Literature Review

2.1 Transportation options

Transportation is a vital activity in moving both freight and passengers around the world (Bardi et al, 2006). When choosing transportation options, a buyer has traditionally thought of five basic modes of transportation, which are rail, road (truck), water, pipe, and air. Table 2-1 shows a ranking of the modes using four cost and performance characteristics.

<Table 2-1> Relative ranking of transportation mode by cost and operating performance characteristics [a] (Ballou, 1992)

Transport mode	Performance characteristics				
	Cost [b]	Average delivery time [c]	Delivery time variability		Loss and damage
			Absolute	Percent [d]	
	1 = Lowest	1 = Fastest	1 = Least	1 = Least	1 = Least
Rail	3	3	4	3	5
Truck	4	2	3	2	4
Water	1	5	5	4	2
Pipe	2	4	2	1	1
Air	5	1	1	5	3

[a]Service is assumed to be available
[b]Cost per ton-mile
[c]Door-to-door speed
[d]Ratio of absolute variation in delivery time to average delivery time

However, nowadays, intermodalism has emerged as a major new approach to planning of transportation system. It is concerned in consecutive section.

2.2 Intermodalism

2.2.1 Definitions of Intermodalism

Although the meaning of intermodalism can vary greatly depending on the definer's perspective (Eno Transportation Foundation), many scholars have been interested in the definition of intermodalism. Barton and Holcomb (1996) agreed that by having a definition it is understood to have a degree of exactness and clarity.

They had believed that the lack of a comprehensive definition has led to a much narrower scope of operational arrangements than necessary. They mentioned that the intermodalism is not only to applying to containers designed but also the non-containerized freight (or transload). The transload refers to a transfer between modes without containers, but utilized in another type of device. Other reference relates it to a practice of transferring bulk shipment from vehicle/container of one mode to that of another at one or a series of terminal interchange points (Muller, 1999).

Many researchers had defined intermodal freight transport as "*the use of two or more modes to move a shipment from origin to destination under a single freight bill"* (Dewitt and Clinger, 2001), (Alt et al., 1997), (TRB, 1998). This definition focused only in the freight movement so that ignored the movement of people.

Jones et al. (2000) also suggested that there was a lack of consensus among existing definitions of intermodal transportation; some of them were too narrow while others were too broad. They presented a definition as follows.
"Intermodal transportation is generally defined as the shipment of cargo and the movement of people involving more than one mode of transportation during a single, seamless journey."
They also mentioned that the shipment of cargo movement includes both containerized and non-containerized ones.

A definition of intermodal transportation from Muller (1999): "*The concept of transporting passenger and freight on two or more different modes in such a way that all parts of the transportation process, including the exchange of information, are efficiently connected and coordinated.*"

In this study, since author focus only in the intermodal freight transportation, a definition as "*the concept of utilizing two or more "suitable" modes, in combination, to form an integrated transport chain aimed at achieving operationally efficient and cost-effective delivery of goods in an environmentally sustainable manner from their point of origin to their final destination*" (Lowe, 2005) is used.

Some principle benefits of unit-load intermodalism are proposed by Lowe (2005) as follows.

- Lower transit cost over long journey;
- Potentially faster delivery times in certain circumstances;

- A reduction in road congestion;
- A more environmentally acceptable solution to congestion and related problems;
- Reduced consumption of fossil fuels since the long-haul section of the route is more fuel efficient;
- Safer transit for some dangerous products.

2.2.2 Characteristics of Intermodalism

According to the guide of Intermodal freight transport (Era-net transport, 2007) to be classified as intermodal, the transport chain needs the following characteristics:

- The goods shall be transported in unbroken Intermodal Loading Unit (ILU) from origin to destination.
- ISO-containers, swap bodies, semi trailers and specially designed load units of corresponding size are included in the definition of ILUs.
- The ILUs must change between two different transport modes at least once between origin and destination.

In a presentation at the 7th meeting of the National Council on Transport, Fagbemi (2006) mentioned the followings as key features of intermodalism.

- Door-to-door shipping;
- Absence of modal barriers;
- Single document transaction;
- Seamless transportation system;
- Ease of data handling, processing and distribution;
- Safe, reliable, and cost effective control of freight and passenger movements;
- Use of Electronic Data Interchange (EDI) – an involving technology that is helping companies and government agencies (customs documentation) cope with an increasing complex global transport system;
- Facilitation of medium and long-haul freight flows across the globe.

2.2.3 Factors impact on transport mode selection

The selection process can affect an entire operation or company and fully understanding it helps company stay competitive (Barton and Holcomb, 1996).

Some carrier/modal-selection factors have been proposed by many researchers are presented in Table 2-2.

<Table 2-2> Carrier/modal selection factors suggested by scholars

Researchers	**Factors**
Ballou, 1992	Cost Transit time and variability Loss and damage
Barton and Holcomb, 1996	Cost structure Loss and damage history Access Carrying capacity
Dewitt and Clinger, 2001	Speed Flexibility Variance elimination Cost
Tuna and Silan, 2002	Reliability and competence Personal service Supporting activities Value added services Accurate and on time documentation Equipment Informing change
Merrina, Sparavigna, and Wolf, 2006	Total cost Total time Service level Social benefits
Zhou and Chen, 2007	Safety Speed Economy Punctuality Convenience Comfort

2.3 The spread of intermodalism

Intermodalism is virtually a worldwide concept; it is widely practiced in most world trading markets. In his book, Lowe (2005) had presented the spread of intermodalism in many countries.

2.3.1 Europe

The application of intermodalism in Europe has been well supplied with strong inter-continent rail systems, an extensive inland waterways network, and a burgeoning road haulage industry. Thanks to these conditions, Europe has essential conditions to facilitate the switch of freight from its heavily congested road systems onto the more environmentally friendly transport model.

2.3.2 North America

By the 1920s intermodal container services in the US were regularly operating bay road-rail. Where the North America experience clearly benefits of intermodalism is from its huge landmass, which offers great potential for long-haul intra continental operations. From that onwards, intermodalism has been developed dramatically. Its majority is on containerization and piggyback intermodalism.

2.3.3 Canada

Canada, like the USA, is heavily dependent on containerization and piggyback intermodalism.

2.3.4 The Baltic States

The Baltic States refer to Estonia, Latvia, and Lithuania. It is a transit corridor for shipments from/to Finland and Russia as well as being a consumer market in its own right. This region is among the fastest growing ones in the world. There is high demand on intermodalism. The dominant transportation mode in this region still remains rail transport. Together with Poland, it has engaged the international railway project.

2.3.5 Asia

Asia is home to 6 of the world busiest container ports. The increasing in trade flows has emerged the need of intermodalism for Asia.

2.3.6 Australia

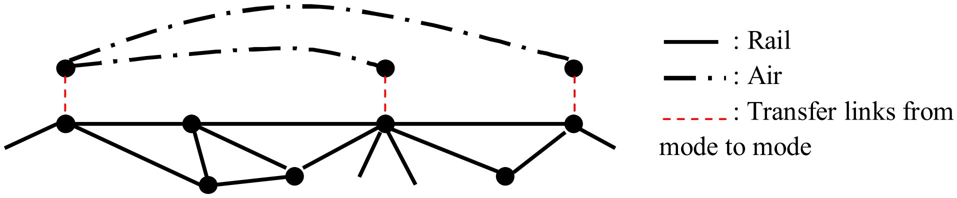
Intermodalism in Australia predominantly means containers on trains for long haul and on trucks to and from collection and delivery location and major ports. It depends heavily on long-distance road transport for its internal freight movements. However, in some routes, railways are preferred. Recently, a lot of efforts have been done to make intermodalism more efficiently.

2.4 Methods to select the best combination of transportation modes

2.4.1 Usage of the shortest path problem

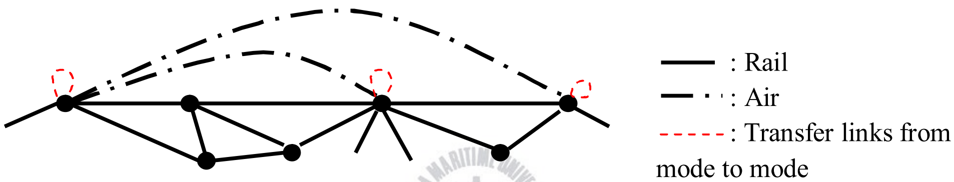
According to Machris and Bontekoning (2004), intermodal transportation system is intrinsically different from single-mode transport system; therefore it is more complex to model. They also suggested that there are many opportunities for operations research in intermodal freight transport. Merrina et al. (2006) have proposed an idea to select the best combination of transportation modes by using operations research. They emphasized that many factors should be considered when addressing intermodal transportation route, which are total cost, total time, service level, and social benefits. In the intermodalism, the model must consider not only the cost for each different mode, but also the transfer cost from mode to mode and the transfer time. Transfer costs depend upon the transfer point at which they occur. They also mentioned that intermodalism problem may be a multi-objective one. For instances, minimizing total cost, time and/or maximizing service level and social benefits are some interested objectives.

They suggested using the Shortest Path Problems to solve the intermodalism routing problem. In the modeling of transportation involving multiple modes between each node of network, they proposed two manners of approach. The first way is to present a node in the network once for each mode of transportation that can enter that city. For example, if a city has three modes of transportation available to enter the city, it is represented by three nodes. Then, there is only one link between each pair of node in this modeling method. Each link corresponds to the transportation cost of the most represented by the node to which it is linked. The transfer cost from one type of node to another is represented in this method with a link. It is a link leaving a node designated as one transportation type, and entering a node designated as another. This kind of links represents transfer cost, as in Figure 2-1.



<Figure 2-1> An example of multiple node method

The second approach is the usage of multiple link method of transportation network. It involves representing each city by one node and allowing more than one link between any two nodes. Each link contains the transportation cost of mode it represents. This type of model is smaller by definition than the multiple node method, but in this case the transfer cost from one type of node to another must be represented by loop on the node, as in Figure 2-2.



<Figure 2-2> An example of multiple link method

A starting and ending node representing the origin and destination are placed on the network. The analysis of path from origin to destination allows for cost calculations.

2.4.2 Usage of AHP (Analytic Hierarchy Process) for models ranking

Biberatore (1995) suggested a usage of AHP in transport carrier and mode selection. This technique supports decision makers to make decision when many criteria are considered simultaneously. A short introduction of AHP, its principle, and steps for calculation are mentioned as follows.

Brief introduction of AHP

AHP is a multi-criteria decision method, which was developed by Saaty in 1970s. It provides a proven, effective means to deal with complex decision making in many domains. It can assist with identifying and weighting selection criteria, analyzing the data collected for the criteria and expediting the decision-making process.

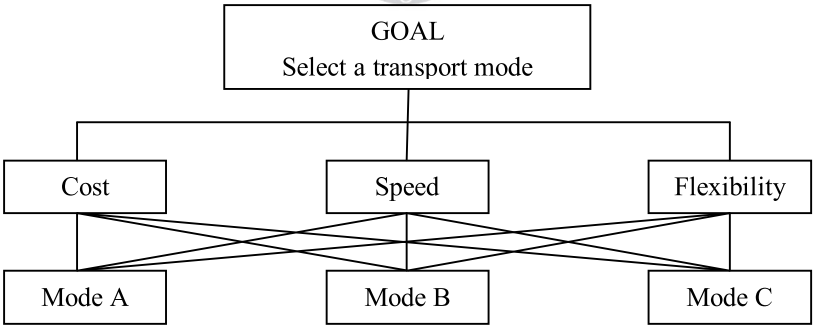
The determination of criteria and alternatives are very subjective, therefore AHP provides a useful mechanism for checking the consistency of the evaluation measure and alternatives suggested by team thus reducing bias in decision making.

Implementation

Steps to conduct AHP are depicted as follows. Accordingly, a numerical example is presented as an illustration.

Step 1: *Set up decision hierarchy*
It involves breaking the decision problem down into a hierarchy of interrelated decision elements. At the top of the tree is a statement of the most general objective of the decision problem. Then the attributes of the decision are set out below. At the next level in the tree, these attributes can be broken down into more detail, and so on.

For illustration purpose, it is assumed that a company wants to select a transport mode based on three criteria. Within each criterion, three alternatives, namely mode A, B, and C are considered. A decision hierarchy is presented as in Figure 2-3.



<Figure 2-3> Decision hierarchy

Step 2: *Construct pair-wise comparison matrices*

In this step, each attribute is compared with every other one at the same level in the hierarchy (e.g., A with B, A with C, and B with C, in which A, B, and C are attributes). For instances, when selecting transportation mode, the attribute of "cost" is twice as importance as "speed", while "speed" is only one forth as important as "flexibility". These judgments lead to a matrix of comparison.

For numerical example, the complete comparison matrices are shown in Tables from 2-3 to 2-6.

<Table 2-3> Comparison matrix for 1^{st} level (among factors)

Factor	Cost	Speed	Flexibility
Cost	**1**	2	0.5
Speed	0.5	**1**	0.25
Flexibility	2	4	**1**

<Table 2-4> Comparison matrix for 2^{nd} level (among modes under factor cost)

Factor	Mode A	Mode B	Mode C
Mode A	**1**	2	1
Mode B		**1**	0.5
Mode C			**1**

<Table 2-5> Comparison matrix for 2^{nd} level (among modes under factor speed)

Factor	Mode A	Mode B	Mode C
Mode A	**1**	3	2
Mode B		**1**	2/3
Mode C			**1**

<Table 2-6> Comparison matrix for 2^{nd} level (among modes under factor flexibility)

Factor	Mode A	Mode B	Mode C
Mode A	**1**	5	3
Mode B		**1**	3/5
Mode C			**1**

Note that the diagonal matrix consists only of 1's; obviously each attribute is equally important when compared with itself. Note also that the comparison matrix is a reciprocal one. This process is carried out at each level of hierarchy. Finally, at a lowest level the attraction of the alternative courses of action are compared in pairs with respect each of the attributes in the level above.

Step 3: *Transform pair-wise comparison matrices into normalized weights*
It is now necessary to convert the matrices of comparisons into set of weights which show the relative importance of all attributes which occur at the same level in the hierarchy.

For the matrices shown in previous tables, the normalized weights are calculated as follows.

First, find the geometric mean w_i by using following equation.

$$w_i = [(a_{1i}) \times (a_{2i}) \times .... \times (a_{mi})]^{\frac{1}{m}}, \forall i = 1,..m$$

In which, m is the size of comparison matrix, or numbers of criteria, and aij represents the importance of criterion i over criterion j, for all i, j.

Normalized weights are then calculated by,

$$nw_i = \frac{w_i}{\sum_{i=1}^{m} w_i}, \quad \forall i$$

Along with the weights, a consistency ratio (C.R.) is also calculated. This ratio should be less than 10%; otherwise it is suggested to adjust the judgment matrix to eliminate the inconsistency. Finally, aggregated weights of all alternatives are computed for ranking purpose.

The consistency ratio (C.R.) is determined as follows.

$$C.R. = \frac{C.I.}{R.I}$$

While, C.I. is consistency index,

$$C.I. = \frac{\lambda_{\max} - m}{m-1}, \quad \text{and } \lambda_{\max} = \sum_{j=1}^{m} (\sum_{i=1}^{m} a_{ij}) \times nw_i, \forall i, j$$

$$R.I. = 1.845 \times \left(1 - \frac{(m-1) \times 2}{m \times (m-1)}\right)$$

Applying above equations to example, the following results are obtained, as shown in Table 2-7. These are results for 1^{st} level, comparison of factors.

<Table 2-7> Calculation results for the 1^{st} level

Factor	Geometric mean	Normalized weight	C.R.
Cost	1	0.286	~ 0
Speed	0.5	0.143	
Flexibility	2	0.571	
Sum		1	

Consistency ratio (C.R.) is approximately zero, which implies that the comparison matrix is consistency.

This process is repeated for next levels (if any). In the numerical example, results for the 2nd level are summarized as in Table 2-8.

<Table 2-8> Calculation results for 2nd level

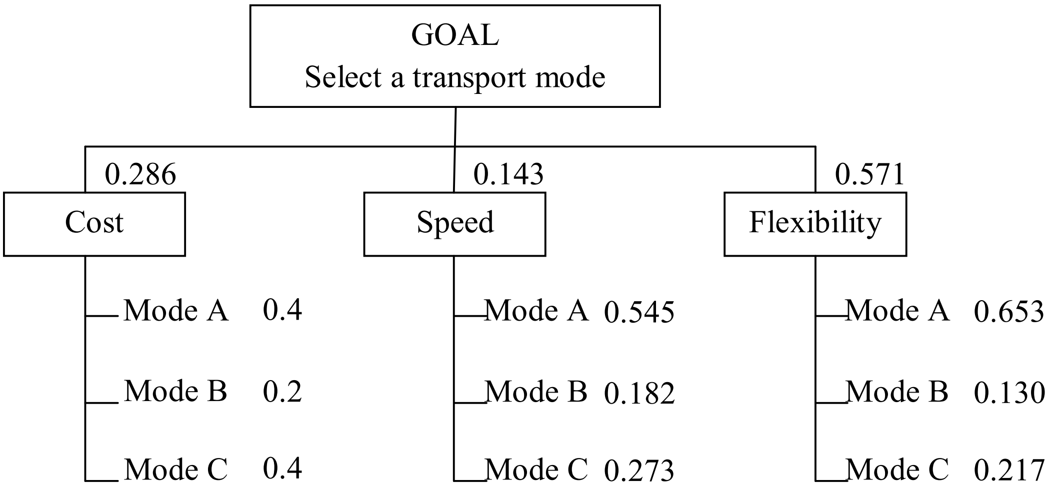
Factor	Mode	Geometric mean	Normalized weight	C.R.
Cost	A	1.26	0.4	~ 0
	B	0.63	0.2	
	C	1.26	0.4	
Speed	A	1.82	0.545	~ 0
	B	0.61	0.182	
	C	0.91	0.273	
Flexibility	A	2.47	0.653	~ 0
	B	0.49	0.130	
	C	0.82	0.217	

All levels have been done thoroughly. Step 4 is carried out to find the aggregated weights to rank alternatives.

Step 4: *Aggregate weights to compare alternatives*

From the obtained weights for each level of hierarchy, the scores of each attribute are calculated in order to compare the alternatives.

For numerical example, after previous steps are done, all results can be shown as in Figure 2-4.



<Figure 2-4> Aggregated weights and alternatives ranking

Aggregated weight for each transport mode is calculated as follows.
Mode A: (0.4) x (0.286) + (0.545) x (0.143) + (0.653) x (0.571) = 0.565
Mode B: (0.2) x (0.286) + (0.182) x (0.143) + (0.130) x (0.571) = 0.157
Mode C: (0.4) x (0.286) + (0.273) x (0.143) + (0.217) x (0.571) = 0.277

Accordingly, mode A should be selected since it has the highest aggregated weight; while mode B is ranked third since its aggregated weight is the smallest. In other words, the ranks of modes are Mode A, Mode C, and mode B, respectively.
Finally, the overall consistency of hierarchy is checked by summing for all levels. The overall consistency of numerical example is given by:

$$\overline{C.R.} = \frac{\sum_i w_i \times C.I._i}{\sum_i w_i \times R.I._i} = 0$$

Since all $C.I._i$ are equal zero. This result means that the hierarchy is consistency.

Remark: it is remarked from previous example, only the first two steps have to be set by decision makers; the remaining steps are repeated calculations, which can be supported by some software. The following is the discussion of that matter.

Decision Support Software

Currently, many firms have supplied computer software to assist in applying process; Expert Choice is one of them. A brief introduction about Expert Choice 9.0 is mentioned below.

Expert Choice 9.0 is software to support decision makers, which is built based on AHP method. Users have to construct decision hierarchy and pair-wise matrices. All calculations are implemented by the software. At each step, users have to adjust the pair-wise matrix based on computed consistency ratio (C.R.). The final results, then, will be displayed including aggregated weights of alternatives and overall consistency index.

Chapter 3: A brief introduction about Vietnam

3.1 Geography

The Socialist Republic of Vietnam is located on the eastern rim of the Indochina peninsula in the Southeast Asia. China borders it to the north, Laos and Cambodia to the west, the Eastern Sea to the east, and the Pacific Ocean to the east and south. It occupies a mainland territory of 331,690 square kilometers and extends about 1,650 km from northernmost point to southernmost point, as in Figure 3-1. The maximum East-West distances in the North and the South are 600 and 400 kilometers, respectively. The minimum East-West distance is 50 kilometers in the Center of Vietnam.

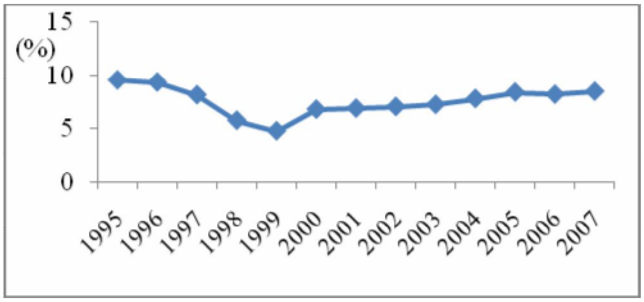
<Figure 3-1> Vietnam's location

Vietnam's territorial waters make around 1,000,000 square meters, with 3,260 kilometer long coastlines. The country has two major river deltas – the Red River Delta in the north, and the Mekong Delta in the south, with the areas of 15,000 and 40,000 square kilometers, respectively. There is more than 41,000 kilometers in length of main rivers and 3,100 kilometers in length of ditches.

Its geography is suitable for developing intermodal freight transport.

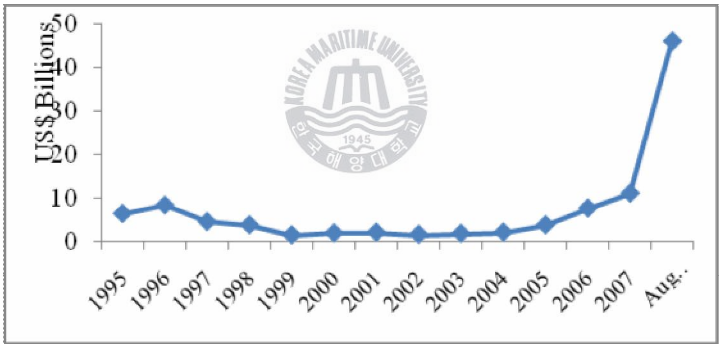
3.2 Economy

In 1986, the Government approved broad economic reforms that dramatically improved the business climate and Vietnam became one of the fastest – growing economies in the world, averaging 9% annual gross domestic product (GDP) growth from 1993 to 1997. In 1998, it fell down to 4% because of the East Asian financial crisis in previous year, then it grew up to 4,8% in 1999. In 2002 – 2003, GDP growth was from 6% to 7% anually. In 2004 – 2007, GDP grew over 8% annually; and it is estimated 7.5 % in 2008, as shown in Figure 3-2.



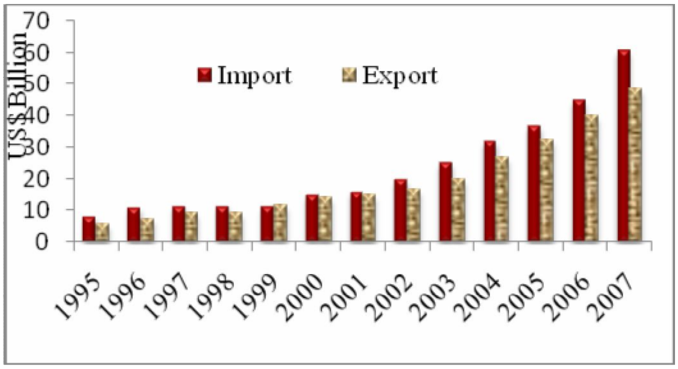
<Figure 3-2> Economic growth rate of Vietnam in the duration of 1995 – 2007
(Source: Vietnamese General Statistics Office)

Vietnam's economic prospects continue to brighten due to the fact that Vietnam has just become member of WTO in January 2007. As a result of favorable governmental policies, a well educated workforce, and concern about China's rising costs, more and more foreign investors consider Vietnam as a potential place to establishing manufacturing and distribution centers. This suggests that logistics should be place a suitable consideration.



<Figure 3-3> Foreign Direct Investment to Vietnam in 1995 – 2008
(Source: Vietnamese General Statistics Office)

Above figure shows the FDI (Foreign Direct Investment) to Vietnam in the duration of 1995 – 2008, in which the last value is just for the first eight months of 2008. The imports/exports of Vietnam are shown in following figure. About 90% of import/export is carried via Vietnam's sea ports.



<Figure 3-4> Import/Export of Vietnam in 1995 – 2008

(Source: Vietnamese General Statistics Office)

3.3 Transportation infrastructure, superstructure

3.3.1 Roads

The road system is the most popular form of transportation in the country, which has a total 151,632 kilometers in length as shown in Table 3-1.

<Table 3-1> Indicators of Vietnam's road capacity in 2006

Road *(Km)*	**151,632**
Asphalted road	64,413
Stone paved road	6,797
Mixed stone & soil road	36,240
Soil road	44,182

(Source: Vietnamese General Statistics Office)

Road transport accounts for about 65 percent of domestic cargo transport. Road system is the pre-export and post-import legs for door-to-door distribution. Generally speaking, roads in Vietnam are limited in quantity and quality resulting in traffic congestion and posited negative impact to logistics activities.

Recently, many projects have been carrying in order to expand existed transport capacity, which construct a road system connects to ports, industrial parks, and economic zones in whole country, as well as the international transport network. For example, the Asian highway network, connecting 32 countries and covering 140,000 kilometers, is an important component of an integrated international intermodal transport network. It connects to major seaports, river ports as well as major container terminals and depots in the Asia-Pacific region. Road haulage vehicles form the backbone of the most intermodal freight operations.

3.3.2 Rail

With a total length of 2600 kilometers, Vietnam Railways network connects residential area to cultural, agricultural and industrial centers, except the Mekong River Delta area. Container transport by rail is still at its primitive stage and operated by the state-owned Vietnamese Railway Corporation. Vietnam Railways are linked to China railways through two directions, Lao Cai province to Yunnan province, and Lang Son province to Guangxi province. When it is more developed, Vietnam railway network is possibly linked to Cambodia, Thailand and Malaysia railways network via which to Singapore and Laos railways

3.3.3 Waterways

Vietnam has an interlacing system of rivers and ditches of more than 41,000 kilometers in length, and the coastline of 3,444 kilometers (excludes islands); and nearly locates at the important international marine line, links current eventful economic centers of the world. They are very advantageous to transport goods and passengers among local areas inside Vietnam, and between Vietnam and other countries in the regions or in the world. Data in the Table 3-2 shows the indicator of Vietnam inland waterways' capacity.

<Table 3-2> Indicators of Vietnam's inland waterways' capacity

Inland waterways *(Km)*	**37,312**
Of which:	
Weight under 50 tons	21,263
Weight 51 tons - 100 tons	6,200
Weight 101 tons - 500 tons	6,557
Weight 501 tons - 1000 tons	1,762
Weight over 1001 tons	1,530

(Source: Vietnamese General Statistics Office-2006)

In the past few years, inland waterway transport accounts for about 30% of the domestic cargo transport volume. Ports should be considered as one of the vital elements of waterway transportation system. For most trading nations, port is the main transport link with their trading partners and thus a focal point for motorway and railway systems. Therefore, it is obvious that a suitable port development will boost a nation's economy.

The Vietnam port system includes more than 110 ports varying in size and capacity and some other potential ports which are under investigation or construction; the current total quay length is more than 36 kilometers. Many ports in Vietnam are very old and out-of-date. They are shallow in draft, and both their yard and warehousing systems are insufficient for accommodating containers and cargo. Today, there are only a few ports with modern handling facilities and equipment to serve big ships such as Saigon, Da Nang, and Hai Phong ports. Freight forwarding activities are conducted mainly in big cities and their suburban areas such as Hochiminh City, Hanoi, HaiPhong, and Da Nang.

3.3.4 Airways

There are about 100 airports throughout Vietnam, but only three serve international routes. There are two national airlines in operation, Vietnam Airline (state-owned) and Pacific Airline (joint-stock), which are basically passenger carriers. There are some companies has been invested in this industry, however they have not provided services yet. Vietnamese freight forwarders use these two lines for approximately 20% of their cargo volume, whereas the other 80% is contracted to the foreign airlines market.

3.4 Freight Transportation

3.4.1 Freight transport volume vs. freight traffic volume

The volume of domestic freight and freight traffic by mode of transport are presented as in Table 3-3, and 3-4.

<Table 3-3> Volume of freight by mode of transport

Unit: 1,000 tons

Year	Total	Of which:				
		Railway	Road	Inland waterway	Maritime transport	Aviation transport
1995	140,709.9	4,515.0	91,202.3	37,653.7	7,306.9	32.0
1996	157,201.9	4,041.5	103,058.7	40,270.3	9,783.7	47.7
1997	176,258.8	4,752.0	114,395.1	46,286.2	10,775.4	50.1

1998	189,184.0	4,977.6	121,716.4	50,632.4	11,793.0	64.6
1999	203,212.7	5,146.0	130,480.0	54,538.1	13,006.1	42.5
2000	223,823.0	6,258.2	144,571.8	57,395.3	15,552.5	45.2
2001	252,146.0	6,456.7	164,013.7	64,793.5	16,815.3	66.8
2002	292,869.2	7,051.9	192,322.0	74,931.5	18,491.8	72.0
2003	347,232.7	8,385.0	225,296.7	86,012.7	27,448.6	89.7
2004	403,002.2	8,873.6	264,761.6	97,936.8	31,332.0	98.2
2005	460,146.3	8,786.6	298,051.3	111,145.9	42,051.5	111.0
2006	513,575.1	9,153.2	338,623.3	122,984.4	42,693.4	120.8
Prel. 2007	569,534.8	9,098.2	369,776.6	190,529.6		130.4

(Source: Vietnamese General Statistics Office)

<Table 3-4> Volume of freight traffic by mode of transport

Unit: Million tons.km

Year	Total	Of which:				
		Rail	Road	Inland waterways	Maritime transport	Aviation transport
1995	30,910.5	1,750.6	5,064.2	8,671.3	15,335.2	89.2
1996	38,710.0	1,683.6	5,710.8	9,036.3	22,172.2	107.1
1997	45,306.7	1,533.3	6,203.0	10,391.1	27,059.1	120.2
1998	46,336.7	1,369.0	6,651.9	12,962.0	25,237.2	116.6
1999	50,054.6	1,445.5	7,057.5	13,826.5	27,619.6	105.5
2000	55,629.7	1,955.0	7,969.9	14,346.1	31,244.6	114.1
2001	63,164.4	2,054.4	9,184.9	16,937.1	34,829.8	158.2
2002	69,417.9	2,391.5	10,667.6	15,936.9	40,250.1	171.8
2003	80,029.5	2,725.4	12,338.0	15,492.3	49,263.2	210.6
2004	90,504.8	2,745.3	14,938.8	16,415.1	56,169.8	235.8
2005	100,728.3	2,949.3	17,668.3	17,999.0	61,872.4	239.3
2006	113,550.0	3,446.6	20,537.1	18,843.7	70,453.2	269.4
Prel. 2007	124,229.5	3,888.4	23,617.7	96,440.7		282.7

(Source: Vietnamese General Statistics Office)

<Table 3-5> Average percentage of freight traffic volume & freight volume by mode

Average percentage (%)	Rail	Road	IWT	Marine	Aviation
Freight volume	2.47	65	25.5	7	0.03
Freight traffic volume	3.5	15.7	27.3	57.7	0.2

By comparing percentages of freight volume and freight traffic volume by each mode, some discussions are presented as follows. First, a large proportion of freight traffic volume is carried by maritime (57.7%) while freight volume occupies only 7% by the same mode. This means that this mode has been used for long-haul transportation. Second, road mode has been used for short – distance transportation. Besides, rail and aviation transport modes are not seemly favorable selection for freight transport. The inland waterway mode is very useful due to geographical conditions of Vietnam, especially in the two big deltas.

3.4.2 Domestic freight transportation costs

The domestic freight transportation costs vary depending on types of cargo, transported volume and distance, as well as the transportation modes. Cargo types and domestic freight transportation costs by each mode are presented as in following tables.

<Table 3-6> Cargo categories

Type	Description
I	Empty container, soil, salt, rubble, furniture …
II	Containers (full), coals (except coke), iron ore, waste materials, waste paper, crude apatite, cement, fertilizes …
III	Coke coal, asbestos, grain, metals, …
IV	Motorbike, rubber, ashlars facing stone,
V	Electronics devices, car, high–glass house wares, enameled, …

<Table 3-7> Domestic freight transportation costs by road (*USD/ton.km)*

	Type of cargo			
km	**Type I**	**Type II**	**Type III**	**Type IV**
1 - 5	0.49	0.59	0.64	-
6 - 10	0.28	0.33	0.36	-
11 - 15	0.23	0.28	0.30	-
16 - 20	0.19	0.23	0.25	-
21 - 30	0.15	0.18	0.20	-
31 - 40	0.12	0.15	0.16	-
41- 50	0.12	0.14	0.15	-
51 - 60	0.12	0.14	0.15	-
61 - 70	0.11	0.14	0.15	-
71 - 80	0.11	0.14	0.15	-
81 - 90	0.11	0.13	0.15	-
91 - 100	0.11	0.13	0.14	-
101 up	0.11	0.13	0.14	-

Converted rate: 1 USD = 16,500 VND
'-': data are not available
Source: data are collected and compiled from circulars of government

<Table 3-8> Average domestic freight transportation costs by rail (*USD/ton.km*)

Type of cargo				
Type I	**Type II**	**Type III**	**Type IV**	**Type V**
0.0215	0.0237	0.0258	0.0285	-

Source: Vietnam Railways Company

<Table 3-9> Domestic freight transportation costs by air, coast, and inland waterways

Mode	Cost	Unit	Remark
Air: - Normal - Bulky	 875.31 1,312.96	USD/ton	Applied for all domestic distances
Coast	0.038	USD/ton.km	
Inland waterways: - First 30 km - 31 km up	 0.11 0.0252	USD/ton.km	

Data are collected and compiled from many sources

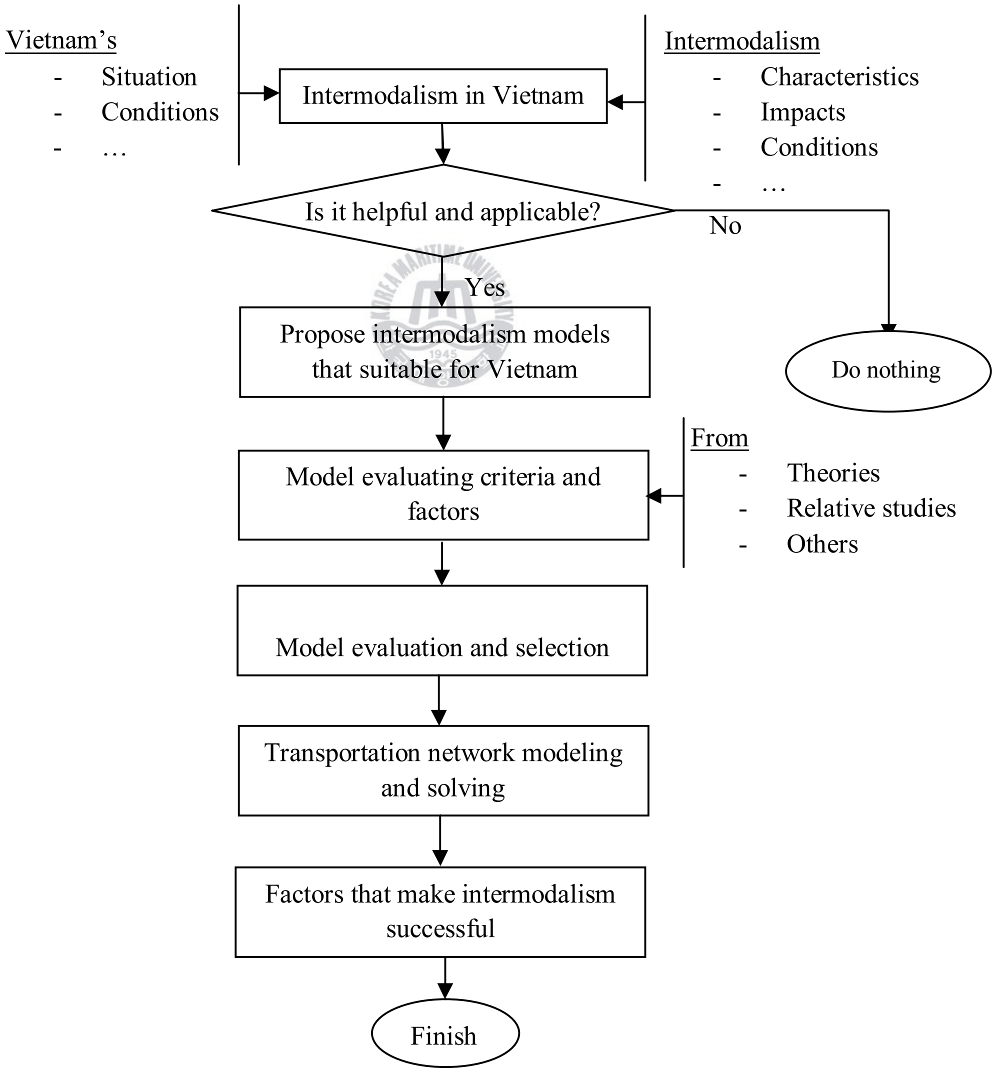
Chapter 4: Methodology

4.1 Description of the methodology

The study concerns answering following questions.

- Whether intermodalism is helpful and applicable regarding the Vietnam situation and conditions?
- Which models should be applied and how to evaluate them?
- How to make it successful?

They will be answered based on a series of analysis, investigation, evaluation, and et cetera. The flow chart of methodology is illustrated as in Figure 4-1.



<Figure 4-1> Flows chart

4.2 An analysis of intermodal applicability in Vietnam

This section aims at the answer of whether intermodalism is helpful (necessary) and applicable in Vietnam. To begin with, it is obviously that the demand of domestic freight transportation continues to grow steadily, about 12% annually (See Table 3.3). It has been placing increasing pressures on transportation infrastructures such as ports, airports, and highways. There is an unbalance among modal selected for freight transportation. For instances, 65% of freight volume are carried by trucks; 25.5% by inland waterways; 7% by marine; 2.47% by rail; and only 0.03% by airways. Besides, the demand of freight transportation increases continuously while transportation infrastructure development rate is lagging behind. Applying intermodalism will help utilizing the existing resources.

As mentioned in chapter 2, applying intermodalism brings about many benefits, such as lower transportation costs so produces more benefits, and potentially faster delivery time will improve customer service levels. Together with the economic development in Vietnam nowadays, more and more manufacturing plants have been built. More than ever companies recognize deeply that by concentrating on logistics activities they will stay competitive. Therefore, intermodalism is a good choice. Policy makers have also paid attention to intermodalism for national and regional economic developments. The ASEAN Transport Cooperation Framework Plan (1999-2004) was designed to achieve a fluid, integrated and coordinated transportation system in the region by infrastructure development, transportation services promotion, and so on. Subsequent to the plan the ASEAN Transport Plan of Action 2005-2010 was released so that strengthens the importance of intermodalism.

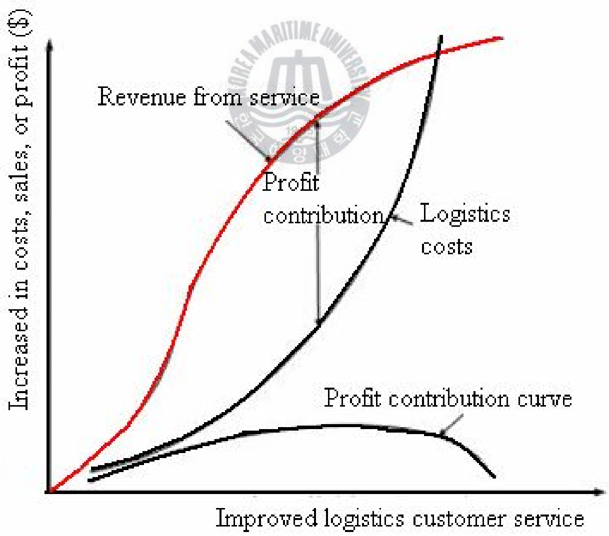
Intermodalism is also welcomed as a more environmentally acceptable solution for traffic congestion and pollution. It reduces the fuel consumption since the long-haul section of the route is more fuel efficiency; then pollution is reduced.

In addition, with the geographical conditions that long and having two large deltas at two sides, and convenient for transporting by any mode such as road, rail, water, and air, Vietnam is suitable for developing intermodalism. Therefore, applying intermodalism is one of the best approaches because it not only brings about many benefits, but also utilizes the existing resources. Integrating the modes and using each to its best advantages is a strategy to optimize the existing resources and to create new capabilities (Szyliowicz, 2000).

4.3 Model selection and evaluation methodology

4.3.1 Selection factors

One of the most important things that managers want to reach when they design freight transport networks is meeting the customer's needs at the lowest costs. Customer service level is determined by the general managers when they make strategic plans. Response time, freight safety, and flexibility are usually used to evaluate the customer service level. The higher is customer service quality provided, the more is revenue received. Sales are affected to some degree by the level of logistics customer service provided. With benefit companies, general managers try to search an optimum customer service level, so as to get a maximum benefit. There is a trade-off between the customer service level that they want to reach and investment costs to have that level. Based on that level, logisticians find out the optimum transport model with the lowest cost. These relations are described in Figure 4.2 (Ballou, 1992).



<Figure 4-2> General cost-revenue trade – offs at varying levels of logistics customer service

The supply chain capacity is of little value if infrastructure is constrained. The transportation network cannot be successful if it affects badly to environment. In addition, expanded capacity is another important factor used to appraise the "quality" of transportation systems. With all what mentioned above, in this study, to evaluate suitable and quality of intermodal freight transport models, these factors will be used, including in Table 4-1.

<Table 4-1> Factors used to evaluate intermodalism models

No.	Factor	Description	Evaluation criteria
1	Costs	The collection, distribution, line hauling, and transshipment of units moved within intermodal system determine the transportation costs.	Minimize (As low as possible)
2	Average delivery time	Time between when customer places and receives an order.	Minimize (As fast as possible)
3	Absolute delivery time variability	A measure of the uncertainty in carrier performance.	Minimize (As small as possible)
4	Loss and damage	The ability to adapt or flexibility response to different circumstances.	Minimize
5	Flexibility	Constrained on and coordination of infrastructure capacity. Transport system's appropriation with individual applying conditions.	Maximize
6	Infrastructure appropriation	Development capacity of systems in the future.	Maximize
7	Expanded capacity	Including noise, pollution, congestion, traffic accidents	Maximize

4.3.2 Market segmentation

Based on Vietnam's particular geographic, popular, and economy, in this study, Vietnam's market is divided into three main economic centers: the north, middle (center), and south of Vietnam.

Vietnam's north market includes main cities and provinces in the Red River Delta area such as Ha Noi, Hai Phong, Thai Binh, Hai Duong, and provinces in adjacent areas such as Ha Giang, Cao Bang, Dien Bien, Lai Chau. It is the second biggest market with approximately 30 million people and more than 100,000 kilometers in square. Hai Phong port is the main port of this area, which is one of the biggest and most modern ports of Vietnam. Its center terminal can serve 11 vessels at the same time with cargo throughput of 6 million tons per year. Noi Bai international Airport is the second biggest airport of Vietnam. Its terminal capacity can serve 4,000 customers at the same time with 2 runways. The railway system goes through this area with many terminals such as Ha Noi, Giap Bat, Van Dien, which serves freight or customer transshipment. In addition, this area has a large Red River Delta with interlacing system of rivers and ditches.

The second main market segment is located on the middle of Vietnam, which includes Da Nang, Quang Ngai, Thua Thien Hue, Phu Yen provinces. Its popular is around 17 million people; area is approximate 84 thousand kilometers in square. Da Nang international Airport is the smallest airport among three international airports of Vietnam, but it is an important gateway to access central Vietnam. Besides, this area has one of the biggest ports of Vietnam, Da Nang ports with two terminals, Tien Sa terminal and Song Han terminal. Da Nang port can serve ships with size less than 45000 DWT, RORO ships, container ships, big and medium sized passenger ships. The system of rivers and ditches is shot and slopping with three main rivers, Han, Cu De, and Co Co. Thong Nhat railway goes through the central Vietnam with many terminals along the railway, such as Hue, An Cuu, Lang Co, Hai Van Bac.

The biggest market segment of Vietnam is located on the south of Vietnam, in which Ho Chi Minh City is the most dynamic and biggest economic center as well as the south of Vietnam. This area has more than 35 million people, and total area is around 130,000 kilometers in square. Mekong River Delta is the biggest flat country of Vietnam, which has an interlacing system of rivers and ditches. There are many ports in the south of Vietnam such as Sai Gon port, Sai Gon New port, Ben Nghe port. The total cargo throughput via only Ho Chi Minh ports is approximately 39 million tons, and container quantity is around 2.3 million TEUs, in 2006. The railway system goes through this area with many terminals along such as Sai Gon, Go Vap, Binh Trieu, Song Than, Trang Bom, Bien Hoa, and so on. In addition, located in this area, Tan Son Nhat international airport is the biggest airport of Vietnam. It is an important gateway of the south of Vietnam. The current capacity of this terminal is 7 million passengers per annum, and a new International Terminal is currently under construction with the first phase due for opening in 2007. When fully completed this four floor terminals will increase capacity to 8 million passengers a year and the total capacity of this airport will reach 15 million passengers per year.

With all what are mentioned above, in this study, the intermodal freight transportation networks are constructed based on the exchange of freight among three main markets located on the north, center, and south of Vietnam. The distances, travel times, and transportation cost between two of main markets are presented as in following table.

<Table 4-2> Distances and times between markets

Market segment	By Mode	Distance (km)	Time (hours)	Cost (USD/ton)
North – South	Road	1710	42.75	239.4
	Rail	1726	41.5	44.53
	Air	1138	2	875.31
	Coast	1485.55	67	56.45
North – Middle	Road	763	19.1	106.82
	Rail	791	19.5	20.41
	Air	606	1.25	875.31
	Coast	570	26	21.66
South - Middle	Road	947	23.68	132.58
	Rail	935	20	24.12
	Air	603	1.17	875.31
	Coast	959	43	36.44

Data are collected and compiled from many sources

4.3.3 Evaluation and selection method

Intermodal freight transportation models are proposed and evaluated based on factors mentioned in section 4.4.1. Due to the lack of data related to costs such as the transshipment costs between modes, models will be evaluated by using qualitative method.

Therefore, in the next chapter, intermodal freight transportation models will be proposed concerning current conditions of Vietnam and market segments. They will be analyzed and then evaluated based on previous analysis. A survey questionnaire, then, will be developed and send to experts who work and have expertise knowledge on the focused field. Besides, evaluation was done based on comparisons among intermodal models and a basic model, road model. With parameters shown as in Table 4-2, a suggested rank score was shown as in Table 4-3.

<Table 4-3> A rank score for evaluating models

	Evaluated level				
Factor	Very bad	Bad	Normal	Good	Very good
Cost	>150%	111 - 150%	91 - 110%	51 - 90%	< 50%
Time	>180%	121 - 180%	81 - 120%	21 - 80%	< 20%

In addition, each model has its owned advantages and disadvantages, and they are suitable for a certain type of products. Besides, carriers may have different interest on evaluation factors, so AHP technique is introduced to select a model based on a certain scenario.

Chapter 5: Model Proposition, Selection, and Evaluation

5.1 Model proposition

Recently, motor vehicles play a potential role in the freight transport industry. In Vietnam, most freight is transported by road-network systems. Cargo is moved directly or indirectly from original locations to destinations by motor vehicle mode. It is called door-to-door service. In this transportation network, motor vehicles, trucks, are mainly used. The most important advantage of this mode is flexibility. With small size, and not depending on geographic or infrastructure like train mode, air mode, or water mode, it can receive cargo from origin sources and deliver to final customers without transfer terminals. It is really useful in short-haul transport.

However, it does not have enough “quality” to compete with other kinds of freight transport models when it is used to transport freight on the long distance. Its transportation costs are higher than train mode or water mode. In addition, because of Vietnam’s underdeveloped highway system, it does not permit freight transport quickly (Heavy truck’s allowing maximum speed on the highways with barrier is 60 kilometers per hour, and without barrier is 50 kilometers per hour), so response time tends to long. Besides, because of limitation of Vietnam’s highway system, it is difficult to expand this network. Air pollution, noise, accident, and congestion make this network become unfriendly with environment. With all of disadvantages mentioned above, appropriating to Vietnam’s characteristics some intermodal freight transport models are considered, evaluated, and suggested.

Based on three main market segments of Vietnam and evaluating factors, each intermodal transport is now described and discussed on its strong and weak points.

5.1.1 Road-Rail-Road transport system

In this model, freight is collected from many origin locations mainly by trucks. At gathering locations, it is passed through many processing needed activities; then, it is transported on the long-haul by train. Freight, at final terminals, is unloaded and transited to road mode (trucks). Finally, it will be distributed to customers by trucks.

One of the best advantages of this transport network is Vietnam’s rail system connecting through north to south areas, which is managed by VNR, Vietnam

Railway Corporation. In the future, there are many developing, extending, and modernizing plans by government organizations. It is premise for researching, constructing road-rail-road models. A promising rail-road-rail model, constructed in Vietnam, is shown in Figure 5-1.

Road-rail-road transport system is one of the transport systems with the lowest transportation costs, due to the economy of scale. Actually, it is lower than trucks' transportation costs. In addition, because of Vietnam's geographic and infrastructure, relative to response time this model is better than truck transport model. On the long-haul transportation, rail-transportation is faster than truck-transportation. For example, from the north to the south of Vietnam and vice versa, average total transport time by rail mode is 40 hours; if freight is transported by trucks, it takes, average, 84 hours. Depending on the type of energy used by modes, environment effects are different. In general, however, this system's effect is evaluated at a medium level, but it is friendlier than road-network. This system is suitable for cargoes which do not require special preventing environment, hardly damage, large quantities of heavyweight and low value, such as coal, chemical, transportation equipment, farm products, and so on. Besides, there are many terminals along the railway system, distributed from the north to the south. It is easy to establish one or more suitable intermodal terminals for the road-rail-road model in any market segment.

<Figure 5-1> Road – Rail – Road

5.1.2 Road-Coast-Road transport system

It is a combination of transportation by road and coast ways. Such a system has proven to be financially and socially beneficial in many parts of the world. This system earns the advantages of the flexibility of road mode and the economy of scale of sea-transport one. Freight is concentrated in terminals from many sources by trucks; consequently, goods were processed, packaged, and loaded on the ships. On the long-haul transportation, freight will be transported by sea-mode; then, road modes will be used to delivery cargoes to customers. Flow products of this system are described in Figure 5-2.

Like road-rail-road model, economy of scale is an advantage of this model, because of using sea-modes for moving freight on a long distance. Transportation cost is lower than road-rail-road system, because transportation cost by ship is lower than by train on the same long way distance. In addition, Vietnam's geographic is a suitable nature condition for this model. It has a long and wide coast with many sea-ports through the North to the South. Road-coast-road transportation network is a model friendly with environment, because congestion is not a problem, with little noise. Extending capacity in the future is advantage, because the Vietnam's government has many policies supporting new port investment in the future.

Vietnam's infrastructure is underdevelopment, especially high way systems as well as rail network, so using nature ways based on geographic characteristics for freight transportation is a good alternative. However, because ship is a slow speed mode, and it takes a long time for loading and unloading from trucks to ships and vice versa, in general, response time is one of the weak points of this model. On the other hand, relative to Vietnam's geographic, total transport distance by coast way from Ha Noi or Hai Phong to Quang Ngai nearly equal a half distance by roadway or railway, response time is not a serious disadvantage of this transportation model. In addition, this model is strongly belonged to seaport systems. It is a viable model of transportation for the movement of products and especially basic raw materials, suitable for movement of bulk commodities such as grains, coal, ores, and chemicals.

<Figure 5-2> Model Road-Coast-Road

5.1.3 Road-Air-Road transport system

Long response time is the general weak point of two models above as well as inland waterway-coast-inland waterway mentioned later. With road-air-road model, response time is a strong point. Freight, after gathered by trucks, will be transported by airplane through the long-haul distance; then, transported to destination locations by trucks. Airplane is the fastest transportation mode, so moving time on the long-haul tends to the shortest when road-air-road system is used. It is really advantageous to moving on the long distance, so the intermodal freight transport should be constructed with three intermodal airport terminals, Tan Son Nhat airport, Noi Bai airport, and Da Nang airport. This model is described in Figure 5-3.

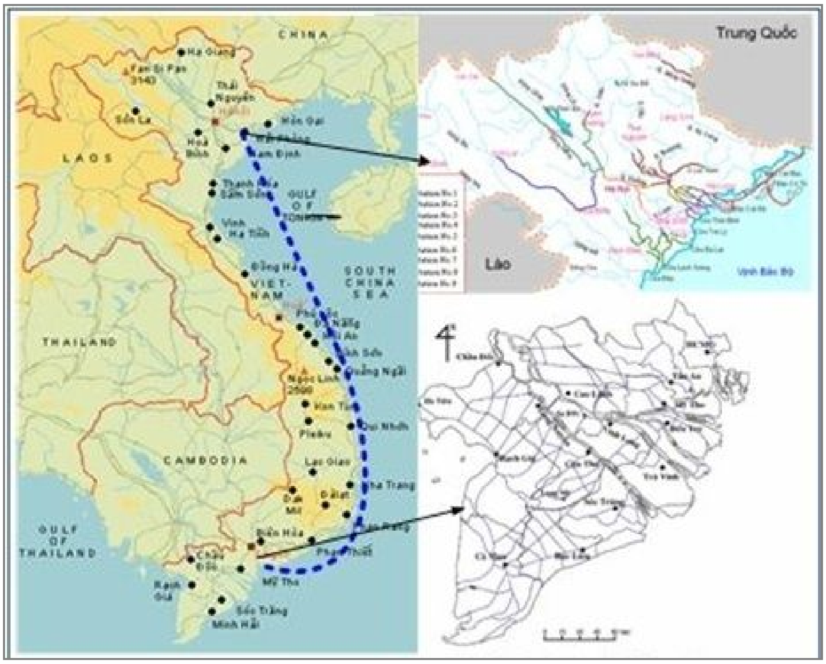
Transportation costs are really the most expensive among the considering intermodal systems, which include terminal's costs. In addition, because of underdevelopment infrastructure especially in Vietnam's airport system, its infrastructure appropriation is evaluated at a low level. However, in future, with many plans extending and upgrading airport terminals, it supports the development of road-air-road system. Besides, it is one of transportation models that are unfriendly with environment, because of directly increasing greenhouse effect. In addition, its flexibility is evaluated at a low level, because it strongly depends on airports.

Road-air-road network is well suited for fast moving, high value, perishable, emergency, or needed high safety level items, such as mail, clothing, communication products and parts of photography equipment, mushrooms, fresh flowers, expensive automobile, jewelry, and so on.

<Figure 5-3> Road – Air – Road

5.1.4 Inland waterway-Coast-Inland waterway transport system

It is constructed based on Vietnam's special geographic. In this model, natural inland waterway networks of the big flat countries in the south and the north are used as natural way transport networks. Small ships are utilized to collect freight from origin resource locations; consequently, big ships are used to transport cargoes on the long-haul distance. Finally, goods are distributed to customers by small ships though inland waterway networks. This model focuses on two inland waterway networks at the north and south of Vietnam. The product flows of inland waterway-coast-inland waterway network are shown in Figure 5-4.



<Figure 5-4> Inland waterways – Coast – Inland waterways

The most advantage of inland waterway-coast-inland waterway is transportation costs. Transporting freight by water way is the cheapest way, so this model has the cheapest transportation costs. This network is really suitable to Vietnam's geographic, which has two big flat countries, the Mekong River Delta and the Red River Delta. Both of them have interlacing rivers and ditches networks appropriating for river traffic. Besides, it is one of the freight transport models so friendly with environment.

Transportation time tends to long, because river traffic speed, in general, is slow. The nature water ways determine the network's structure as well as it belongs to water ports. Such a network is best suitable for low moving items or items which are cumbersome items with low value, especially basic raw materials.

5.2 Evaluating intermodal freight transport network design

Logisticians should consider freight's characteristics, customer service level that needs to meet, individual country's infrastructure, and transportation network's features before they make decisions to choose the best suitable transportation network. Most companies, countries, or areas are best served by combination of transportation networks based on many conditions.

Companies or organizations determine the freight transport network suitable to their capacity, characteristics, and objectives that they want to reach. They can construct one or more models simultaneously. With different freight, different transportation models can be used.

In addition, belonging to geographical market segmentation that companies want to service as well as performance characteristics of intermodalism networks, the most suitable distribution model will be chosen and applied for freight transportation among them. The suitability of the different intermodalism models in exchange of freight between north and middle, middle and south, or south and north market segments of Vietnam is considered in detail and following.

5.2.1 North-Middle market segment

Because of Vietnam's geographic, average total transport distance by coast way (570 kilometers from Haiphong port to Danang port) is equal around 72% by railway (791 kilometers from Hanoi to Danang), and a little shorter than by airway (606 kilometers Noibai airport to Danang airport) on the long haul. Besides, there are existing road network systems in the north and the middle, so collection and delivery freight by roadway are carried out easily. On the other hand, interlacing rivers and ditches network in the north market with Mekong River Delta is an advantage for constructing a freight transport network by inland waterway, but in the middle market transportation by inland waterway is not a favorable alternative. There are road network systems as well as railway systems and airports in this market segment, but average total transport distance by railway or airway longer than coast way.

Transportation time on the long haul from north to middle and vice versa by coast way is 1 day 2 hours (from Haiphong port to Danang port and vice versa at ship's speed 12 nautical miles), by railway (from Hanoi to Danang and vice versa with TN train) is 18 hours 21 minutes, and by airway (from Noibai airport to Danang airport with Airbus) is 1 hour 15 minutes, approximately. In addition, clearly freight transport by IW absorbs longer time than by road way, because ship's speed (nearly 22kms/hour) is equal around ½ road's speed (average 40kms/hour).

Flexibility of freight transport by roadway is used in Road-Rail-Road, Road-Air-Road, and Road-Coast-Road models for gathering or delivering freight. However, the difference of flexibility of three models is freight transport on the long haul.

With Road-Rail-Road model, the terminal transfer links are easily set up and there are many rail terminals along the railway. On the other hand, Road-Air-Road model is strongly belonged to airports (Noibai Airport and Danang Airport), and they are usually located far from the center of main markets. Another model is not strictly belonged to terminals like Road-Air-Road model, but it is still belonged to limited number as well as characteristics of seaports with two main seaports, Haiphong seaport and Danang seaport. With IW-Coast-IW model, in the middle market, collection or delivery of freight by IW is not a good alternative, because the inland waterway network is not suitable.

Using waterway to transport freight is the cheapest alternative. For collecting or delivering goods, transportation costs by inland waterway are very cheaper around 5.4 times than by roadway. On the long haul from north to middle, average total transport distance by coast way is the shortest way (mentioned above), and its transportation costs are cheapest (equal 35% by railway). On the other hand, using airplane to transport freight is the most expensive way. Because of special geographic characteristics of north-middle market segment, average total transport distance is a little longer than by seaway. Freight transportation costs on the long haul by train or ship are very cheaper than by trucks; from the north to the middle by railway it is approximately 9.5% by roadway.

In this market segment, based on special geographic, freight transportation on a long distance by coast way is the shortest and cheapest way among rail, coast, and air ways (mentioned above). In addition, many developing seaport projects are supported by government. Many important industrial areas have been constructed, and operated such as Dungquat. Because of limitation of the inland waterway network in the middle market, expanded capacity of IW-Coast-IW model is restricted. With Road-Air-Road model, total transportation distance on the long haul is not enough long to manifest its fastest speed advantage. Finally, although transportation time of the Road-Rail-Road model is around 30% shorter than of the Road-Coast-Road model, its transportation costs are not enough to compete with Road-Coast-Road model because of total transport distance on the long haul.

In the north market, with underdevelopment roadway systems, congestion, accidence, pollution, and so on make collection and delivery freight by roadways unfriendly with environment. In the other hand, using inland waterway is better in this aspect, based on interlacing rivers and ditches networks of Red River Delta. Besides, on the long haul, actually using coast way is friendlier with environment than railway or airway.

With all characteristics mentioned above, experts including authors proposed ranking scores for all the models as in Table 5-1.

<Table 5-1> Evaluating models' performance for the first market segment

Factor		Intermodal freight transport model			
		(I)	(II)	(III)	(IV)
Cost [a]	1 = Lowest	2.17	2	5	1.67
Average delivery time [b]	1 = Fastest	2.67	3	1.5	4.33
Absolute delivery time variability	1 = Least	3	3.17	2	4
Loss and damage	1 = Least	3.33	3.17	1.83	4
Flexibility	1 = Highest	2.67	3.5	3.17	4
Infrastructure appropriation	1 = Best	2.83	2.17	3.5	4.17
Expanded capacity	1 = Highest	3.17	2.83	3.83	4.5
Environment impacts	1 = Least	3	2.17	2.5	1.83

(I): Road-Rail-Road
(II): Road-Coast-Road
(III): Road-Air-Road
(IV): Inland waterways-Coast-Inland waterways
[a]: Cost per ton-km
[b]: Door-to-door speed

5.2.2 Middle-South market segment

On the long haul, transport freight by airway is the shortest way. Average total transport distance by airway is 603kms (from Tansonnhat airport to Danang airport), equal 65% by railway (935kms (from Danang to Saigon) and 63% by coast way (959kms from Danang to Hochiminh). It is suitable to establish intermodal transport models. Similar to North-Middle market segment, the south and middle markets have road systems suitable for gathering or delivering goods, but they are under development. In addition, there are rail terminals, seaports, and airports in the center and south of Vietnam. With Road-Air-Road model, especially its average total distance on the long haul is equal a little more than a half by others. Although in the south of Vietnam there is an advantageous inland waterway system, in the middle of Vietnam it is not a favorable condition.

Flexibility of roadway is used in the stages of collection or delivery freight. Recently, Saigon railway terminal is located nearly the center of Hochiminh city as well as some seaports such as Tancang, Saigon, and Ben Nghe. Hochiminh city is the center of south market, so it is an advantage for gathering or delivering freight.

Road-Air-Road model is strongly belonged to airports. With IW-Coast-IW model, in the south area, interlacing rivers and ditches networks make it easy to establish transport freight networks, but it is limited with inland waterway system in the center.

Because rail terminals, seaports, and airports are located closely to the center of Hochiminh city, one of the biggest and most dynamic cities of Vietnam, traffic jams, pollution, noise, and accidence are serious problems. Using waterway to transport freight is a good alternative in this occasion. On the long haul transport, ship is evaluated friendlier than train or airplane.

Response time in this market segment is an advantage of Road-Air-Road model. Average transportation time on the long haul by airway (1 hour 10 minutes) is only equal around 5.8% by railway (around 20 hours) and 2.7% by coast way (1 day 19 hours). Transportation time between the south and the center of Vietnam by train is equal approximately ½ by ship. With IW-Coast-IW model, not only does transportation freight on the long haul by ship take the longest time, but also does using ship to collect or deliver freight absorb more time than using trucks.

Transportation costs for gathering and distributing cargoes by inland waterway is approximately 18.6% by roadway. Besides, on the long haul in this market segment, using ship is the cheapest alternative. Its transportation costs are around 35% by using train, and absolutely it is cheaper than using airplane for exchange of freight between the middle to south markets.

Although IW-Coast-IW model is considered as the cheapest transportation model, similar to the north-middle market segment, inland waterway systems in the middle market are limited. With Road-Air-Road model, because of geographic in this market segment, its transportation time and distance are remarkable characteristics for competition. The government of Vietnam supports to develop seaports especially in the north market. Transportation distance on the long haul is more than 900 kms by both railway and seaway. It is a suitable condition for applying Road-Rail-Road model and Road-Coast-Road model. The results of the evaluation are stated in Table 5-2.

<Table 5-2> Evaluating models' performance for the second market segment

Factor		Intermodal freight transport model			
		(I)	(II)	(III)	(IV)
Cost [a]	1 = Lowest	2.67	2	4.83	1.67
Average delivery time [b]	1 = Fastest	2.5	3.67	1.67	4.33
Absolute delivery time variability	1 = Least	2.67	3.5	2	3.33
Loss and damage	1 = Least	3.33	2.83	1.67	4.17
Flexibility	1 = Highest	2.17	3.5	4.33	4.5
Infrastructure appropriation	1 = Best	2.67	2.83	3.67	4
Expanded capacity	1 = Highest	2.83	2.33	3.67	3.67
Environment impacts	1 = Least	3	2.17	3	1.67

5.2.3 North-South market segment

The difference of the intermodalism models is obviously presented in this market segment. On the long haul, by airway total transportation distance is 1138 kms (between Noibai airport and Tansonnhat airport), and average total transportation time is 2 hours which is approximately 5% by railway (1 day 15 hours 50 minutes from Hanoi terminal to Saigon terminal), and 3% by coast way (2 days 19 hours from Haiphong port to Saigon ports). Transportation time only on the long haul by ship is the longest time, nearly 3 days, and using inland waterway to collect and deliver freight absorbs more time than using roadway. On the long haul, although average total transportation time by railway is around 60% by coast way, it still needs a long time nearly 40 hours.

On the other hand, with IW-Coast-IW model transportation costs are a strong point for competition. Actually, not only is using inland waterway cheaper nearly 5 times than using roadway, but also is transportation freight by ship the cheapest way especially in this market segment. On the contrary, if goods are transported by airway in this market segment, transportation costs are approximately 378USD/ton. In the same situation, if railway is used to transport commodities, it is 30 times less expensive. Actually, it is more expensive than coast way. Obviously, because of economy of scale, on the long haul more than 1000 kms, transportation costs by railway is less nearly 14 times than roadway.

With two natural inland waterway systems on the north and the south of Vietnam, it is a specific condition for constructing IW-Coast-IW model. According to underdevelopment road network systems, especially in two big market places, Mekong River Delta and Red River Delta flat countries, different from others market segments its infrastructure appropriation is considered at a very good level. Two biggest airports, Tan Son Nhat and Noi Bai, locate on two biggest cities of Vietnam. There are main seaports in Haiphong city and Hochiminh city. Besides, railway systems connect the south market and the north market. Together with existing road network systems which are major ways to collect or distribute freight.

Road network systems and inland waterway systems are advantageous conditions for collecting and delivering freight in the north and the south markets. Except Road-Air-Road model, logisticians are easy to constructing transfer terminals for other models, because in this market segment there are suitable seaports and rail terminals. Although activities of Road-Air-Road are belonged to two main airports, both of them locate nearly two big cities, so delivery and collection of freight is done easily.

Each model has individual advantageous characteristics which are manifested clearly in this market segment. Exchange of goods between the north and south markets increases along with the economic development. Economy of IW-Coast-IW model or Road-Coast-Road model, or speed of Road-Air-Road model is special peculiarities for expanding. Railway network systems are out of date and difficult to upgrade.

Congestion, pollution, noise, and accidence are serious problems of two biggest cities of Vietnam as well as of this market segment. Therefore, using inland waterway networks for gathering and delivering freight are better than using road networks together with using ship friendly with environment. On the other hand, because railway systems of Vietnam are under development, their effects are evaluated unfriendly with environment. Airway directly makes greenhouse effect.

Evaluation of the intermodal freight transport models in this market are summarized as in Table 5-3. Questionnaires are provided by experts who work in transport industry and know clearly Vietnam's conditions and author. They are average results of all of them. Detail information is presented in Appendix 1.

<Table 5-3> Evaluating models' performance for the third market segment

Factor		Intermodal freight transport model			
		(I)	(II)	(III)	(IV)
Cost [a]	1 = Lowest	2.33	1.83	5	1
Average delivery time [b]	1 = Fastest	3.17	3.83	1.17	5
Absolute delivery time variability	1 = Least	3	3.83	2	4.67
Loss and damage	1 = Least	3	2.83	1.33	4
Flexibility	1 = Highest	2.83	2.83	3.83	2.83
Infrastructure appropriation	1 = Best	3.17	2.67	3.5	2.83
Expanded capacity	1 = Highest	2.67	2.5	3.17	2.33
Environment impacts	1 = Least	3.5	2.17	2.5	1.33

It is obvious that none of them dominates the others concerning all factors. Selecting an intermodal model, therefore, is not an easy task. Depending on products' characteristics and company's objectives, some multi-criteria decision making (MCDM) or multi-objective decision making (MODM) techniques should be applied. In the next section, an AHP (Analytic Hierarchy Process) technique is proposed to deal with this matter.

5.3 Model ranking based on AHP method

As mentioned above, companies may have different interests on evaluation factors or in other words, they have set different priority levels to factors. In this section AHP is used to rank modes based on a certain carrier's interest. The brief introduction of AHP, and its principle, as well as detailed calculation steps are presented in Section 2.4.2 with a numerical example.

The calculation in this section is supported by Expert Choice 9.0, which is also introduced in Section 2.4.2.

In this thesis, four intermodal models have been proposed for three different market segments, and the decision of which model should be selected are depended on product's characteristics, company's objectives (priority for each factor), as well as market segment. Therefore, some assumptions should be mentioned as follows.

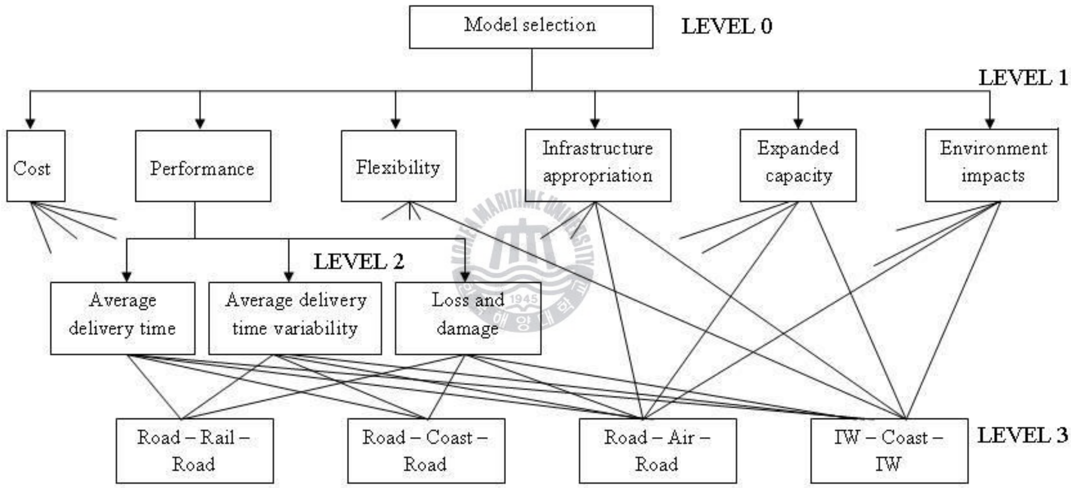
Notations:

- This section aims to show an example that illustrates the model selection for the North – South market segment only.
- Models are considered under multi-criteria as mentioned before.

- As mentioned in section 2.4.2, with the support of Expert Choice 9.0, users only have to construct the decision hierarchy, comparison matrices, and check the consistency ratio at each level; all the calculations will be done and displayed by software.
- For illustration purpose, author has sent a survey to companies which are operating in freight transportation industry to get data. The data in the comparison matrices of level 1 and level 2 therefore are obtained from a company, and the whole data are shown in Appendix. Comparison matrices for level 3 are constructed based on evaluation from Section 5.2.

5.3.1. AHP model construction

The AHP decision hierarchy:



<Figure 5-5> AHP decision hierarchy

As mentioned above, Table 5.4 and Table 5.5 show the relative importance levels among objectives by company 3, and they handle mainly products type II and type III.

Table 5.4: Comparison matrix for level 1

	Cost	Performance	Flexibility	Infrastructure	Capacity	Environment
Cost	**1**	2	2	3	4	5
Performance		**1**	1	1/3	2	3
Flexibility			**1**	2	2	4
Infrastructure				**1**	3	4
Capacity					**1**	2
Environment						**1**

Consistency ratio = 0.05 << 0.1 → Acceptable.

<Table 5-5> Comparison matrix for level 2

	Average delivery time	Absolute variability	Loss and damage
Average delivery time	**1**	1	¼
Absolute variability		**1**	1/3
Loss and damage			**1**

Consistency ratio = 0.01 << 0.1 → Acceptable.

Generally, the model comparison matrices at lower level (level 3) under each selection factor are established based on relative judgments that presented in Table 5-1, 5-2, and 5-3. Since this problem deals with the North-South market segment only, the data in Table 5.3 are used to construct pair-wise comparison matrices for intermodal models under each factor, which are presented as in Tables from 5-6 to 5-13.

<Table 5-6> Comparison matrix for intermodalism models under factor of cost

	I	II	III	IV
I	1	1.83/2.33	5/2.33	1/2.33
II		1	5/1.83	1/1.83
III			1	1/5
IV				1

Consistency ratio = 0.00 < 0.1 → Acceptable.

<Table 5-7> Comparison matrix for intermodalism models under factor of average delivery time

	I	II	III	IV
I	1	3.83/3.17	1.17/3.17	5/3.17
II		1	1.17/3.83	5/3.83
III			1	5/1.17
IV				1

Consistency ratio = 0.05 < 0.1 → Acceptable

<Table 5-8> Comparison matrix for intermodalism models under factor of absolute variability

	I	II	III	IV
I	1	3.83/3	2/3	4.67/3
II		1	2/3.83	4.67/3.83
III			1	4.67/2
IV				1

Consistency ratio = 0.00 < 0.1 → Acceptable

<Table 5-9> Comparison matrix for intermodalism models under factor of loss and damage

	I	II	III	IV
I	1	2.83/3	1.33/3	4/3
II		1	1.33/2.83	4/2.83
III			1	4/1.33
IV				1

Consistency ratio = 0.00 < 0.1 → Acceptable

<Table 5-10> Comparison matrix for intermodalism models under factor of flexibility

	I	II	III	IV
I	1	1	3.83/2.83	1
II		1	3.83/2.83	1
III			1	2.83/3.83
IV				1

Consistency ratio = 0.00 < 0.1 → Acceptable

<Table 5-11> Comparison matrix for intermodalism models under factor of infrastructure appropriate

	I	II	III	IV
I	1	2.67/3.17	3.5/3.17	2.83/3.17
II		1	3.5/2.67	2.83/2.67
III			1	2.83/3.5
IV				1

Consistency ratio = 0.00 < 0.1 → Acceptable

<Table 5-12> Comparison matrix for intermodalism models under factor of expanded capability

	I	II	III	IV
I	1	2.5/2.67	3.17/2.67	2.33/2.67
II		1	3.17/2.5	2.33/2.5
III			1	2.33/3.17
IV				1

Consistency ratio = 0.0 < 0.1 → Acceptable

<Table 5-13> Comparison matrix for intermodalism models under factor of environment impacts

	I	II	III	IV
I	1	2.17/3.5	2.5/3.5	1.33/3.5
II		1	2.5/2.17	1.33/2.17
III			1	1.33/2.5
IV				1

Consistency ratio = 0.00 < 0.1 → Acceptable

5.3.2 Results

By applying supported computer software Expert Choice 9.0, obtained results are presented as follows.

Overall consistency index = 0.03 < 0.1 → Hierarchy is consistent.
Aggregated weights for intermodal model are summarized as in Table 5-14.

<Table 5-14> Results and model ranks

Model	Aggregated weight	Rank
Road – Rail – Road (I)	0.230	3
Road – Coast – Road (II)	0.259	2
Road – Air – Road (III)	0.201	4
IW – Coast – IW (IV)	0.309	1

From obtained result, IW-Coast-IW combination should be used since it is ranked as the first.

5.4 Chapter discussions and conclusions

In this chapter, author has:

- Proposed four intermodal transportation models concerning Vietnam's conditions, which include road – rail – road, road – coast – road, road – air – road, and inland waterways – coast – inland waterways. These models are constructed for three market segments, which are the North – South, North – Middle, and Middle – South ones.
- Analyzed and evaluated these models concerning market segments based on many factors, which are costs, model performances, flexibility, infrastructure appropriation, expanded capacity, and environment impacts.

- In order to support decision makers to choose a model for certain types of cargoes under different favorable on evaluation factors (or different priorities), AHP method is proposed. An illustration example is also presented and solved. For a real world application, priorities or weight of each factor should be given by decision makers. From these data, pair-wise comparison matrices of level 1 and 2 will be constructed. Other pair-wise matrices are supposed to be kept. The solution is obtained in similar manner to support decision makers in selecting an intermodalism model.

Although mentioned problems have been carried out, there is another importance problem concerning consolidation/distribution at each market should be carried out. Therefore, this matter will be mentioned in the next chapter.

Chapter 6: Transportation Network Problems: An experience way to construct and solve

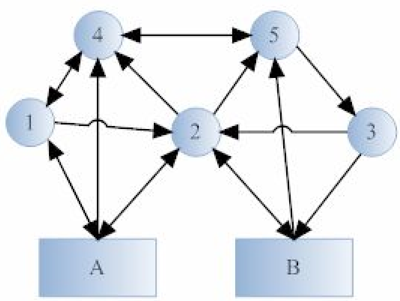
One of very important issues in intermodalism is freight collection and delivery. At each major market such as Hochiminh city, Danang, and Hanoi, companies have face with the decision that what the best routes for freight collection and delivery are because their customers are located scattered everywhere.

6.1 Transportation problem description

Freight from (to) different distribution (consolidation) centers is delivered (collected) to (from) a number of customers. It is of a great importance that ensures to delivery (collect) freight to (from) right place, in right time, at right customer demand. Determination of such a best transportation network is essentially required. At the highest level, the quality of the distribution network is evaluated based on two factors:

1. *Satisfying customer needs at the highest level*
2. *Minimizing cost of meeting customer needs*

With any distribution/consolidation network, the general characteristics are that freight is transported from one or many distributer(s) to one or many customer zone(s). Figure 6-1 is a simple distribution network with two distribution/consolidation centers A and B and five customer zones numbered from 1 to 5.



<Figure 6-1> An example of distribution/consolidation network

The transportation problem is defined as following: with the known number of demand locations and customer demands, in the limited number of distribution centers as well as their capacities, how the optimization transportation network is constructed, in which the best resource scheduling planning is suggested.

6.2 An experience-solving method

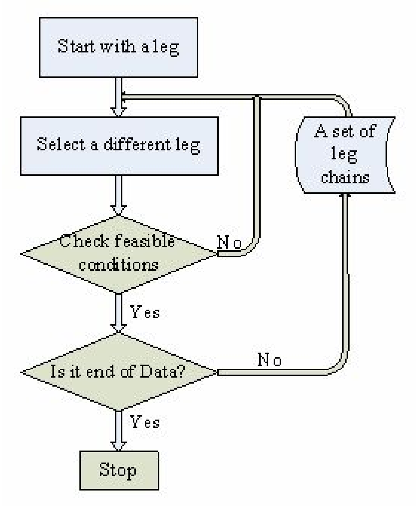
An optimum transportation network includes a number of tours which have to satisfy all requirements at the lowest used resources. A tour includes some legs which is responsible by a fleet. A leg is a segment of network, which locates between two locations. To simplify, the problem is solved through three main phases. First of all, a set of possible tours is generated; then a sub set of tours is determined based on it, which has to cover all of customer zones at the lowest total transportation costs; finally, it is assigned to minimum total of fleets. Each phase is described detail following.

a) Phase 1: generate a possible set of tours

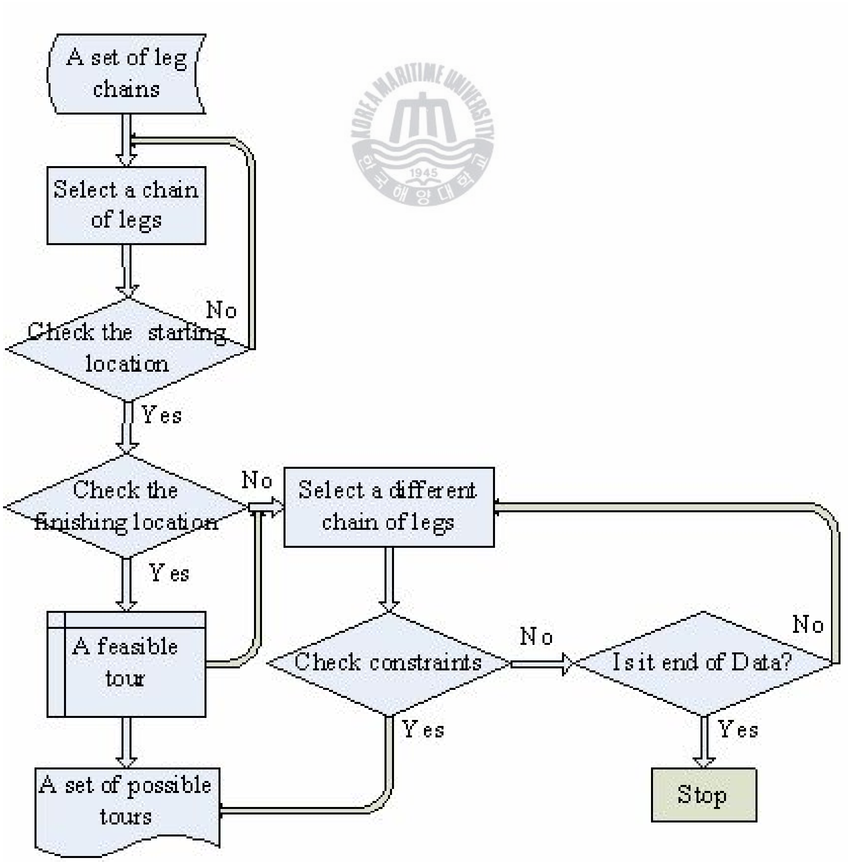
From relative data, a set of feasible tours is created, which includes as many as possible the number of tours. In this phase, the objective function is ignored. A feasible tour is a chain of legs satisfying all of constraints. Process of generating a possible set of tours goes through two steps.

In the first step, a set of chain of legs is created in a determined period, which has to satisfy constraints such as time, location, resources constraints; a starting or finishing point of any chain is either in any supplier point or customer zone point. Transportation legs were ordered following their starting time. Procedure started with the first leg, which could be considered as a leg chain with one leg. A suitable leg among remain legs, which satisfies some required constraints as mentioned above, was selected as an element of leg chains. This procedure was done until the end of the data. The final results of this step are a set of leg chains, which are temporary results and input data for next step. Process of this step is described in Figure 6-2.

In the next step, a set of possible tours is created. A tour is defined as a chain of legs, in which the starting and finishing points have the same distribution location. It is generated from the set of leg chains, results of step 1. All of required constraints have to be satisfied. A chain of legs was chosen if its starting location locates in any depot; If its finishing one locates in depot too, it could be considered as a feasible tour; If not, a different chain among remain others was considered as a candidate for making a possible tour. The process was repeated until all of data was checked. The results of this step are a set of feasible tours, which is solution space of problem. The procedure of this step is shown in Figure 6-3.



<Figure 6-2> Process of generating possible legs chains



<Figure 6-3> Process of generating possible tours

b) Phase 2: determine the optimizing alternative

An optimum alternative is determined in this phase, which has to cover all customer zones at the lowest total costs. From the set of possible tours, results of previous phase, an optimum sub-set of possible tours is determined, which does not violate any constraints. One of important things in this phase is the procedure of converting the original transportation problem model to integer programming model. Its objective is to minimize total costs, which satisfies equation (1). Subject to functions ensure that each customer zone has to be served as least one time, which are shown as equation (2).

Integer programming model:

Objective function: $\text{Min} \sum_{j=1}^{N} c_j x_j$ (1)

Subject to: $Ax = e_m$, $x_j \{0,1\}$ for $j = 1, \ldots, n$. (2)

$x_j \in \{0, 1\} \ldots 1$, if tour j is chosen

c_j is cost of tour j

e_m is a vector having m elements with value 1

m is the number of customer zones in solution

n is number of possible tours

A is matrix with its elements a_{ij}, in which

$a_{ij} = 1$, if leg i is included in tour j

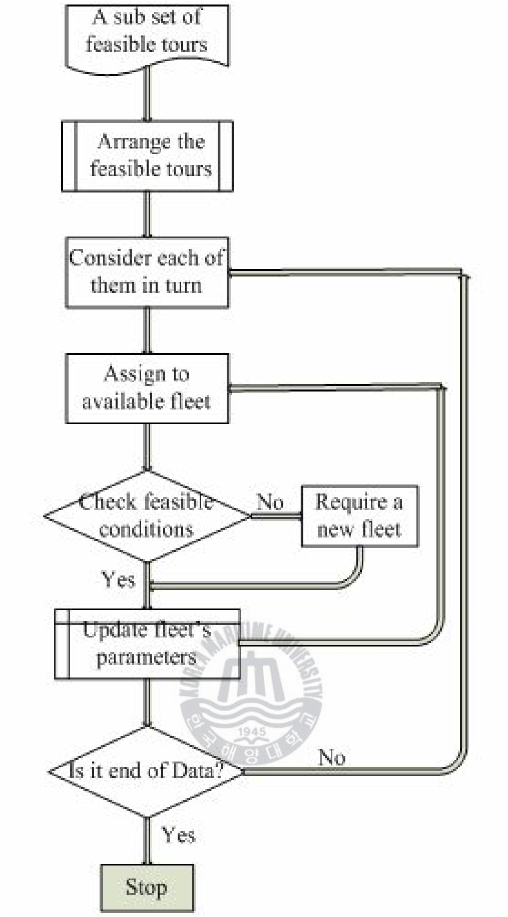
$a_{ij} = 0$, other.

Each row of matrix A presents a leg and each column of matrix A presents a possible tour.

An optimum transportation network is determined from this model by applying optimization methods. One of them is using optimization software, Lingo program. The main purpose of LINGO is to allow a user to quickly input a model formulation, solve it, assess the correctness or appropriateness of the formulation based on the solution, quickly make minor modifications to the formulation, and repeat the process. The way to apply this software is mentioned detail in the example section.

c) Phase 3: assign fleets

After determining an optimum transportation network, next step is to assign fleets to be responsible for them. A fleet is considered as a crew including required resources, which undertakes at least one tour. A sub-assignment problem is solved by an experience way, as in the Figure 6-4.

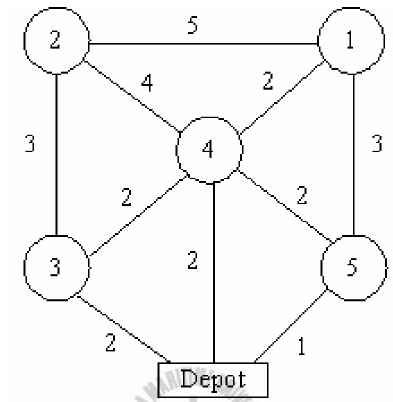


<Figure 6-4> Process of fleets-assignment

A set of feasible tours is to order following EDD (Earliest Due Date) rule. The tour with earliest finishing time is the first tour considered to assign to available fleets. This rule is used because of noting to relaxing time of fleets. If a tour has to be assigned by a fleet, among available fleets, which has a longer relaxing time, is to be responsible for it. A fleet could only undertake a tour if it satisfies some required conditions such as location, time, relaxing time, total working time, skill, and so on. If there are not any available fleets, which can undertake it, a new fleet is required. Parameters of fleets are updated continuously. After finishing this phase, an optimum transportation network is generated. In addition, a suitable fleet assignment is proposed. Following section is an applying example.

6.3 A numerical example

For example, a transportation network with one depot center and five customer zones is considered. Freight is delivered (collected) to (from) customer zones. Because of limitation of capacity, each tour can serve to maximum two customer zones. Each route has a transportation cost. All of them are two ways roads. After finishing missions, crews have to go back depot center. Transportation costs and possible routes or legs to move freight between locations are shown in Figure 6-5.



<Figure 6-5> A transportation network

The goal of this problem is to construct a transportation network satisfying all constrains above at the lowest transportation costs.

To solve this problem, a set of possible tours is created by phase 1 mentioned above, shown in Table 6-1, in which fifteen tours could be considered as candidates to select. Tour j has a cost c_j, which serves a customer i^{th} noted 1 instead of 0. There are five customer zones presented as the lowest five rows in Table 6. For examples, tour 1^{th} only serves a customer zone 1, so its lowest cost is 8; with tour 15^{th}, although it deliveries freight to two customer zones 4 and 5, its lowest cost is only 5.

<Table 6-1> Set of feasible tours and their costs

Tour	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
c_j	**8**	**10**	**4**	**4**	**2**	**14**	**10**	**8**	**8**	**10**	**11**	**12**	**6**	**6**	**5**
	1	0	0	0	0	1	1	1	1	0	0	0	0	0	0
	0	1	0	0	0	1	0	0	0	1	1	1	0	0	0
	0	0	1	0	0	0	1	0	0	1	0	0	1	1	0
	0	0	0	1	0	0	0	1	0	0	1	0	1	0	1
	0	0	0	0	1	0	0	0	1	0	0	1	0	1	1

The problem now becomes an integer programming problem. The simplest solution is that each tour serves each customer zone, which includes tour 1^{th}, 2^{th}, 3^{th}, 4^{th}, and 5^{th} and total cost is 28. There are many methods and algorithms to find out the better solutions. Using optimization software, Lingo, is one of useful methods. Lingo model and its results are shown in following.

<Table 6-2> Lingo model and its results

Integer programming problem	Results of Lingo programming

Sets:
Legs /1..5/ : demand;
Tours / 1..15/ : cost, DEVARIABLE;
Allocation(Legs, Tours): volume;
Endsets
min= @sum(Tours(I): DeVariable(i) * cost(i));
@ for (Legs(i):
@sum(allocation(i, j): DeVariable(j) * volume(i, j)) = demand(i));
@ for (Tours(i): @bin(DeVariable(i)));
Data:
demand = 1 1 1 1 1;
cost = 8 10 4 4 2 14 10 8 8 10 11 12 6 6 5;
volume = 1 0 0 0 0 1 1 1 1 0 0 0 0 0 0
0 1 0 0 0 1 0 0 0 1 1 1 0 0 0
0 0 1 0 0 0 1 0 0 1 0 0 1 1 0
0 0 0 1 0 0 0 1 0 0 1 0 1 0 1
0 0 0 0 1 0 0 0 1 0 0 1 0 1 1;
ENDDATA
	Optimal solution found at step: 6
	Objective value: 20.00000
	Branch count: 0
	Variable Value Reduced Cost
	DEVARIABLE(1) 0.0000000E+00
	8.000000
	DEVARIABLE(2) 0.0000000E+00
	10.00000
	DEVARIABLE(3) 0.0000000E+00
	4.000000
	DEVARIABLE(4) 0.0000000E+00
	4.000000
	DEVARIABLE(5) 1.000000
	2.000000
	DEVARIABLE(6) 0.0000000E+00
	14.00000
	DEVARIABLE(7) 0.0000000E+00
	10.00000
	DEVARIABLE(8) 1.000000
	8.000000
	DEVARIABLE(9) 0.0000000E+00
	8.000000
	DEVARIABLE(10) 1.000000
	10.00000
	DEVARIABLE(11) 0.0000000E+00
	11.00000
	DEVARIABLE(12) 0.0000000E+00
	12.00000
	DEVARIABLE(13) 0.0000000E+00
	6.000000
	DEVARIABLE(14) 0.0000000E+00
	6.000000
	DEVARIABLE(15) 0.0000000E+00
	5.000000

The results indicate that the optimum objective function is 20. The values of DeVariable(5), DeVariable(8), and DeVariable(10) are 1 that mean tour 5, 8, and 10 is chosen. Their transportation costs are 2, 8, and 10, in a row. It is an optimum solution for this problem.

6.4 Chapter conclusions

This section proposes a general way to solve the transportation network problem, based on which more complex issues are worked out by using the experience gained from this example as an illustration. It is effective in constructing the transportation network for medium or small companies. Constructing the optimizing transportation network means that one of the most important problems of the logistics system is solved. However, it is only a part of distribution problem. When applying this method, other information need to collect, and other factors should be considered such as random factors, transfer costs, and so on.

Chapter 7: Conclusions and recommendations

7.1 Conclusions

Although intermodalism is efficient and effective method in freight transportation, none of study about its applicability in Vietnam regarding nation's conditions has been done. This thesis has been implemented in order to reach that potential matter. Besides, despite the huge benefits of intermodalism as well as its wide applications, there are a few researches relating to model evaluation and selection problems. In this study, selecting factors and evaluation process are presented.

In short, all aimed objectives have been achieved throughout works done, which are presented in previous chapters.

- A fulfilled literature review concerning intermodalism definitions and studies relating to this field has been carried out.
- Four suitable models have been proposed regarding to specific conditions of the country. They are, then analyzed, and evaluated based on many factors.
- AHP method is used to support model selection with a numeric example.
- For freight collection and distribution issues, an experience ways was also proposed for constructing and solving transportation network problem.

7.2 Recommendations

7.2.1 Factors that make intermodalism successful in Vietnam

Considering current nation's conditions, only four possible models have proposed. However, in order to pursue intermodalism successfully, there many issues should be obtained enough attention. These issues relate to transportation infrastructure and superstructure developments, technology applications, education, policies and so on.

First, transportation infrastructure and superstructure should be invested adequately to benefit by intermodalism. All transport modes should be connected together. For instance, if railways were connected to ports, some other models could be the promising ones. Besides, an intermodal transportation is only as good as the links that facilitates the transfer of goods between modes. For example, cargo might be delayed if the link between modes such as road – waterways is in poor condition, so vehicles are backed up waiting to enter or exit ports. The best way to do that is to make the transition from one mode to the other as smooth and effortless as possible. As noted earlier, trucks offer flexibility and speed over relative short distances but are less efficient over longer routes, while train is best at moving large amount of freight long distances but less effective on short trips. Thus, a smooth transition between the two would encourage the use of both to achieve the most efficient total move.

Second, technology plays very important role to the development and success of intermodalism. Technologies include two broad categories, which are equipments and information and communication services. These technologies provide customer higher levels of services at lower costs. Transportation companies are challenged as well as empowered by information technology and communication capability. As increasingly more pieces of freight equipment, and possibility freight itself, become electronically tagged for tracking and operational execution, the data available to manage line-haul and terminal operations will increase dramatically. This increased information communication technology will support information to make management decisions regarding intermodal trade-offs, and alternatives.

Third, knowledge and skills for new operational and information-communication technologies are essentially addressed to benefit effective and efficient intermodal transportation systems. To be able to optimized transport options, managers will have to be highly knowledgeable in all of current and future intermodal options and alternatives. This need may well drive heightened transportation education. Much of this education will be focused toward the operational, marketing, financial, economic, and competitive factors of modes and intermodal execution.

Last but not least, in order to meet the intermodalism challenges, countries must enact creative and innovative policies and programs. To be successful, their plans and projects must include new and emerging transportation concepts and technologies (Muller, 1999). Support policies contribute much to the successful promotion of intermodalism. Due to its large benefits to social issues, such as reducing traffic congestions, air pollutions, and so on, intermodalism should be considered as first priority in transport policies. Deregulations and regulations should be considered in manners that improve efficiencies of intermodalism.

7.2.2 Recommendation for further studies

Some of future trends to study:

- Enlarging the intermodalism problem to broader region such as South East Asia, and/or Asia.
- Applying simulation to simulate intermodalism.
- Considering interacting among shippers/carriers/and policy makers.

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논문요약

화물운송은 물류시스템에서 총 물류비용의 1/3 에서 2/3 을 줄일 수 있는 중요한 요소이다. 운송회사들은 최선의 경로나 다른 경쟁력 있는 운송수단(도로, 철도, 항공 및 선박)을 통해 비용을 줄일 수 있는 대안을 찾기 위해 노력한다.

본 논문에서는 운송 시스템을 더 효과적으로 만들기 위해 운송수단 사이의 관계를 기반으로 한 화물운송 네트워크를 구성하고자 한다. 여러 상황을 고려한 최선의 복합운송 모델을 제시할 것이다. 베트남 상황에 알맞은 복합운송모델을 구성, 분석, 평가할 것이다. 화물을 유통 거점으로부터 소비자에게 또는 소비자로부터 유통거점으로 모집 또는 분배를 위한 최적의 운송 네트워크를 구성한다. 운송모델의 구성에는 객관적이고 제약적인 기능이 나타난다. 이러한 문제를 해결하기 위한 method 는 다음 3 가지를 따른다. 첫째, 가능한 모든 루트를 나열한다. 둘째로 최적의 대안은 최적화 프로그램인 'Lingo software'를 이용하여 결정한다. 마지막으로 알맞은 루트는 응답을 통해 선정한다. 수송수단의 문제점을 보여줌으로서 method 를 설명하고자 한다.

Appendix

Department of Logistics Engineering
Korea Maritime University
#1 Dongsam-dong, Yeongdo-gu,
Busan 606-792, Korea

Busan, Nov. 29th, 2008

OPEN LETTER

Dear Madam/Sir,

I am Do Ngoc Hien, a graduate student at department of Logistics Engineering, Korea Maritime University, Korea, has been conducting my master thesis about **"A study on intermodal freight transport models in Vietnam"**. In this study, four intermodalism models have been proposed including Road-Rail-Road, Road-Coast-Road, Road-Air-Road, and Inland waterways – Coast-Inland waterway ones.

In order to select a suitable model for a preferable market segment at a company, many objectives such as cost, average delivery time and its variability, loss and damage and so on are under consideration with different interests (priority).

It is very valuable for my study if you can fill in the attached questionnaire. The provided information will be confidential. I assure that the provided data are used for academic research purpose only.

I do hope that I will receive the kindly support from you. I appreciate your time and support.

Please kindly send the response on or before Dec. 7, 2008.

For any further inquiries and return questionnaire, I can be reached at hienise97@yahoo.com.

I wish you and your company always success and more success!

Sincerely yours,

Do Ngoc Hien

QUESTIONNAIRE

Please kindly answer the following questions by ***selecting the most appropriate answers*** *or* ***filling in blank****.*

I. GENERAL INFORMATION

1. Company information:
   Company name: 1
   Address: Danang City
   Tel.: Fax:
   Email: Website:

2. Date of establishment: (DD/MM/YYYY)

3. Major type of transport freight:
   ☐Type I: *Empty container, soil, salt, rubble, furniture, and so on*
   ☒Type II: *Container (full), coals (except coke), iron ore, waste materials, waste paper, crude apatite, cement, fertilizes, and so on.*
   ☐Type III*: Coke coal, asbestos, grain, metals, and so on.*
   ☐Type IV: *Motorbike, rubber, ashlars facing stone.*
   ☐Type V: *Electronics devices, car, high-glass house wares*

4. Collaborator information:
   Name: Nguyen Minh Dung
   Position: Manager
   Years of experience: 1 Years 2 months

II. EXPERTISE EVALUATION

A. INTERMODALISM MODEL EVALUTION

5. Please evaluate the intermodalism model under each evaluation factor on the scale from **1 to 5**.
   In which, I: Road- Rail- Road, II: Road- Coast-Road, III: Road-Air-Road, and IV: Inland Waterway-Coast-Inland Waterway.

5.1 For transport freight between North-Middle market segment

Factor		Intermodal freight transport model			
		(I)	(II)	(III)	(IV)
Cost [a]	1 = Lowest	3	2	5	1
Average delivery time [b]	1 = Fastest	2	2	1	5
Absolute delivery time variability	1 = Least	3	4	2	5
Loss and damage	1 = Least	4	4	1	5
Flexibility	1 = Highest	3	3	5	2
Infrastructure appropriation	1 = Best	3	3	4	4
Expanded capacity	1 = Highest	3	2	4	4
Environment impacts	1 = Least	3	2	3	2

5.2 For transport freight between Middle-South market segment

Factor		Intermodal freight transport model			
		(I)	(II)	(III)	(IV)
Cost [a]	1 = Lowest	2	2	5	1
Average delivery time [b]	1 = Fastest	2	3	1	5
Absolute delivery time variability	1 = Least	3	4	2	4
Loss and damage	1 = Least	4	4	1	5
Flexibility	1 = Highest	3	4	5	5
Infrastructure appropriation	1 = Best	3	2	4	3
Expanded capacity	1 = Highest	4	3	3	4
Environment impacts	1 = Least	2	2	3	2

5.3 For transport freight between North-South market segment

Factor		Intermodal freight transport model			
		(I)	(II)	(III)	(IV)
Cost [a]	1 = Lowest	3	2	5	1
Average delivery time [b]	1 = Fastest	3	3	1	5
Absolute delivery time variability	1 = Least	2	4	2	5
Loss and damage	1 = Least	3	2	1	5
Flexibility	1 = Highest	3	3	4	3
Infrastructure appropriation	1 = Best	4	3	4	3
Expanded capacity	1 = Highest	3	3	4	2
Environment impacts	1 = Least	3	2	2	2

B. *INTERMODALISM MODEL SELECTION*

For selecting a suitable intermodal freight transport model among Road-Rail-Road, Road-Coast-Road, Road-Air-Road, and Inland waterways – Coast-Inland waterway ones, please answer the following questions.

6. When selecting a transportation model (among the proposed ones), which of following objectives are considered by your company:

☒Cost
☒Performance
- Average delivery time
- Absolute delivery time variability
- Loss and damage

☒Flexibility
☒Infrastructure appropriation
☒Expanded capacity
☒Environment impacts
☐Others

7. Among the following objectives, please specify **the relative importance level** for each objective preferred by your company regarding to your major type of products, **in scale from 1 to 5, in which 1 means equally importance**.

For example, if cost is 3 times important than the performance, and 4 times important than expanded capacity (or expanded capacity is 4 times less important than cost).
These statements will be filled as follows:

	Cost	*Performance*	*Flexibility*	*Infrastructure appropriation*	*Expanded capacity*	*Environment impacts*
Cost		*3*			*4*	
Expanded capacity	*[1/4]*					

	Performance	Flexibility	Infrastructure appropriation	Expanded capacity	Environment impacts
Cost	4	3	4	2	5
Performance	1	1/3	2	2	4
Flexibility		1	1	1/2	4
Infrastructure appropriation			1	2	4
Expanded capacity				1	2
Environment impacts					1

8. If the performance objective is under consideration, please indicate the relative important levels for the following factors:

	Absolute delivery time variability	Loss and damage
Average delivery time	2	1/3
Absolute delivery time variability	1	1/4
Loss and damage		1

THANK YOU VERY MUCH FOR YOUR VALUABLE TIME AND SUPPORT.
I WISH YOU SUCCESS AND PROSPEROUS!

QUESTIONNAIRE

Please kindly answer the following questions by ***selecting the most appropriate answers*** *or* ***filling in blank****.*

I. GENERAL INFORMATION

1. Company information:
   Company name: 2
   Address: Hanoi
   Tel.: Fax:
   Email: Website:

2. Date of establishment: (DD/MM/YYYY)

3. Major type of transport freight:
   ☐Type I: *Empty container, soil, salt, rubble, furniture, and so on*
   ☒Type II: *Container (full), coals (except coke), iron ore, waste materials, waste paper, crude apatite, cement, fertilizes, and so on.*
   ☒Type III*: Coke coal, asbestos, grain, metals, and so on.*
   ☒Type IV: *Motorbike, rubber, ashlars facing stone.*
   ☐Type V: *Electronics devices, car, high-glass house wares*

4. Collaborator information:
   Name: Tran Ke Tuc
   Position: Marketing
   Years of experience: 2 Years 4 months

II. EXPERTISE EVALUATION

C. INTERMODALISM MODEL EVALUTION

5. Please evaluate the intermodalism model under each evaluation factor on the scale from **1 to 5**.
   In which, I: Road- Rail- Road, II: Road- Coast-Road, III: Road-Air-Road, and IV: Inland Waterway-Coast-Inland Waterway.

5.1 For transport freight between North-Middle market segment

Factor		Intermodal freight transport model			
		(I)	(II)	(III)	(IV)
Cost [a]	1 = Lowest	3	2	5	2
Average delivery time [b]	1 = Fastest	4	4	2	5
Absolute delivery time variability	1 = Least	2	3	2	3
Loss and damage	1 = Least	3	4	2	4
Flexibility	1 = Highest	3	3	4	5
Infrastructure appropriation	1 = Best	3	3	2	4
Expanded capacity	1 = Highest	2	3	4	4
Environment impacts	1 = Least	4	3	2	1

5.2 For transport freight between Middle-South market segment

Factor		Intermodal freight transport model			
		(I)	(II)	(III)	(IV)
Cost [a]	1 = Lowest	3	3	5	2
Average delivery time [b]	1 = Fastest	2	4	2	4
Absolute delivery time variability	1 = Least	3	3	1	4
Loss and damage	1 = Least	4	3	2	4
Flexibility	1 = Highest	2	4	5	5
Infrastructure appropriation	1 = Best	3	2	3	4
Expanded capacity	1 = Highest	3	2	4	4
Environment impacts	1 = Least	3	2	2	1

5.3 For transport freight between North-South market segment

Factor		Intermodal freight transport model			
		(I)	(II)	(III)	(IV)
Cost [a]	1 = Lowest	2	2	5	1
Average delivery time [b]	1 = Fastest	4	4	1	5
Absolute delivery time variability	1 = Least	3	4	2	4
Loss and damage	1 = Least	2	4	2	5
Flexibility	1 = Highest	3	3	4	3
Infrastructure appropriation	1 = Best	3	2	4	3
Expanded capacity	1 = Highest	3	4	4	2
Environment impacts	1 = Least	3	2	2	1

D. INTERMODALISM MODEL SELECTION

For selecting a suitable intermodal freight transport model among Road-Rail-Road, Road-Coast-Road, Road-Air-Road, and Inland waterways – Coast-Inland waterway ones, please answer the following questions.

6. When selecting a transportation model (among the proposed ones), which of following objectives are considered by your company:

☒Cost
☒Performance
- Average delivery time
- Absolute delivery time variability
- Loss and damage

☒Flexibility
☒Infrastructure appropriation
☒Expanded capacity
☒Environment impacts
☐Others

7. Among the following objectives, please specify **the relative importance level** for each objective preferred by your company regarding to your major type of products, **in scale from 1 to 5, in which 1 means equally importance**.

For example, if cost is 3 times important than the performance, and 4 times important than expanded capacity (or expanded capacity is 4 times less important than cost).

These statements will be filled as follows:

	Cost	*Performance*	*Flexibility*	*Infrastructure appropriation*	*Expanded capacity*	*Environment impacts*
Cost		*3*			*4*	
Expanded capacity	*[1/4]*					

	Cost	Performance	Flexibility	Infrastructure appropriation	Expanded capacity	Environment impacts
Cost	1	3	2	4	5	5
Performance		1	2	1/4	3	2
Flexibility			1	3	4	2
Infrastructure appropriation				1	1/3	2
Expanded capacity					1	2
Environment impacts						1

8. If the performance objective is under consideration, please indicate the relative important levels for the following factors:

	Average delivery time	Absolute delivery time variability	Loss and damage
Average delivery time	1	1/2	2
Absolute delivery time variability		1	3
Loss and damage			1

THANK YOU VERY MUCH FOR YOUR VALUABLE TIME AND SUPPORT.
I WISH YOU SUCCESS AND PROSPEROUS!

QUESTIONNAIRE

Please kindly answer the following questions by ***selecting the most appropriate answers*** *or* ***filling in blank****.*

I. GENERAL INFORMATION

1. Company information:
   Company name: 3
   Address: Hanoi
   Tel.: Fax:
   Email: Website:

2. Date of establishment: (DD/MM/YYYY)

3. Major type of transport freight:
   ☐Type I: *Empty container, soil, salt, rubble, furniture, and so on*
   ☒Type II: *Container (full), coals (except coke), iron ore, waste materials, waste paper, crude apatite, cement, fertilizes, and so on.*
   ☒Type III*: Coke coal, asbestos, grain, metals, and so on.*
   ☒Type IV: *Motorbike, rubber, ashlars facing stone.*
   ☐Type V: *Electronics devices, car, high-glass house wares*

4. Collaborator information:
   Name: Tran Huu Nghi
   Position: Team leader
   Years of experience: 3 Years 6 months

II. EXPERTISE EVALUATION

E. INTERMODALISM MODEL EVALUTION

5. Please evaluate the intermodalism model under each evaluation factor on the scale from **1 to 5**.
   In which, I: Road- Rail- Road, II: Road- Coast-Road, III: Road-Air-Road, and IV: Inland Waterway-Coast-Inland Waterway.

5.1 For transport freight between North-Middle market segment

Factor		Intermodal freight transport model			
		(I)	(II)	(III)	(IV)
Cost [a]	1 = Lowest	2	2	5	2
Average delivery time [b]	1 = Fastest	3	3	2	4
Absolute delivery time variability	1 = Least	4	3	2	4
Loss and damage	1 = Least	3	3	2	4
Flexibility	1 = Highest	3	4	1	3
Infrastructure appropriation	1 = Best	3	2	4	5
Expanded capacity	1 = Highest	4	3	4	5
Environment impacts	1 = Least	3	2	2	2

5.2 For transport freight between Middle-South market segment

Factor		Intermodal freight transport model			
		(I)	(II)	(III)	(IV)
Cost [a]	1 = Lowest	3	2	5	2
Average delivery time [b]	1 = Fastest	3	4	2	4
Absolute delivery time variability	1 = Least	3	4	3	2
Loss and damage	1 = Least	3	2	2	4
Flexibility	1 = Highest	2	4	4	5
Infrastructure appropriation	1 = Best	3	4	5	5
Expanded capacity	1 = Highest	3	2	4	4
Environment impacts	1 = Least	3	2	3	2

5.3 For transport freight between North-South market segment

Factor		Intermodal freight transport model			
		(I)	(II)	(III)	(IV)
Cost [a]	1 = Lowest	2	2	5	1
Average delivery time [b]	1 = Fastest	3	4	1	5
Absolute delivery time variability	1 = Least	4	4	2	5
Loss and damage	1 = Least	3	2	1	3
Flexibility	1 = Highest	3	3	4	3
Infrastructure appropriation	1 = Best	4	3	4	3
Expanded capacity	1 = Highest	2	2	3	3
Environment impacts	1 = Least	4	2	2	1

F. INTERMODALISM MODEL SELECTION

For selecting a suitable intermodal freight transport model among Road-Rail-Road, Road-Coast-Road, Road-Air-Road, and Inland waterways – Coast-Inland waterway ones, please answer the following questions.

6. When selecting a transportation model (among the proposed ones), which of following objectives are considered by your company:

☒Cost
☒Performance

- Average delivery time
- Absolute delivery time variability
- Loss and damage

☒Flexibility
☒Infrastructure appropriation
☒Expanded capacity
☒Environment impacts
☐Others

7. Among the following objectives, please specify **the relative importance level** for each objective preferred by your company regarding to your major type of products, **in scale from 1 to 5, in which 1 means equally importance**.

For example, if cost is 3 times important than the performance, and 4 times important than expanded capacity (or expanded capacity is 4 times less important than cost).
These statements will be filled as follows:

	Cost	*Performance*	*Flexibility*	*Infrastructure*	*Expanded*	*Environment*

				appropriation	*capacity*	*impacts*
Cost		*3*			*4*	
Expanded capacity	*[1/4]*					

	Cost	Performance	Flexibility	Infrastructure appropriation	Expanded capacity	Environment impacts
Cost	1	2	2	3	4	5
Performance		1	1	1/3	2	3
Flexibility			1	2	2	4
Infrastructure appropriation				1	3	4
Expanded capacity					1	2
Environment impacts						1

8. If the performance objective is under consideration, please indicate the relative important levels for the following factors:

	Average delivery time	Absolute delivery time variability	Loss and damage
Average delivery time	1	1	1/2
Absolute delivery time variability		1	1/3
Loss and damage			1

THANK YOU VERY MUCH FOR YOUR VALUABLE TIME AND SUPPORT.
I WISH YOU SUCCESS AND PROSPEROUS!

QUESTIONNAIRE

Please kindly answer the following questions by ***selecting the most appropriate answers*** *or* ***filling in blank****.*

I. GENERAL INFORMATION

1. Company information:
   Company name: 4
   Address: Hanoi
   Tel.: Fax:
   Email: Website:

2. Date of establishment: (DD/MM/YYYY)

3. Major type of transport freight:
   ☐Type I: *Empty container, soil, salt, rubble, furniture, and so on*
   ☐Type II: *Container (full), coals (except coke), iron ore, waste materials, waste paper, crude apatite, cement, fertilizes, and so on.*
   ☐Type III*: Coke coal, asbestos, grain, metals, and so on.*
   ☒Type IV: *Motorbike, rubber, ashlars facing stone.*
   ☒Type V: *Electronics devices, car, high-glass house wares*

4. Collaborator information:
   Name: Tran Tien Dat
   Position: Marketing
   Years of experience: 1 Years 4 months

II. EXPERTISE EVALUATION

G. INTERMODALISM MODEL EVALUTION

5. Please evaluate the intermodalism model under each evaluation factor on the scale from **1 to 5**.
   In which, I: Road- Rail- Road, II: Road- Coast-Road, III: Road-Air-Road, and IV: Inland Waterway-Coast-Inland Waterway.

5.1 For transport freight between North-Middle market segment

Factor		Intermodal freight transport model			
		(I)	(II)	(III)	(IV)
Cost [a]	1 = Lowest	2	3	5	2
Average delivery time [b]	1 = Fastest	2	3	1	5
Absolute delivery time variability	1 = Least	3	3	3	5
Loss and damage	1 = Least	4	2	3	4
Flexibility	1 = Highest	2	3	4	4
Infrastructure appropriation	1 = Best	3	3	5	4
Expanded capacity	1 = Highest	2	4	5	4
Environment impacts	1 = Least	3	2	3	3

5.2 For transport freight between Middle-South market segment

Factor		Intermodal freight transport model			
		(I)	(II)	(III)	(IV)
Cost [a]	1 = Lowest	3	2	5	2
Average delivery time [b]	1 = Fastest	3	4	2	5
Absolute delivery time variability	1 = Least	2	3	2	4
Loss and damage	1 = Least	3	3	2	4
Flexibility	1 = Highest	2	3	4	4
Infrastructure appropriation	1 = Best	2	3	4	3
Expanded capacity	1 = Highest	2	3	5	2
Environment impacts	1 = Least	3	2	3	2

5.3 For transport freight between North-South market segment

Factor		Intermodal freight transport model			
		(I)	(II)	(III)	(IV)
Cost [a]	1 = Lowest	3	2	5	1
Average delivery time [b]	1 = Fastest	3	4	2	5
Absolute delivery time variability	1 = Least	2	3	3	4
Loss and damage	1 = Least	3	3	2	3
Flexibility	1 = Highest	3	3	4	3
Infrastructure appropriation	1 = Best	3	4	4	3
Expanded capacity	1 = Highest	4	3	4	3
Environment impacts	1 = Least	3	2	3	2

H. INTERMODALISM MODEL SELECTION

For selecting a suitable intermodal freight transport model among Road-Rail-Road, Road-Coast-Road, Road-Air-Road, and Inland waterways – Coast-Inland waterway ones, please answer the following questions.

6. When selecting a transportation model (among the proposed ones), which of following objectives are considered by your company:

☒Cost
☒Performance
- Average delivery time
- Absolute delivery time variability
- Loss and damage

☒Flexibility
☒Infrastructure appropriation
☒Expanded capacity
☒Environment impacts
☐Others

7. Among the following objectives, please specify **the relative importance level** for each objective preferred by your company regarding to your major type of products, **in scale from 1 to 5, in which 1 means equally importance**.

For example, if cost is 3 times important than the performance, and 4 times important than expanded capacity (or expanded capacity is 4 times less important than cost).
These statements will be filled as follows:

	Cost	*Performance*	*Flexibility*	*Infrastructure appropriation*	*Expanded capacity*	*Environment impacts*
Cost		*3*			*4*	
Expanded capacity	*[1/4]*					

	Cost	Performance	Flexibility	Infrastructure appropriation	Expanded capacity	Environment impacts
Cost	1	3	2	4	4	3
Performance		1	2	1	1	2
Flexibility			1	1/2	1/3	2
Infrastructure appropriation				1	1	2
Expanded capacity					1	4
Environment impacts						1

8. If the performance objective is under consideration, please indicate the relative important levels for the following factors:

	Average delivery time	Absolute delivery time variability	Loss and damage
Average delivery time	1	1	1/4
Absolute delivery time variability		1	1/2
Loss and damage			1

THANK YOU VERY MUCH FOR YOUR VALUABLE TIME AND SUPPORT.
I WISH YOU SUCCESS AND PROSPEROUS!

QUESTIONNAIRE

Please kindly answer the following questions by ***selecting the most appropriate answers*** *or* ***filling in blank****.*

I. GENERAL INFORMATION

1. Company information:
   Company name: 5
   Address: Hanoi
   Tel.: Fax:
   Email: Website:

2. Date of establishment: (DD/MM/YYYY)

3. Major type of transport freight:
   ☒Type I: *Empty container, soil, salt, rubble, furniture, and so on*
   ☒Type II: *Container (full), coals (except coke), iron ore, waste materials, waste paper, crude apatite, cement, fertilizes, and so on.*
   ☒Type III*: Coke coal, asbestos, grain, metals, and so on.*
   ☒Type IV: *Motorbike, rubber, ashlars facing stone.*
   ☒Type V: *Electronics devices, car, high-glass house wares*

4. Collaborator information:
   Name: Le Hong Ha
   Position: Planning
   Years of experience: 2 Years 3 months

II. EXPERTISE EVALUATION

I. INTERMODALISM MODEL EVALUTION

5. Please evaluate the intermodalism model under each evaluation factor on the scale from **1 to 5**.
   In which, I: Road- Rail- Road, II: Road- Coast-Road, III: Road-Air-Road, and IV: Inland Waterway-Coast-Inland Waterway.

5.1 For transport freight between North-Middle market segment

Factor		Intermodal freight transport model			
		(I)	(II)	(III)	(IV)
Cost [a]	1 = Lowest	3	2	5	3
Average delivery time [b]	1 = Fastest	3	3	3	3
Absolute delivery time variability	1 = Least	3	2	1	3
Loss and damage	1 = Least	3	3	2	4
Flexibility	1 = Highest	2	2	5	5
Infrastructure appropriation	1 = Best	3	3	4	4
Expanded capacity	1 = Highest	4	2	5	5
Environment impacts	1 = Least	3	2	3	2

5.2 For transport freight between Middle-South market segment

Factor		Intermodal freight transport model			
		(I)	(II)	(III)	(IV)
Cost [a]	1 = Lowest	3	4	5	2
Average delivery time [b]	1 = Fastest	3	4	2	5
Absolute delivery time variability	1 = Least	2	3	2	4
Loss and damage	1 = Least	3	4	3	4
Flexibility	1 = Highest	2	3	5	5
Infrastructure appropriation	1 = Best	2	2	4	4
Expanded capacity	1 = Highest	2	3	4	4
Environment impacts	1 = Least	3	3	2	1

5.3 For transport freight between North-South market segment

Factor		Intermodal freight transport model			
		(I)	(II)	(III)	(IV)
Cost [a]	1 = Lowest	3	2	5	1
Average delivery time [b]	1 = Fastest	3	4	1	5
Absolute delivery time variability	1 = Least	2	3	2	4
Loss and damage	1 = Least	3	3	2	4
Flexibility	1 = Highest	3	3	5	3
Infrastructure appropriation	1 = Best	4	3	4	3
Expanded capacity	1 = Highest	3	3	3	2
Environment impacts	1 = Least	3	2	3	1

J. *INTERMODALISM MODEL SELECTION*

For selecting a suitable intermodal freight transport model among Road-Rail-Road, Road-Coast-Road, Road-Air-Road, and Inland waterways – Coast-Inland waterway ones, please answer the following questions.

6. When selecting a transportation model (among the proposed ones), which of following objectives are considered by your company:

☒Cost
☒Performance
- Average delivery time
- Absolute delivery time variability
- Loss and damage

☒Flexibility
☒Infrastructure appropriation
☒Expanded capacity
☒Environment impacts
☐Others

7. Among the following objectives, please specify **the relative importance level** for each objective preferred by your company regarding to your major type of products, **in scale from 1 to 5, in which 1 means equally importance**.

For example, if cost is 3 times important than the performance, and 4 times important than expanded capacity (or expanded capacity is 4 times less important than cost).

These statements will be filled as follows:

	Cost	*Performance*	*Flexibility*	*Infrastructure appropriation*	*Expanded capacity*	*Environment impacts*
Cost		*3*			*4*	
Expanded capacity	*[1/4]*					

	Cost	Performance	Flexibility	Infrastructure appropriation	Expanded capacity	Environment impacts
Cost	1	3	2	2	4	3
Performance		1	1/3	1	1	2
Flexibility			1	2	2	4
Infrastructure appropriation				1	1	2
Expanded capacity					1	2
Environment impacts						1

8. If the performance objective is under consideration, please indicate the relative important levels for the following factors:

	Average delivery time	Absolute delivery time variability	Loss and damage
Average delivery time	1	1	1
Absolute delivery time variability		1	2
Loss and damage			1

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QUESTIONNAIRE

*Please kindly answer the following questions by **selecting the most appropriate answers** or **filling in blank**.*

I. GENERAL INFORMATION

1. Company information:
   Company name:
   Address:
   Tel.: Fax:
   Email: Website:

2. Date of establishment: (DD/MM/YYYY)

3. Major type of transport freight:
   ☒Type I: *Empty container, soil, salt, rubble, furniture, and so on*
   ☒Type II: *Container (full), coals (except coke), iron ore, waste materials, waste paper, crude apatite, cement, fertilizes, and so on.*
   ☒Type III*: Coke coal, asbestos, grain, metals, and so on.*
   ☒Type IV: *Motorbike, rubber, ashlars facing stone.*
   ☒Type V: *Electronics devices, car, high-glass house wares*

4. Collaborator information:
   Name: Do Ngoc Hien
   Position: Researcher
   Years of experience: 2 Years

II. EXPERTISE EVALUATION

K. INTERMODALISM MODEL EVALUTION

5. Please evaluate the intermodalism model under each evaluation factor on the scale from **1 to 5**.
   In which, I: Road- Rail- Road, II: Road- Coast-Road, III: Road-Air-Road, and IV: Inland Waterway-Coast-Inland Waterway.

5.1 For transport freight between North-Middle market segment

Factor		Intermodal freight transport model			
		(I)	(II)	(III)	(IV)
Cost [a]	1 = Lowest	2	1	5	1
Average delivery time [b]	1 = Fastest	2	2	1	3
Absolute delivery time variability	1 = Least	2	3	1	4
Loss and damage	1 = Least	3	3	1	3
Flexibility	1 = Highest	2	3	4	4
Infrastructure appropriation	1 = Best	2	1	2	4
Expanded capacity	1 = Highest	3	1	3	5
Environment impacts	1 = Least	3	2	3	1

5.2 For transport freight between Middle-South market segment

Factor		Intermodal freight transport model			
		(I)	(II)	(III)	(IV)
Cost [a]	1 = Lowest	2	1	4	1
Average delivery time [b]	1 = Fastest	2	3	1	4
Absolute delivery time variability	1 = Least	2	3	1	4
Loss and damage	1 = Least	3	3	1	4
Flexibility	1 = Highest	2	2	4	3
Infrastructure appropriation	1 = Best	2	2	1	4
Expanded capacity	1 = Highest	2	2	2	4
Environment impacts	1 = Least	4	3	4	1

5.3 For transport freight between North-South market segment

Factor		Intermodal freight transport model			
		(I)	(II)	(III)	(IV)
Cost [a]	1 = Lowest	2	1	5	1
Average delivery time [b]	1 = Fastest	3	4	1	5
Absolute delivery time variability	1 = Least	3	4	1	5
Loss and damage	1 = Least	4	4	1	5
Flexibility	1 = Highest	2	2	3	2
Infrastructure appropriation	1 = Best	1	1	1	2
Expanded capacity	1 = Highest	2	1	1	1
Environment impacts	1 = Least	4	3	4	1

L. *INTERMODALISM MODEL SELECTION*

For selecting a suitable intermodal freight transport model among Road-Rail-Road, Road-Coast-Road, Road-Air-Road, and Inland waterways – Coast-Inland waterway ones, please answer the following questions.

6. When selecting a transportation model (among the proposed ones), which of following objectives are considered by your company:

☒Cost
☒Performance
- Average delivery time
- Absolute delivery time variability
- Loss and damage

☒Flexibility
☒Infrastructure appropriation
☒Expanded capacity
☒Environment impacts
☐Others

7. Among the following objectives, please specify **the relative importance level** for each objective preferred by your company regarding to your major type of products, **in scale from 1 to 5, in which 1 means equally importance**.

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These statements will be filled as follows:

	Cost	*Performance*	*Flexibility*	*Infrastructure appropriation*	*Expanded capacity*	*Environment impacts*
Cost		*3*			*4*	
Expanded capacity	*[1/4]*					

	Cost	Performance	Flexibility	Infrastructure appropriation	Expanded capacity	Environment impacts
Cost	1	3	2	2	4	3
Performance		1	1/3	1	1	2
Flexibility			1	2	2	4
Infrastructure appropriation				1	1	2
Expanded capacity					1	2
Environment impacts						1

8. If the performance objective is under consideration, please indicate the relative important levels for the following factors:

	Average delivery time	Absolute delivery time variability	Loss and damage
Average delivery time	1	1	1
Absolute delivery time variability		1	2
Loss and damage			1

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I WISH YOU SUCCESS AND PROSPEROUS!