2009

INTER-PORT COMPETITION AND INLAND CONTAINER TRANSPORT: A Multiple Criteria Decision-Making Approach to Achieve Intermodal Transport System Development Strategies in Taiwan

JUANG, YIH-CHING

http://hdl.handle.net/10026.1/2833

INTER-PORT COMPETITION AND INLAND CONTAINER TRANSPORT:

A Multiple Criteria Decision-Making Approach to Achieve Intermodal

Transport System Development Strategies in Taiwan

by

YIH-CHING JUANG

**A thesis submitted to the University of Plymouth
in partial fulfilment for the degree of**

DOCTOR OF PHILOSOPHY

International Logistics and Supply Chain Management Research Unit

Plymouth Business School

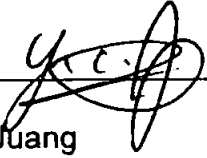**University of Plymouth**

2009

Copyright Statement

This copy of the thesis has been supplied on condition that anyone who consults it is understood to recognise that its copyright rests with its author and that no quotation from the thesis and no information derived from it may be published without the author's prior consent.

Signed: _____ 21 September 2019

Yih-Ching Juang

The author

Abstract

YIH-CHING JUANG

INTER-PORT COMPETITION AND INLAND CONTAINER TRANSPORT:

A Multiple Criteria Decision-Making Approach to Achieve Intermodal

Transport System Development Strategies in Taiwan

Inland container transport has intensified over the past thirty years in Taiwan. It is closely related to inter-port competition and port selection by container carriers. In the 1980's, large containerships only berthed at Kaohsiung port due to the limit of container terminal operation capacities of Keelung port and the carrier's regional hub port decision in the country region. The container traffic of the south-north motorways made them more crowded and increased road maintenance expenses.

The purpose of this research is to study inter-port competition and inland container transport flows in Taiwan. Although Taiwan is an island, the freight transport policy has been focused on rail and motorway rather than sea transportation. Therefore, it is intended to study the contexts of inland container traffic flows and the inter-port competition model. Following from this, the main objectives are to understand the details of container ports in order to identify the major criteria and variables related to the development of the intermodal freight transport system and then to create an integrated decision-making process model as a framework to help the public sector make quality decisions. We designed, tested and evaluated a public involvement process that identified public values for use in the development of an intermodal transport system for the container port. The methodology of this research includes the development of a Multiple Criteria Decision-Making (MCDM) model based on the Analytic Hierarchy Process (AHP) and validated by the use of priority setting for the intermodal transport system at Kaohsiung port as a case study. The main idea behind mathematical programming is the optimal selection of a set of research activities given limited resource availability, decision constraints and the pursuit of multiple objectives. A final model addresses the simultaneous analysis of the selection process clearly able to be traced back by all parties. This research developed a framework that will enable the public sector to make better decisions when selecting intermodal transport system proposals and also save decision-makers time and effort.

List of Contents

List of Tables

List of Figures

Acknowledgements

x

Firstly, I would like to thank my supervisor, Professor Michael Roe, for his consistent, patient and insightful supervision. I owe my thanks to the people who have consistently helped and encouraged me during my PhD study. Dr. Richard Gray was my previous Director of Studies and helped me greatly during my early research. Dr. Irma Pasukeviciute was one of my supervision team members. Mr. Michael Comerford helped me to proof my English writing. Without the above persons, this research would have been impossible. Special thanks are owed to Professor Peter Marlow from Cardiff University and Dr. John Dinwoodie with their insightful commentaries on my thesis had greatly improved its quality. Finally, I have to thank my family members for their unfailing support and understanding throughout the long-time PhD research in Plymouth.

Author's Declaration

No part of this thesis has been submitted for any award or degree at any institute. At no time during the registration for the degree of Doctor of Philosophy has the author been registered for any other University award without prior agreement of the Graduate Committee.

Papers were published and presented by the author:

Juang, Y-C. and Gray, R. (2002). Modelling Intermodal Transport Systems: A Methodology for Inland Container Traffic. *Proceedings of the Logistics Research Network 7th Annual Conference*, Technology Innovation Centre, Birmingham, U.K. 4-6 September. pp.175-180, Institute of Logistics and Transport, Corby. (ISBN: 1-870214-96-X).

Juang, Y-C. and Gray, R. (2002) Challenges to Intermodal Supply Chains: A Strategy for Container Ports. *Proceedings of 2002 Annual Conference for the International Association of Maritime Economists*, Panama City, Panama, 13-15 November 2002. (CD-ROM).
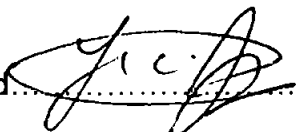
Juang, Y-C. and Gray, R. (2003) The Economic Impact of Inter-port Competition on Container Transport: a Taiwanese Case. *Proceedings of the Logistics Research Network 8th Annual Conference*, City University, London, U.K. 11-12 September. pp.466-471, Institute of Logistics and Transport, Corby. (ISBN: 1-904-564-02-X).
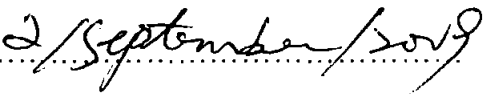
And attendance at relevant workshops:

The Logistics Research Network PhD Student Workshop, Technology Innovation Centre, Birmingham, U.K., 4 September 2002.

The Logistics Research Network PhD Student Workshop, City University, London, U.K., 11 September, 2003.

Word count of main body of thesis: 41,122 words.

Signed....................

Dated....................

CHAPTER ONE

INTRODUCTION

1.1: Introduction

The objective of this study is to develop and assess a Multiple Criteria Decision Making (hereafter MCDM) approach to intermodal transportation system research in the process of choosing development strategies, with special emphasis on inter-port competition and inland container transport for the case of Taiwan. The case study served to assess the validity and practicability of the approach. The experience of this MCDM exercise also led to suggestions for modifications in future applications. The research analysis and review of the literature on background and theory will suggest its potential role in transportation planning research in Taiwan and provide the basis for identifying the main difficulties in the research decision making field. These difficulties include the multiple criteria nature of decision making processes, the measurement and aggregation problems regarding different types of research impacts, and the poor information base due partly to the forward-looking nature of the research.

This study is focused on the methodology of a MCDM model based on the techniques of Analytic Hierarchy Process (hereafter AHP) to achieve a systematic process and selection of criteria guiding decision makers within the public sector to make quality selections about the complex problem of development strategies for transportation systems.

1

Using the MCDM application in order to achieve intermodal transport system development strategies in Taiwan is an innovative research project as there is no similar earlier work referred to in the literature reviews. Furthermore, it will detail the research background, purpose, the methodology used, and structure of the thesis as follows.

1.2: Background

According to Kite-Powell (2001:2768), the maritime shipping industry carries ninety percent of the world's five billion tons of international trade, and ocean container shipping is the fastest growing sector. It supports the supply chain for manufacturing industry and makes global sourcing economically possible. However, the importance of shipping to the business world is never in any doubt. Any company that is engaged in international trade should appreciate the role of shipping in the business world. In particular, for some countries relying heavily on international trade, it is inconceivable not to put a high priority on shipping and marine transport. Transportation planners are becoming increasingly interested in freight transportation movements, and the interest, however, highlights the inadequacy of existing data (Ogden, 1992; Holguin-Veras and Thorson, 2003; Hensher and Puckett, 2005; Puckett et al, 2007). A container port is the linking part of intermodal transportation systems such as by sea, inland waterway, motorway, and railway. It is a major component of freight payment, which is approximately six percent of the total cost of imported cargoes (Kite-Powell, 2001). As perceived by most

transportation experts in the early days, container ports require heavy investment to attract ocean container carriers' patronage.

The continuing growth in the use of containers as standardised units, the creation of joint ventures in the maritime industry and the trend to larger Post-Panamax container ships have all put pressure on seaports. The concept of hinterland is becoming obsolete through the use of containers providing intermodality and reducing the sphere of influence of ports. Efficient sea transportation is heavily dependent on the smooth operation of modal interchange, meaning that intermodal transfer is a key element in successful shipping operations with massive transhipment in major seaports.

Many container ports seek to be a global logistics management centre in the expectation of boosting trading activities with other countries. Intermodal transport is used to describe carriage where one operator assumes liability for the carriage of goods by a route involving a number of different modes of transport (European Conference of Ministers of Transport, 2001). In Europe it has also often been referred to as "combined transport", although this terminology appears to have been displaced to some extent by the term "multimodal transport". This implies a demand for good quality logistics services and a requirement for investment in logistics facilities to attract business to any new location. Both small and large shippers require value-added logistics activities,

which play a key role in providing an effective service to their customers, and achieving a profit for the enterprises.

According to the definitions from 2009 UNECE Glossary of Transport Statistics, Intermodal freight transport was "*Multimodal transport of goods, in one and the same intermodal transport unit by successive modes of transport without handling of the goods themselves when changing modes. The intermodal transport unit can be a container, swap body or a road or rail vehicle or a vessel. The return movement of empty containers/swap bodies and empty goods road vehicles/trailers are not themselves part of intermodal transport since no goods are being moved. Such movements are associated with intermodal transport and it is desirable that data on empty movements be collected together with data on intermodal transport*" (UNECE, 2009:147).

Multimodal freight transport was "*Transport of goods by at least two different modes of transport. Intermodal transport is a particular type of multimodal transport. International multimodal transport is often based on a contract regulating the full multimodal transport*" (UNECE, 2009:147).

Combined freight transport was "*Intermodal transport of goods where the major part of the journey is by rail, inland waterway or sea and any initial and/or final leg carried out by road is as short as possible. According to EU Directive 92/106/ECC the road distance should be less*

than 100 km for road-rail transport and 150 km for road-inland waterway or sea" (UNECE, 2009:147).

Competition for intermodal links in container ports is sometimes a short-term objective towards the longer-term vision of establishing a container port logistics system and a global logistics management centre. The context of inland container transport originally resulted from the port-hinterland relationship between regional industries and port infrastructure. However, the development of inter-port competition and inland container transport has developed in more recent times according to the concept of a hub port with feeder ports or peripheral ports (The Institute of Transportation, 2007). Therefore, the Taiwanese Kaohsiung port plans to invest more money on new basic infrastructure in order to serve the world's largest container ships. However, does better infrastructure and service quality guarantee ocean container carriers' patronage? Thus, how should one systematically and scientifically measure and understand container carriers', port operators' and shippers' decision processes and identify which are their concerns about service attributes in intermodal container transportation, or more precisely, what do container carriers care about in service attributes? This will become a matter of urgency for many global port service providers (World Cargo News, 2004).

The majority of port operation related studies conduct comprehensive reviews which are essential for research work (Pallis et al, 2007). They include the concepts of ports as elements in supply chains (Robinson, 2002), port regionalisation (Noteboom and Rodriguez,

2005), intra-port competition (De Langen and Pallis, 2006), ports co-opetition (Song, 2003), globalisation of port operations (Slack and Fremont, 2005), governance of port devolution (Brooks and Cullinane, 2007), and private entry in container terminal operations (Peters, 2001; Olivier, 2005). But only a limited number of studies have been conducted on the development strategies for intermodal transport systems in the Taiwanese ports region. The purpose of this thesis is to develop useable techniques to integrate a broader range of potential impacts of transportation development strategies into transportation planning and decision making with the most common approach used in the selection of development strategies of intermodal transportation system proposals. The objective of this study is to assess a MCDM approach to achieve an intermodal transportation system through the process of choosing development strategies, with special emphasis on inter-port competition and inland container transport sustainable in the Taiwanese environment.

The case study served to assess the validity and practicability of the approach. The experience of this multiple criteria decision-making exercise also led to suggestions for modifications in future applications. This analysis and a review of the literature on background and theory will indicate its potential role in transportation planning research for Taiwan and provide the basis for identifying the main difficulties in research decision making. These difficulties include the multiple criteria nature of decision making processes, the measurement and aggregation problems

regarding different types of research impacts, and the poor information base due partly to the forward looking nature of research.

This research will develop a multiple criteria framework that can be used to assist in organising and synthesising information to measure the development strategies in an intermodal transportation system. A modular approach was taken in developing individual techniques to quantify the potential impacts that could be utilised within the framework. The framework is flexible enough to accommodate the incorporation of additional techniques over time. To determine the range of potential impacts to consider, the values and needs of various stakeholders in port operation and intermodal transportation systems were taken into account and incorporated into variables, or indicators, to be used in a comprehensive system for evaluating development of the approach. The following working hypotheses were developed.

Hypothesis one:

● **H1: The specific features of all transportation planning research require the definition and incorporation of special criteria into the Multiple Criteria Decision Making approach.**

Hypothesis two:

● **H2: The sources of uncertainty regarding the success of transportation planning research and the successful**

adoption of the results by end users have to be carefully identified and included in the approach.

Hypothesis three:

- **H3: The development strategies of intermodal transportation system research should be explicitly assessed.**

After reviewing various MCDM approaches, the AHP is selected as the methodological basis for this study. The AHP hierarchically structures multiple criteria decision problems and employs pair-wise comparisons to determine preferences among a set of alternatives. It is adapted in order to deal with the issues stated in the working hypotheses.

1.3: Purpose of the study

The purpose of this study is to provide a somewhat less-narrowly focused approach to decision making in transportation planning research. The overall objective is to develop and assess a more problem-driven multiple criteria decision-making approach which takes into account the specific features of intermodal transportation systems and the need to strengthen scientific capacities. The study aims to provide an approach to support transportation planners facing multiple criteria decision problems with limited information. Specifically, the study focuses on the decision-making process by suggesting various procedures to identify and select decision criteria and elicit subjective judgements. Thus, the specific

8

objective of the study is to develop a decision making support tool that facilitates the participation of stakeholders allowing them to express their preferences.

The study consists of three phases. The first phase involves the development of a conceptual framework for MCDM processes in transportation planning research. This phase also includes the analysis of key issues for development strategies for an intermodal transportation system and the identification and modification of a suitable decision support method. The second phase tests the usefulness of the approach in a pilot application in the Taiwanese transportation development program. The third phase is devoted to the assessment of the approach, based on the experiences from the case study. Finally, suggestions are made to improve the tool through further research. The research will focus on ocean container port operators and ocean container carriers in Taiwan, an island country in South East Asia. This research proposes a conceptual model of logistics development strategies for decision making processes.

1.4: Methodology of the research

A methodology was developed to quantify accessibility impacts associated with development strategy alternatives of the intermodal transportation system. This multiple criteria framework is consistent with the Taiwanese Ministry of Transportation's overall planning direction of including the perspectives of more individuals/groups and potential impacts in decision making of intermodal transportation and port systems

9

(The Institute of Transportation, 2000). In this application of this approach to research modelling concerning development strategies for a Taiwanese transportation system, a unique decision-making procedure is elaborated (Zietsman, et al, 2006). It includes the modelling of the specific decision problem, the elicitation of criteria weights by research decision makers, and the assessment of research impacts based on collected data and subjective judgments of project leaders and research planners. The second part of the assessment focuses on conceptual and methodological issues. Overall, the specific transportation planning features seem to be strongly context-dependant and, therefore, no general conclusions can be drawn as to their relevance for decision making research.

The clear conceptual separation between the evaluation of potential impacts and the chances to effectively realise them permits a detailed analysis of the sources of uncertainty and provides useful information on potential shortcomings of the research and adoption process. A major difficulty of the approach was evaluation of the adoption success for transportation planning and development strategy research, since the end users are shippers rather than port operators and container carriers. A better solution for future applications would be to develop a set of criteria that is not specific in terms of end users for shippers, port operators and container carriers. A further modification is suggested to allow for uncertainty caused by the rapidly changing environment of research organisations.

The findings related to optimal development strategies have been captured by the specific criteria survey. The Analytic Hierarchy Process provided a suitable basis for the methodological framework of the approach. It has confirmed its potential to cope with MCDM problems. The flexibility in modelling the problem allowed the accommodation of the issues developed in the working hypotheses. The AHP also met the requirements regarding transparency and standardised measurement procedure. Because it is simple and logical, the AHP does not require particular analytical skills in structuring and visualising complex decision problems. The use of pair-wise comparisons to produce relative preferences of alternatives is particularly attractive for assessing qualitative impacts. The major shortcoming of the AHP is the large amount of work involved in the pair-wise comparisons when there are many alternatives. Various ways to deal with this issue are suggested.

Future research should assess these options to determine the potential to save time and the implications on the quality of the decision outcome. More research is also needed to examine the optimal point for solving difficulties in the decision problem. Particular attention is paid to the identification and selection of relevant decision criteria for which a conceptual framework is developed. The chances of research and adoption success are separately evaluated and the results combined with those of the impact assessment in order to arrive at a final ranking of the research projects. From the perspective of the research project, the main purpose of this study was to evaluate the decision support tool. In order to

analyse the relationship between the service purchase behaviour and the degree of satisfaction, statistical factor analysis was employed for the purpose of data reduction and sensitivity analysis of the salient selection criteria.

1.5: Structure of the research

The outline of the study is as follows. The structure of the thesis is shown in Figure 1.1.

Chapter 1 begins the introduction with a general background related to the research. Then the purpose of the study, the research methodology and the structure of the thesis are presented.

Chapter 2 introduces the review of background literature related to inter-port competition and inland container transport. It begins with a definition of ports and their hinterlands relationship and explains inter-port competition, container revolution for new ports' system, hub port development, inland container transport and issues relating to its impact in Taiwan.

Chapter 3 reviews the literature relating to theory about decision making for transport planning and modelling. The purpose of this review is to provide a perspective on previous publications and studies that have been conducted as well as to illustrate relevant research areas.

Chapter 4 presents an understanding of the details of the conceptual model and formulates the research hypotheses. The successful development of a conceptual model should properly link the literature review with the analysis of the data in order to illustrate each construct as a variable with a logical link to the research that can formulate several research questions. Based on the research questions, testable hypotheses are discussed and developed in this chapter.

Chapter 5 proposes a framework for the research methodology that outlines the conceptual framework of the study. Following the discussion on the need for formal decision making the MCDM approach used in this study is based on the AHP. This method is described in detail in this section.

Chapter 6 presents the strategic planning of intermodal transport systems and transport practices and attitudes towards intermodal transport system modelling in Taiwan. These findings are derived from an analysis of development strategies for the intermodal transport system in Taiwan.

Chapter 7 discusses the validating of the model with an empirical case study, following the research design, strategic decision making system and case study survey procedure of AHP approach proposed.

Chapter 8 evaluates survey results for alternative development strategies of intermodal transport systems that are available to shippers, port operators and container carriers in Taiwan. A strategic development model illustrates the methods of data collection in order to help the identification of the most competitive assessments in assessing the decision making approach with regard to the working hypotheses. The statistical analysis for results of the factor analysis show a set of three separately identifiable alternative activities factors that have positive and significant impact on the success of intermodal transport system development strategies in Taiwan.

.

Chapter 9 concludes the thesis with a summary of the research and a discussion of conclusions drawn from the findings of the study. In addition, this chapter presents the implications of the research in relation to both theory and practice of the study. Finally, chapter 9 closes with suggestions for future research.

1.6: Limitations of study

There is no research project without limitations and no such thing as a perfectly designed study. The research could make a significant contribution, but in the statistical sense no qualitative study can be generalised but its findings can be transferable (Marshall and Rossman, 1999). There are limitations for this research as well.

Chapter 1 Introduction

Chapter 2 A Review of Background Literature

Chapter 3 A Literature Review of Theory

Chapter 4 Conceptual Model of Research

Chapter 5 The Analytic Hierarchy Process

Chapter 6 Strategic Planning of Intermodal Transport System

Chapter 7 Validating the Model with An Empirical Case Study

Chapter 8 Survey Results Analysis

Chapter 9 Conclusions and Discussions

(Source: The author)

Figure 1.1: Title structure of the thesis

CHAPTER TWO
A REVIEW OF BACKGROUND LITERATURE: CONTAINER PORTS AND INLAND CONTAINER TRANSPORT

2.1: Introduction

This chapter will review the history of the work done in the area of container transportation. It will focus on studies dealing with container port development, port competition, inland container transport, and intermodal freight transport systems. The literature review in this study is divided between the disciplines of transport economics and transportation planning.

The study provides a general assessment of the topic of port systems dispersed through a wide range of disciplines including maritime policy, regional science, transport geography and transportation economics by using the literature and data available for analysis. For the aspect of theoretical and empirical works to this study and the purposes of this review, relevant literature has been divided into two sections. The goal of the first section of the review is to assemble representative works from diverse fields in order to demonstrate the state of theory and research in this area. The objective of the second section is to highlight recurring themes and unanswered questions in previous research that lead to the formulation of hypotheses in the present study.

2.2: Ports and their hinterlands

As major connecting nodes in national and international transport systems, ports play a very important role in the trade development of a regional economy. Container ports were the important nodal points in the entire global logistic chains of containerised freight transportation (van Klink and van den Berg, 1998; Baird, 2006). Global trends in containerisation inevitably affect container ports both directly and through changing the environment in which they operate. The new trends affecting the container freight industry are explored mainly by reviewing the recent literature on containerisation (Slack et al., 1996; Alix et al., 1999; McCalla, 1999; Cullinane and Khanne, 2000; Hess and Rodrigue, 2004) and container port development in different parts of the world (Slack, 1990; Todd, 1990; Heaver, 1993; Comtois, 1994; Notteboom, 1997; Rimmer, 1998; Wang, 1998; Loo, 1999; Helling and Poister, 2000; Jauernig and Roe, 2000; Woodburn, 2001; Barros and Athanassiou, 2004; Song and Yeo, 2004; Notteboom and Rodrigue, 2005; Notteboom and Rodrigue, 2008). The port, being an interface of land and sea transport, has been conceptualised as the first and most fundamental anchorage point for colonial powers to control the developing world. It was only at later stages that lateral interconnections and inland nodes were developed (Tan, 2007).

An early and widely cited work on the subject of port geography was produced by Weigend (1958), who discussed the evolution of the intermodal shipping network, port hinterlands, and forelands from this

17

earlier era, and articulated the discrete components of this academic focus. These elements, port, carrier, cargo, hinterland, foreland, and maritime space were defined and emphasised a need for study of ports in the context of relational patterns, rather than as isolated entities. He noted that each port tended to serve its own hinterland, as "a port does not necessarily have exclusive claim to any part of its hinterland, and an inland area may be the hinterland of several ports" (Weigend, 1958:193). Initially, ports served their hinterlands and forelands using newly laid railroad tracks. "Effective organization and utilization of the land exert a powerful influence both on the evolution of ports and port functions and on the organization of maritime space, and the character and growth of a port play a leading role in the development and prosperity of the hinterland and maritime organization" (Weigend, 1958:200). As a general framework for analysis of ports and their activities, these delineations of the components and subsystems of port geography were a contribution of major importance.

Under the traditional view of the shipping industry, cargo was always shipped from its inland production centre to the nearest port. Carriers normally designed routes to cover all ports within a coastal range. Under these circumstances, ports secured the cargo from their captive hinterlands and port competition was scarce. Ships early in the last century handled cargo in the break-bulk method. General cargo was often packed in burlap sacks or shipped loose or unpackaged, later placed on wooden pallets, and loaded and off-loaded onto other modes

of transportation by longshoremen. This was a slow, labour-intensive process that could leave the ship in port for several days. This scenario began to change during the 1960s with the introduction of the container. Containerisation eased cargo handling and reduced loading and unloading times at a vessel's berth. Important innovations on the inland transportation systems arose as well. Containers are reusable, either 20 or 40 feet in length known as TEU (20-foot-equivalent-unit) or FEU (40-foot-equivalent-unit) in the industry. Containerisation was an important technological advancement in shipping (Cullinane and Khanna, 2000).

The containerised system was so successful that more and more large ports began to install new and costly gantry cranes. The gantry cranes are situated on tracks along the container ship berths and are devised especially for rapid container handling at their terminals. The large container ships required not only new shore-side equipment; they also required deeper water for berthing and deeper turnaround channels and harbour entrances. Larger ports that could afford to expand and modernize their facilities began installing gantry cranes for containers and began plans for the deepening of channels. They can be single or double stacked on containerised vessels and are lifted on and off ships, truck beds, or rail cars by large overhead gantry cranes or carried to adjacent container yards by straddle cranes. Cargo in the container does not have to be individually handled or repacked as it moves from the ship to the dock and finally to the truck or train on the way to its final destination. The combination of transportation modes appeared as a

19

competitive alternative to all-water services, and ocean carriers began offering intermodal services at competitive rates (Foggin and Dicer, 1985; Brooks, 1992).

Intermodalism implied a profound change in the organisation of the shipping business. The number of ports through which an individual shipment could be directed increased significantly, and ports began to compete for the intermodal cargo. At the same time, ocean carriers began organizing their fleets to serve primarily the ports where the intermodal cargo would be concentrated. The historical connection between each port and its hinterland has been explained as a result of the regulation of both maritime and inland transportation (Foggin and Dicer, 1985). The growing progression in the use of standardized containers in maritime transport and the technological revolution associated with this has involved deep changes in the nature of inter-port competition. For example, the concept of the hinterland is becoming obsolete because the use of containers provides intermodality and so removes the monopolistic position of ports in adjacent influencing areas.

Inter-port competition is not focused, however, exclusively in their adjacent area and more and more it has to do with the function of transhipment, which is attracting throughput with origin or destination at another port. Shippers organise container throughput sometimes by means of Round-The-World services (RTW). Their reasoning lies in using huge ships that call in at a few strategic ports where transhipments

are carried out from/to ports of origin or destination ports through feeder ships. The broadening of container use has involved deep changes in maritime transport, especially with regard to port competition. Van Klink and Van der Berk (1998) led to discover a more precise definition; those areas that can be provided from a port with the least generalised transport costs and the hinterland concept are becoming obsolete, at least in the sense of influence-area where a port has a monopolistic position.

In transport economics, the generalised cost for freight transport is the sum of the monetary and non-monetary costs of a journey. The monetary costs might include warehousing, transport, inventory control, insurance, security and information technology. Non-monetary costs refer to the time spent undertaking the journey. Time is converted to a money value using a value of time figure, which usually varies according to the purpose of the freight trip. The generalised cost is equivalent to the price of the good in supply and demand theory, and so demand for journeys can be related to the generalised cost of those journeys using the price elasticity of demand. Freight transport is essential in modern societies. Fast, reliable, and relatively cheap transport of goods allows firms to compete efficiently and effectively in markets that have become increasingly internationalised and in which ever higher logistical demands are requested. In practice, shipping firms who generate the demand for freight transport have become less and less sensitive to transport costs: the logistical organisation has become more and more

transport-intensive, due to among other factors centralisation of production and elimination of inventories. Minimization of logistical costs other than the cost of transport seems to be of primary importance to shipping firms. This raises the question to what extent transport policies that aim to affect transport costs will prove to be effective in reducing the growth in freight transport (Runhaar, 2002).

Containers as a transport cargo unit improve intermodality so that it became common that different ports share the same hinterland (Hoare, 1986), whose borders now will depend on the development of intermodal transport corridors and not on the exclusive market areas of each port. Direct competition takes place between distant ports. The transhipment concept has traditionally referred to cargo movements through an intermediate port in the route from origin port to destination port. Nowadays, the origin-destination route of cargo will optimise, the total transport cost, which includes the sum of the multiplicity of transport mode's costs. To be integrated in this route will be the competitive strategy of a port, although it does not belong to any specific origin or destination country. So the transhipment function has a new dimension because it is possible to undertake it both by maritime and land ways. In this context, it is necessary to make a distinction between the terms that could be used to define dominant port load centres (Hayuth, 1991).

Maritime hubs: Ports where there is a concentration/distribution of great volumes of cargo. Part of this cargo has its origin and/or

destination in the transportation process out of the conventional port hinterland. The hub port concentrates its resources basically in transhipment for ship to ship and where the relevance of local cargo is very small.

Gateways: Ports with transhipment functions, whose hinterlands provide high volumes of commercial cargo, are located next to important consumption areas and endowed with good intermodal transport connections, which allow cargo concentration and distribution by means of all kinds of transport modes including land, maritime, river and even air ways.

Throughput highlights maritime hubs but can overestimate the economic significance of these ports because of the limited regional impact of operations such as storage. Investment in these ports can take place in developing areas. However, its status is relatively occasional because it depends on strategies of a reduced number of large shippers whose interests have nothing to do with economic regional growth. This gateway strategy not only supposes a greater creation of economic added value but it has strategic value as well, due to the fact that the gateway becomes a land and logistic chain node, which interlinks the main metropolitan areas. The increasing maritime transport containerisation has transformed the nature of inter-port competition in two directions. Firstly, it encourages intermodality in terms of this competition, allowing competition between ports far away from each

other. And secondly, the larger shippers tend to reduce port container calls on long distance trips in order to take advantage of scale economies in sailing with these huge ships. A port hierarchy at the regional systems level thus develops load centres that are specialised in transshipment functions.

2.3: Inter-port competition

A seaport gateway is a basic import/export door-to-door element of a nation's economy. Port infrastructure is an important part of every country's communication system. In recent decades, seaport operation has been modified dramatically. Important changes in the worldwide trade patterns have resulted from the rapid emergence of new economies. The booming Asian economies and the increasing globalisation of production systems have changed substantially affecting maritime flows, favouring some ports and disfavouring others (Foggin and Dicer, 1985). Forces of globalisation have increased competition just as trade flows have increased, causing more and more competitors to share part of the economic benefit. The speeds by which goods can be transported across vast areas have therefore made the efficiency of logistical infrastructure a central aspect of economic growth. Since the primary gateways for goods flowing across oceans remain seaports, the efficiency of ports is central to the economic growth and prosperity of regions that extend beyond the ports themselves.

However, more important than this geographically evolving cargo distribution has been the profound transformation occurring in the organisation of the shipping business. With the growth of containerisation and the enhancement of the inland transportation system, new capabilities have been opened for intermodal freight transportation. The number of ports through which cargo could be efficiently shipped to or from each inland location has increased significantly (Brooks, 1992; Kumar, 1998). Carriers have gradually increased their influence toward the routing of cargo, selecting ports that better fit their overall scheme. The concept of a port as a unique 'gateway' to its proprietary hinterland has vanished. Ports are now more dependent upon carriers' decisions. Under these circumstances, competition among ports has intensified, particularly among container ports.

Seaports compete in a relatively free market system as carriers are free to choose, within limits imposed by the commodity, shippers and the inland carriers, and their ports of call. Therefore individual ports have to continually upgrade their facilities and services to keep pace with the competition and with changes in the shipping industry. The trends towards larger vessels, containerised shipments, intermodalism, relaxed shipping regulation, shipping alliances and mergers, and service rationalization have all directly impacted on ports (McCalla, 1999). Port competition can exist in two geographical ways: international and domestic. In the international dimension, ports in different countries can

compete to handle the same business, because they serve similar hinterlands or can both serve as land bridge access points. Shippers are requesting an improved distribution of their goods as they seek worldwide coverage. Carriers as a result are streamlining their operations while simultaneously broadening their operations' scope and geographical reach. The fact that neighbouring countries can follow differing policies regarding infrastructure planning is extremely salient with regard to the effect such policies will have on affecting trade volume. In the domestic dimension, ports within the same country compete with each other for business. This can occur between ports over great geographic distance, as when they compete with others for cargoes imported/exported to/from the same country; such regions that serve similar hinterlands and/or functions compete for the same cargoes. This port competition can occur domestically or internationally.

Major carriers must now offer complete logistical support for the door-to-door movement of freight. Carriers at the same time are facing competition from within, responding to a realignment of the industry. Mergers and alliances between carriers are evolving, pushing the sector toward consolidation. Services offered by carriers are constantly being modified to satisfy efficiency requirements for these alliances. Seaports, as an important part of the maritime network, are being affected. This new competitive environment presents a challenging situation for port managers and public administrators, one in which planning strategies and investment decisions must be evaluated carefully. The demand for

seaports comes from shippers and carriers, who choose which ports they will use based on a number of criteria, such as cargo compatibility, access to hinterlands, cost, security, labour productivity, customs, equipment availability, and the presence of foreign trade zones (Goss, 1986; Kumar, 2001).

There are two key areas of competition including the ability of ports to attract business by seamlessly handling intermodal freight movements and meeting environmental regulations in a cost-efficient and non-burdensome manner (Goss, 1986). In order to be competitive in today's market, a port that wishes to be a major load centre must offer these services, and offer them at a price low enough to retain demand for those services. Because port services are so capital-intensive, it is easy to assume that large economies of scale must be necessary to operate competitively, and that economies of scale will only benefit large load centres. However, large load centres also have large costs, and economies of scale may not make up for those sizeable costs. The costs in the shipping industry are a consequence of an unstable market due to loading factors and fuel price. The reduction in the speed of vessels to save on fuel costs will mitigate the effects of a possible down turn in world trade. Port operation will not be directly affected anywhere near as much by the fuel price but the sunk cost of facilities are inescapable.

Either the large costs have to be made up for by some other method, or small ports can take advantage of some of the inefficiencies

of larger ports. "It should be noted that competition between ports is far from perfect in an economic sense. There are barriers to entry, such as the intense capital requirements just mentioned, and there are some ports that enjoy highly monopolistic situations, and therefore face little competition" (Goss, 1986:85).

These factors limit the speed and effectiveness of competitive marketplace forces, producing, in effect, inelastic supply, at least in the short term. Over the long term, this supply becomes more elastic as ports can eventually adjust their ability to compete. Competition can be more intense between ports that already have made the necessary capital investments in shore-side facilities and that serve similar trades and have overlapping hinterlands. "Within the range of ports stretching from Le Havre to Hamburg, for instance, there is a string of ports of various sizes serving similar trades and offering overlapping hinterlands" (Goss, 1986:101). In North America, Seattle and Tacoma are known to compete for the same business, offering similar services and essentially identical hinterlands. However, no two ports are identical and each port offers its own unique mix of services and assets. This means that competition between ports occurs not on the basis of price alone, but on the basis of a port's complete offerings. Even small ports find that they can meet a certain market niche better than others do and survive on that basis.

2.4: The container revolution and port system

The container revolution brought tremendous changes in port connections with hinterlands and forelands. The container revolution had prompted change in the design of ships, which in turn changed port operations. The larger volumes of cargo made possible from the container revolution also put increased demands on the inland transportation. Both rail companies and the trucking industry have shifted a large part of their operations to accommodate containerised cargo. The role of ports as basic elements of the intermodal chain, where cargo is transferred between ships and inland modes, is being emphasized. In addition, ports are acquiring a new function as the use of larger vessels and the formation of new alliances leads to a restructuring of maritime operations. Ports are being transformed into load centres where cargo is concentrated and where carriers focus their operations. This appears to have exacerbated the competitive situation between ports. Ports now depend on carrier decisions to ensure substantial volumes of cargo. Thus, more important to ports' competitive position is the aspect influencing a carrier to select a port as a load centre.

Another important change in the port network system has been the development of the port load centre and the debate over port concentration (Hayuth, 1988). Load centres are ports chosen by the larger shipping lines to be the hub centres for the collection and transfer of cargo, much like the hub and spoke system used in the airline industry today for the collection and transfer of passengers. There are economies

of scale derived from high cargo volumes at the hubs. The spokes, in the shipping example, extend to ports that have become feeder links in the shipping lines' transportation network. The development of load centres with port concentration is putting a strain on certain port resources, and concerns are voiced throughout the industry over the impact on the networks.

Traditionally, the competitive advantage of a transportation hub has been analysed in terms of its strategic location. This approach is clearly applicable to the current structure of ports but also fails to include other aspects that define a port's competitive position. The strategic location of a port has been defined according to two different concepts: centrality and intermediacy (Fleming and Hayuth, 1994). Centrality is intimately linked to the concept of natural hinterland and the traffic generated within this hinterland. Intermediacy refers to the local advantage of a port in attracting through-traffic. In the past, centrality alone could have caused the individual success of a port. Obviously, centrality is still a relevant factor for the carrier today, since local markets ensure certain cargo levels. Intermediacy, however, has become more important as carriers have shifted operations away from hinterlands. The position of a port must now take into account the possibilities it offers to carriers toward their entire system. One condition that must be evaluated is the intermodal capability of the port infrastructure. Adequate inland network connections and intermodal port facilities are basic. Most of the efforts of current port authorities focus within this area.

A second important condition refers to how the geographic location of a port fits in the network of services desired by a carrier. The structuring of adequate networks is a significant issue. For instance, many carriers choose the first port of call on a coast as the port at which all intermodal imported cargoes are unloaded. This port need not necessarily be the closest to the inland destinations. Similarly, they would prefer to direct all intermodal exports to the last port of call. With this strategy, intermodal cargo is not burdened with additional transit times due to intermediate port calls. This saving generally covers the larger inland transit times incurred in routing cargo to distant ports. This dependence of ports upon the selection of the cargo routing by carriers complicates each port's desire for stability. The largest carriers, however, were calling on fewer and fewer ports, leading Hayuth (1988) to speculate that the port system had become concentrated. Surprisingly, however, his empirical data (containerised cargo tonnage only) revealed that this was not the case, and that in fact there had been a de-concentration from the 1970s to mid-1980s. He felt that this de-concentration was partially a result of the challenge made by peripheral ports as discussed above. He concluded that large load centre containerised ports, because of their size, had overextended their capability to sufficiently move large volumes of cargo, giving small- and medium-sized surrounding ports an opportunity to offer their unique services to carriers.

Kuby and Reid (1992) disputed the findings based on a different grouping of tonnage data and concluded that United States ports were shown to be more concentrated by using total tonnage data, meaning carriers were calling at fewer and fewer ports. The size of the contemporary main line container ships, and whether or not the researcher looks at total cargo tonnage, or only containerised tonnage seems to have a bearing on the port concentration question.

Robinson (1998) used the intra-Asian maritime trade system to show how maritime networks were gradually being organized into a complex hierarchical hub-and-spoke system. Primary flows move through first-order networks articulated in the traditional Asian hubs, Hong-Kong and Singapore. At the same time, a range of important second order ports were evolving as the capacity of these hubs became insufficient to handle the recent increase in traffic. The second order feeder ports were connected by second-order networks that were independent of the primary hubs. This evidence seems to mesh with the hierarchy of load centres proposed by Marti (1988).

2.5: Development of hub ports

According to the rapid growth of world trade volume, seaport container terminals have seen dramatic changes in the last two decades. Massive hub ports have been developed quickly in South East Asia. Container transportation, as a main part of the marine transportation system, has a fixed combination with the worldwide supply chain network.

Many countries are planning to build more hub ports with deep and large berths in order to provide mooring services for new container vessels. Containerisation plays an important role in the growth of international trade and the demand for container ports in the South East Asia region will increase in the future. This trend will focus on the competitive pressures for major ports in this region. According to statistical reports in recent years, the top five worldwide container ports are located in the South East Asian area (Containerisation International Yearbook 2005, 2006, 2007, 2008). The ports in the South East Asian basin have experienced significant growth in container traffic over the last decade. These ports already had considerable experience with transhipment service. They are well placed to explore the option of developing as major transhipment hub ports for container traffic, as well as maintaining their significant role as a gateway to markets in Asia.

For example, in the last 20 years, Taiwanese Kaohsiung port became one of the transshipment ports in South East Asia. The rapid growth of the transshipment container throughput of Kaohsiung port was based on strong economic growth and international trade in Taiwan. Kaohsiung port planned to become the transshipment centre of the region by improving the transportation system and custom clearance operation. Kaohsiung port intends to be one of the Asia-Pacific container hub ports that can be identified not only by the fact that it ranked in the top ten largest container ports in the world, but also on the basis of the large volume of transshipment containers through the port. The

33

Taiwanese Keelung and Taichung ports do not play a role as hub ports due to the constraints in accommodating larger containerships. They basically serve as feeder ports for major container carriers on the trunk routes.

The ports of the Western Mediterranean had seen the emergence of two types of port; the established ports of the northern part of the basin which serve a gateway function and a set of new ports in the south region which act as transshipment hubs in the development of gateway and hub functions (Gouvernal et al., 2005). New port facilities to handle potential increased transhipment traffic would require a major investment commitment, but the investment would be well worth it, particularly if container vessels continue to grow in size and are no longer able to enter the harbours. The evolution of container shipping networks and the changing situation of container ports attracted academics to focus on the major expansion of the regional port development interests (Ridolfi, 1999; Zophil and Prijon, 1999; Gouliemos and Pardali, 2002).

There are a long list of studies undertaken over the past decade that have focused on various aspects of the South East Asian region's ports and transportation infrastructure. A number of consistent themes run through all of these studies including the need to optimise logistical flows via the hub gateway and transhipment node by integrating the complete value chain. Other ideas that have gained some primacy, and have experienced some recent success, are the attraction of transhipment

load and distribution activity, in effect, to increase the size of the local market (Fleming, 2000).

World container port capacity was projected to grow by 125 percent between 2000 and 2012, or more than ten percent per annum (Ocean Shipping Consultants 1999:5-9). Thus, early in this new century, instead of reaching the end of its "port life cycle" (Sletmo, 1999), the hub port has a major window of opportunity to develop as a major gateway and transhipment point, providing their partners are willing to make the appropriate investments. In North America alone, demand for container terminal capacity was expected to increase by 7.8 million TEUs between 1996 and 2005, requiring the building of sixteen new container terminals (Drewry Shipping Consultants 1997:1-4).

A transhipment hub is a container port that provides terminal and marine services to handle and facilitate the transfer or transhipment of containers between feeder and mother vessels in the shortest possible time (Baird, 2001). Cargo is transferred from large mother ships at load centre ports onto small feeder ships destined for smaller, regional ports. There are many examples of successful hub ports around the world. The world's largest transhipment hub, Singapore tranships most of its cargo to destinations in South East Asia, such as Indonesia, Thailand, Malaysia, Vietnam, Bangladesh, and India, as well as to Australia and New Zealand. In fact, many examples of hub ports predicated on the concept of transhipment have very little origin-destination cargo; most of

35

their container throughput is transhipped. There is, however, a downside to developing hub ports purely as transhipment centres. As ports in the Mediterranean and South East Asia have found out, carriers are able to play ports off against each other. This inter-port competition can exert significant downward pressure on container-handling rates. With even larger vessels coming into service, it might be prudent for the lines of a hub-and-spoke concept called "Malacca-max," which envisions three hubs located at Rotterdam, Singapore, and Hong Kong and able to handle vessels with a capacity of as much as 18,000 TEUs, the maximum size of ship able to negotiate the vital Strait of Malacca between Singapore and Indonesia (Wijnolst et al. 2000).

Increasingly, transhipment hubs are seen as a critical link in supply-chain management (Osman 2002). This has to be responsive, provide global service coverage, and be flexible and fully integrated with the whole distribution function. Their success also depends on a port's ability to add value to the logistical chain. The quickest and perhaps most efficient way to develop a hub port is to build a significant amount of transhipment business. In transshipping, a hub port potentially handles each container four times; the container is lifted off the inbound mother ship, onto the outbound feeder, off the inbound feeder, and back on to an outbound mother ship as well. In addition, containers are typically grounded either on the quay or in the container yard between ship movements.

Each move contributes revenue to the terminal operator. In determining the location of a hub, carriers look for its strategic location relative to the primary origins and final destinations of cargo, its proximity to main shipping lines and its location relative to feeder ports that it would serve. Beyond location, the most critical attributes of a potential transhipment hub are its ability to handle large ships, the extent of its terminal facilities, the efficiency of container-handling operations, the availability of frequent feeder services with an appropriate geographical spread, and attractive cargo-handling charges (Fleming, 2000; Wijnolst et al., 2000; World Bank, 2002). Ideally, the hub should also have some hinterland cargo. In addition, carriers and investors look for a port with an impressive growth rate and growth potential for feeder service. The development of such feeder services could augment the port's role as a gateway, increase its market share, and open up new markets in places.

2.6: Inland container transport

The continuing growth in the use of containers as standardised units, and the creation of joint ventures in the shipping industry and the trend to larger container ships have all put pressure on seaports. The concept of hinterland is becoming obsolete through the use of containers providing intermodality and reflecting inter-port competition on an international basis, and global trends towards port concentration. The context of inland container transport originally resulted from the port-hinterland relationship between regional industries and port

37

infrastructure. The seaport was traditionally a dependent element of the transportation systems within which they operated, and the rise of intermodal transport has resulted in dramatic changes in the pattern of freight transport and port competition in worldwide shipping (Hayuth, 1987, 1991).

Transport systems have seen both revolution and evolution. The first revolution was in the ship-to-shore transfer, the invention of containers; the second revolution was in the ship-to-rail transfer sometimes called intermodal; and the third was in the ship-to-ship transfer at transhipment (Ashar, 1999). First, containerisation and then intermodality in the late 1970s, have caused a tremendous impact on every facet of the transport system (Hayuth, 1987). While containers have greatly improved the intermodal transfer of general cargo, containerisation and intermodality are not synonymous terms (Muller, 1999), although intermodality is a natural continuation of containerisation (Hayuth, 1987). When containerisation became a dominant technology in the general cargo trade, the intermodal transport network expanded and container traffic further concentrated on a limited number of larger ports or terminals (European Conference of Ministers of Transport, 2001: 21).

There are different schools of thought regarding containerisation and intermodality. The movement of goods in a single container by more than one mode of transport was an important development in the transport industry and for all elements in international and domestic trade

(Hayuth, 1987). The unitisation in the use of containers as standard equipment, the creation of joint ventures in the shipping industry and the trend to larger container ships have all put pressure on seaports. In international shipping we have to understand three very fundamental concepts; port to port, port to point and point to point (Coyle, et al., 1996). Point to point and origin-to-destination moves imply transportation between the shipper's door and the customer's door. The point-point movement is characteristic of intermodalism. There has been rivalry among ports for traffic to and from hinterland regions, but the concept of hinterland is becoming obsolete through the use of containers providing intermodality. This reflects inter-port competition on an international basis and global trends for the issues related to port concentration.

2.7: The impact of inter-port competition on inland container transport in Taiwan

Taiwan is an island, lies 150 km off the south east coast of mainland China, separated by the Taiwan Straits. It also borders the South China Sea, the East China Sea and the Pacific Ocean (Figure 2-1). Taiwan had developed steadily into a major international trading power all over the world and joined the World Trade Organization (WTO) in 2002. This has expanded Taiwanese trade opportunities and further strengthened its standing in the global economy. Foreign trade has been the engine of Taiwan's rapid growth during the past 50 years (The Institute of Transportation, 2000). Export composition changed from predominantly agricultural commodities to industrial goods. The

39

electronics sector is Taiwan's most important industrial export sector.

Taiwanese firms are the world's largest suppliers of computer monitors

and leaders in PC manufacturing. Taiwan has an excellent geographical

location among South East Asia with three major container ports. The

major Taiwanese container ports are Kaohsiung, Keelung and Taichung

each ranking in the top 100 container ports in the world. In 2007, the

container traffic of Kaohsiung port had a throughput of over 10 million

TEUs but dropped in ranking to 8th place in the world. Keelung port's

container traffic transcended 2.2 million TEUs and Taichung port

exceeded 1.2 million TEUs (The Institute of Transportation, 2007). The

following Table 2-1 shows the traffic of major container ports in Taiwan

from 1999 to 2007.

Figure 2.1: The geographic location of Taiwan

Table 2-1: Traffic of major container ports in Taiwan 1999-2007

Year\Ports	Kaohsiung	Keelung	Taichung
1999	6,985,361 (3)	1,665,618 (26)	1,106,668 (43)
2000	7,425,832 (4)	1,957573 (27)	1,130,357 (47)
2001	7,540,525 (4)	1,815,854 (31)	1,069,355 (59)
2002	8,493,052 (5)	1,918,597 (32)	1,193,657 (60)
2003	8,843,365 (6)	2,000,707 (33)	1,246,027 (61)
2004	9,714,115 (6)	2,070,192 (39)	1,245,185 (67)
2005	9,471,056 (6)	2,091,458 (41)	1,228,915 (70)
2006	9,774,671 (6)	2,128,815 (49)	1,198,530 (79)
2007	10,256,830 (8)	2,215,483 (50)	1,247,750 (83)

Unit: TEUs (World Ranking)

(Source: Containerisation International Yearbook 2001-2008; Cargo Systems Net 2008)

The context of inland container transport in Taiwan has resulted from the port-hinterland relationship between regional industries and port infrastructure (Watanabe and Hirohito, 1988). A problem of inland container transport has resulted from the imbalanced flow between origin-destination traffic. In the past ten years, this has been apparent in inter-port competition and the traffic of inland container transport for the three major ports in Taiwan. The share of modal split for road freight transport is better than rail freight transport. Port development for sea transport is more in the south than in the north of Taiwan due to the road network and here it is well developed. The pattern of container traffic has resulted from the focus of national port planning on port development at the Port of Kaohsiung, in the south of Taiwan, and not the Port of

Keelung. The Taiwanese government will develop Kaohsiung port to be the "Logistics Management Centre" (The Institute of Transportation, 1999) but the source of containers is mainly from the northern area and, since container transport by railway and coastal shipping is not well developed, there are millions of container trailers on the roads each year. The phenomenon of inland container south-north transport makes the roads more crowded and creates the need for a lot of social investment and road maintenance. Since 1980, Taiwan has had an inland container flow problem, resulting from a rapid growth in flow volume from 510,625 TEUs in 1990 to 897,297 TEUs in 2006 (The Institute of Transportation, 2007). The inland container transportation had intensified in Kaohsiung port related to inter-port competition and port selection by container carriers. In the 1980's, large containerships only berthed at Kaohsiung port due to the limit of container terminal operation capacities of Keelung port and the carrier's decision to establish a hub port in the country region. The container traffic of the south-north motorways makes them more crowded and increases road maintenance expenses. The problem was caused by insufficient industrial distribution in the south or lack of port capacity in the north. For example, in Taiwan the programme called "Inland Container Transfer by Coastal Shipping" (The Institute of Transportation, 2000) was not carried out between Keelung and Kaohsiung, owing to the cost of road freight transport between the two ports being cheaper than coastal shipping. Because Taiwanese authorities have adopted a transport policy more appropriate for a continental land-map for many years, sea transport is

weaker than land transport. The inland container flow ratio in Taiwan is given in Table 2-2 with the key locations. The inland container transportation access flow of major ports and highway network system in Taiwan are shown in Figures 2-2 and 2-3. For the purposes of this research, the phenomenon of inland container flow will be divided into six categories of container flow: Taichung port to Keelung port, Kaohsiung port to Keelung port, Keelung port to Taichung port, Kaohsiung port to Taichung port, Keelung port to Kaohsiung and Taichung port to Kaohsiung port[*1].

Table 2-2: The 2006 inland container transport volume in Taiwan

Unit: TEUs

Port To Port	Taichung To Keelung	Kaohsiung To Keelung	Keelung To Taichung	Kaohsiung To Taichung	Keelung To Kaohsiung	Taichung To Kaohsiung
Inbound Cargo	26,848	175,210	9,950	96,315	8,453	4,603
Port To Port	Keelung To Taichung	Keelung To Kaohsiung	Taichung To Keelung	Taichung To Kaohsiung	Kaohsiung To Keelung	Kaohsiung To Taichung
Outbound Cargo	28,528	189,420	16,540	241,435	34,645	65,350
Total	897,297 TEUs in year of 2006					

(Source: The Annual Report of Ministry of Transportation, Taiwan, 2007).

[*1] *For outbound cargo, containers have finished the customer clearance from the origin ports and transport to departure ports; for inbound container cargo unloaded from the arrival ports and transported to the destination ports for customer clearance check.*

44

As most people live in the western region of Taiwan, that is where the greatest concentration of railway systems are located. This region has the biggest network chain of railways that include the general rail and the high-speed rail system. The Taiwan Railway Administration (hereafter TRA) is an agency of the Ministry of Transportation and Communications responsible for managing, maintaining, and running passenger and freight services on 1097 km of general railway. In freight traffic, 13.04 million metric tons were carried resulting in revenues of NT$1.2 billion in 2005 (The Institute of Transportation, 2007). The general railway system operated for passenger transport has an extremely extensive network. Taiwan's high population density continues to make rail transport an extremely important form of passenger transportation, especially along the densely populated western corridor. As Taiwan is heavily urbanised with a high population density, the use of general railways for freight traffic was limited. The operation of the railways is an important element in domestic passenger transportation. Most of the main lines are fully electrified and the service is generally efficient and reliable. The Taiwanese rail transport system is a legacy of a Japanese system built in the colonial period between 1896 to 1946 (The Taiwan Railway Administration, 2007).

Recent growth competition in the Taiwanese high-speed rail system has led to a decline in long distance passenger rail travel, though short and intermediate distance travel is still heavily utilised by commuters and students. The high-speed rail line is not run by the TRA

and is a major source of competition for passenger rail transportation. The Taiwan High Speed Rail Consortium as the Taiwanese first privitisation transportation company used bulid-operate-transfer (BOT) to develop the high-speed rail network along the west coast of Taiwan from Taipei to Kaohsiung and is approximately 335.50 km. As a legacy with the partial French TGV high speed rail work, Taiwan High Speed Rail Consortium started operation of its Japanese-built trains by adopting Japan's Shinkansen technology for the core system. It uses the Taiwan High Speed 700T train, which was manufactured by a consortium of Japanese companies, most notably Kawasaki Heavy Industries. The total cost of the project is about US$ 20 billion. It is one of the largest privately funded transport schemes to date (Taiwan High Speed Rail Consortium, 2008).

The market share of freight rail transportation in Taiwan has declined, mainly due to the completion of more comprehensive motorway networks in recent years. In addition, the TRA has adapted a business strategy that prioritises passenger rail transportation over freight rail transportation. This has occurred along with the increasing demand for just-in-time freight transportation delivery by shippers. But the limitations in the freight rail transport capability and capacity will slow the market share decline when the high-speed rail became operational in 2005. It is expected to attract a large percentage of long-distance passenger trips from TRA's routes in the west corridor. As a result, part of the TRA passenger demand on certain routes will be diverted and the route and train capacity will be spared.

The TRA must therefore take advantage of this threat as well as opportunity to establish an overall development policy and strategy for its freight rail transportation have changed the direction of its business to respond effectively to the fierce freight market competition in the future. It is necessary for the development of a highly efficient, sustainable freight rail logistics system with high quality of service. The consideration of operation of Taiwan Rail Intermodal Consortium between TRA and container carrier (OOCL) has the advantage of possessing a comprehensive freight rail network. There are relevant ideas and recommendations that call for TRA to introduce logistics to transform and revive its freight rail services.

Relative alternatives under consideration for freight rail logistics services include: (1) Warehouse rental: without additional investments and with minor renovation, TRA can rent out existing warehouses to domestic logistics companies; (2) Warehouse BOT (Build-Operate-Transfer): TRA can enter into long-term contract with domestic logistics companies, where the domestic logistics companies will construct the needed facilities, pay royalties and have the right to use the facilities within the period specified in the contract, and transfer such facilities to TRA upon contract expiration.; (3) Intermodal logistics: TRA can be responsible for long-distance line-haul transportation across cities, while the domestic logistics companies can be responsible for pickup and delivery within cities (The Taiwan Railway Administration, 2007).

47

Although some professional domestic logistics companies in Taiwan may own large fleets of vehicles and may have years of experience, stations and parking lots are hard to acquire due to limited land resources. As a result, the companies' overall business performance and quality of service are adversely affected. Therefore, if the TRA's advantages and the existing resources of domestic logistics companies can be properly integrated and utilised, they can develop a cooperative strategy with enormous potential profit and consistent with the policy of sustainable transportation. The TRA and domestic logistics companies can implement a cooperative strategy by using freight rail for long-distance line-haul transportation across cities and small pickup/delivery trucks within the cities as an intermodal transportation business model. The plan for the exchanges in intermodal transportation nodes and pickup/delivery networks must be highly efficient to exhibit its operational advantages.
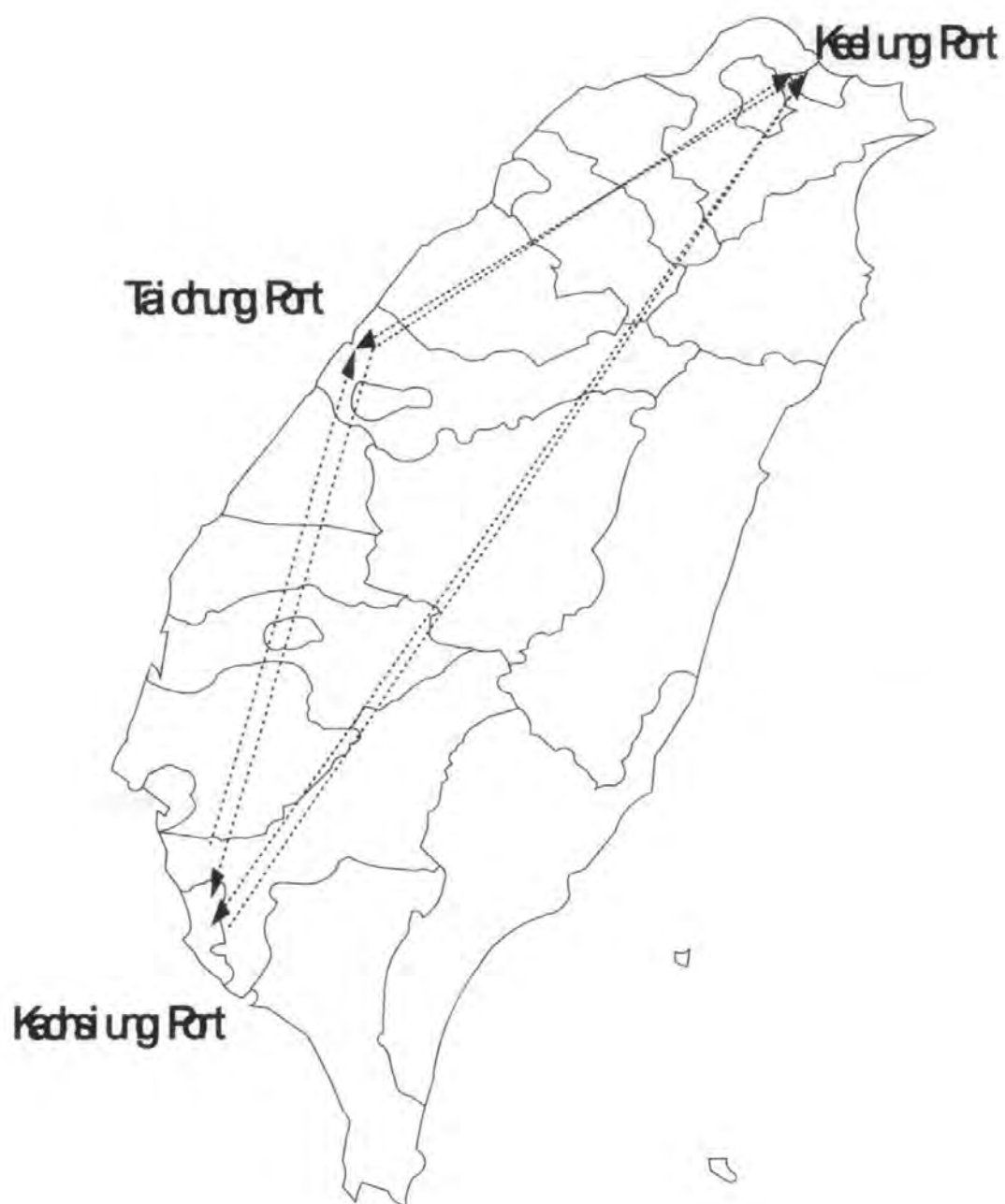
(Source: The Author)

Figure 2-2: Inland container transportation access to major ports in Taiwan

Wanli
Bali
Keelung
Guanyin
Taipei
Rueibin
Jhonghe
Sihih
Nanliao
Dasi
Sindian
Hsinchu
Jhunan
Jhudong
Yilan
Houlong
Suao
Wunshuei
Taichung
Jhangbin
Hanbao
Hualien
Caotun
Fonglin
Taisi
Gukeng
Rueisuei
Dongshih
Chiayi
Yuli
Beimen
Yujing
Tainan
Guanmiao
Taitung
Kaohsiung
Chaojhou

— Western Coastal Expressway	— East-West Expressways
— Sun Yat-sen Freeway	— Chiang Wei-shui Freeway (— Hsuehshan Tunnel)
— Formosa Freeway	- - - - Sections under planning or construction

Source: Ministry of Transportation and Communications

(Source: Taiwanese Ministry of Transportation and Communication)

Figure 2-3: Highway network systems in Taiwan

Based on the annual reports of the Taiwanese Ministry of

Transportation from 1991-2007, statistics indicate the haul distance of

the inland container transportation between the three major container

ports shown in Table 2-3, and Figures 2-4, 2-5 and 2-6.

Table 2-3: The average inland container haul distance for major ports
In Taiwan

unit: km

Ports	1995	2000	2005
Kaohsiung port	*179.2*	*143.0*	*163.6*
Taichung port	*70.0*	*53.1*	*78.4*
Keelung port	*57.0*	*48.2*	*87.5*

(Source: The Ministry of Transportation and Communication annual report: 1991-2007)
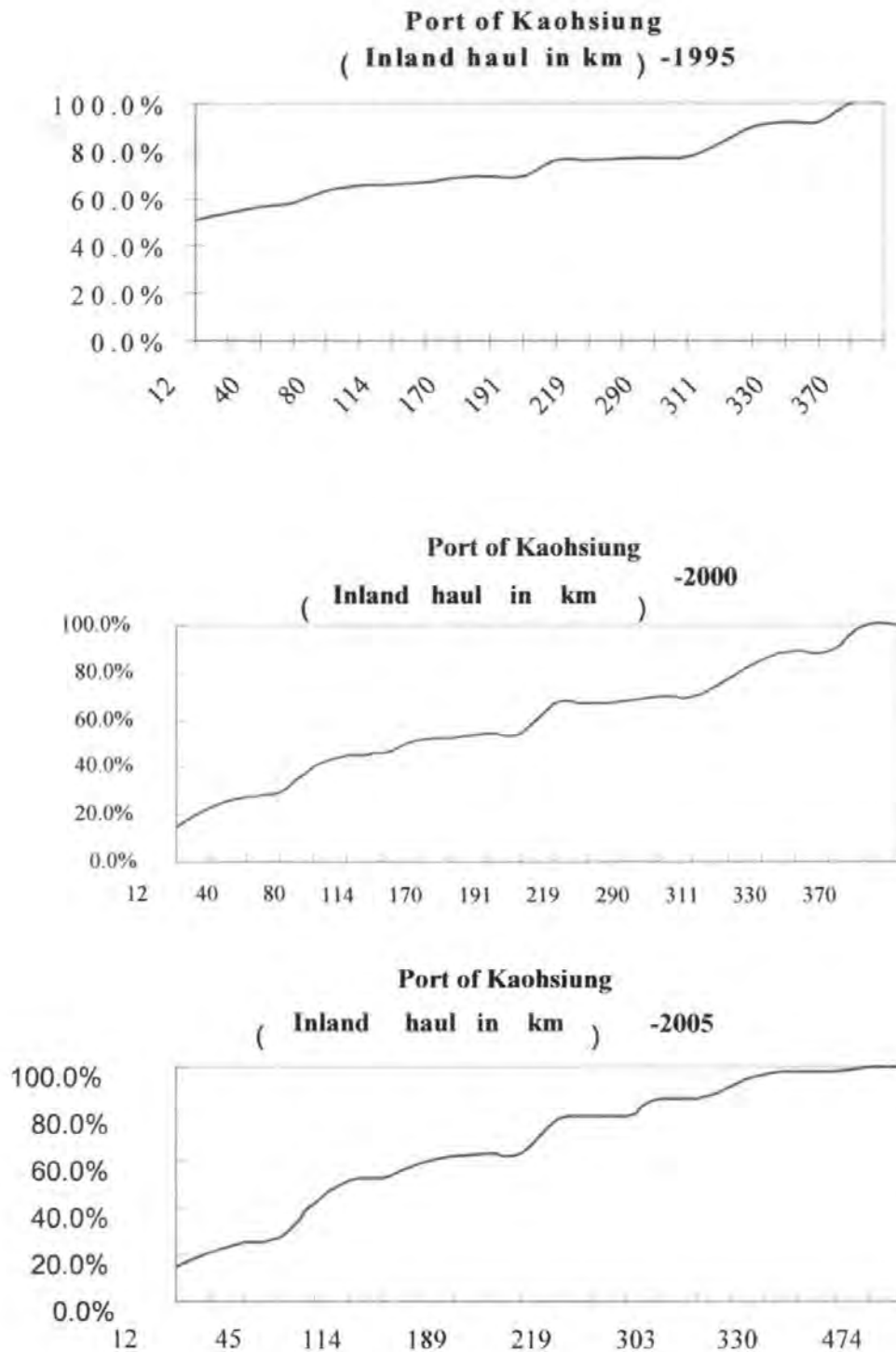
Port of Kaohsiung
(Inland haul in km) -1995

Port of Kaohsiung
(Inland haul in km) -2000

Port of Kaohsiung
(Inland haul in km) -2005

Figure 2-4: Length of inland container haul for Port of Kaohsiung
(1995/2000/2005)
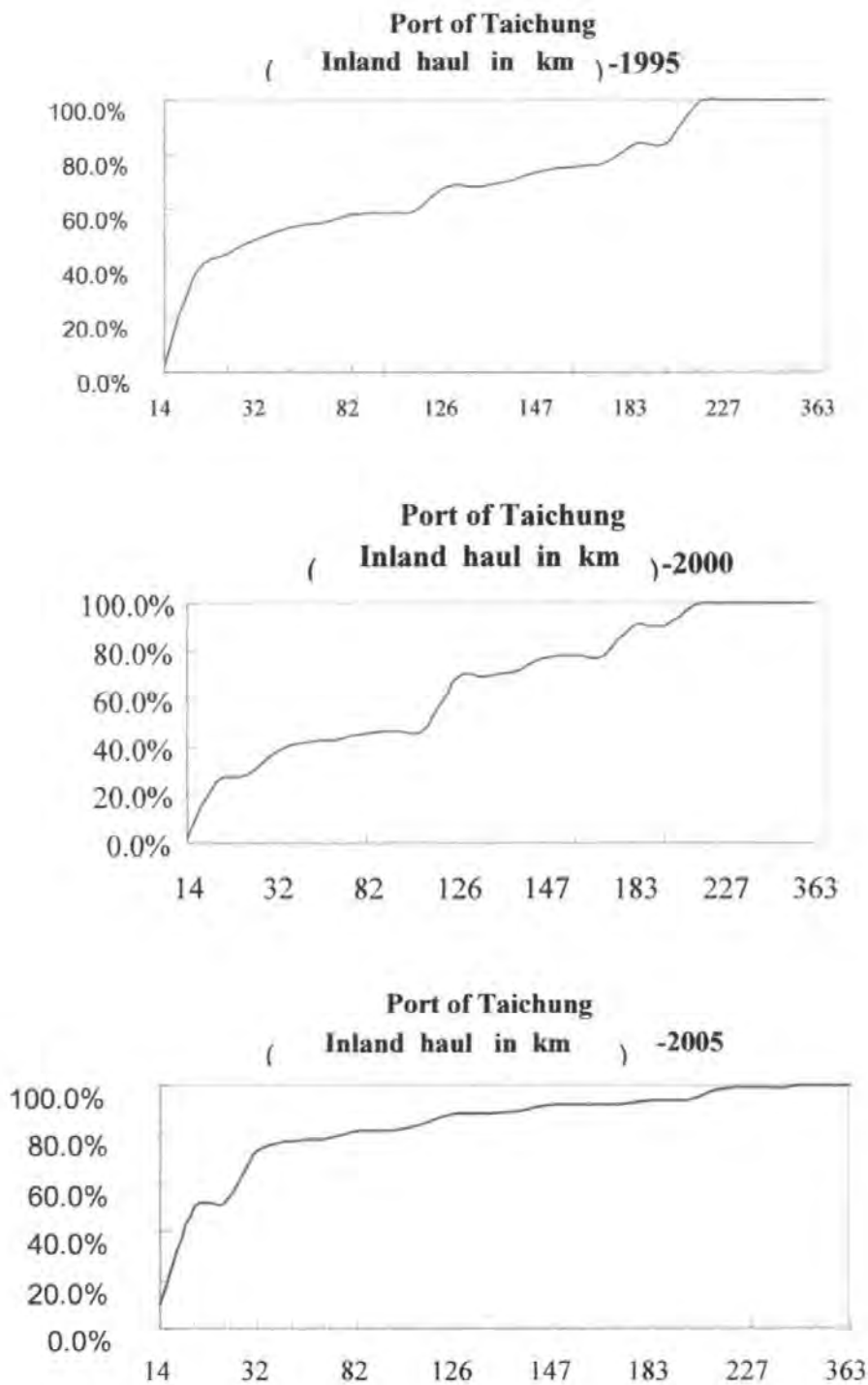
Port of Taichung
(**Inland haul in km**)-1995

Port of Taichung
(**Inland haul in km**)-2000

Port of Taichung
(**Inland haul in km**) -2005

(Source: The Ministry of Transportation and Communication annual report: 1991-2007)

**Figure 2-5: Length of inland container haul for Port of Taichung
(1995/2000/2005)**
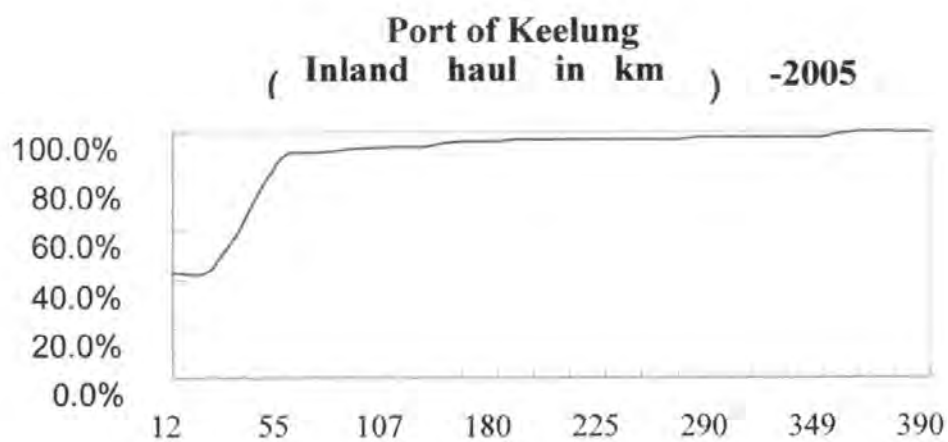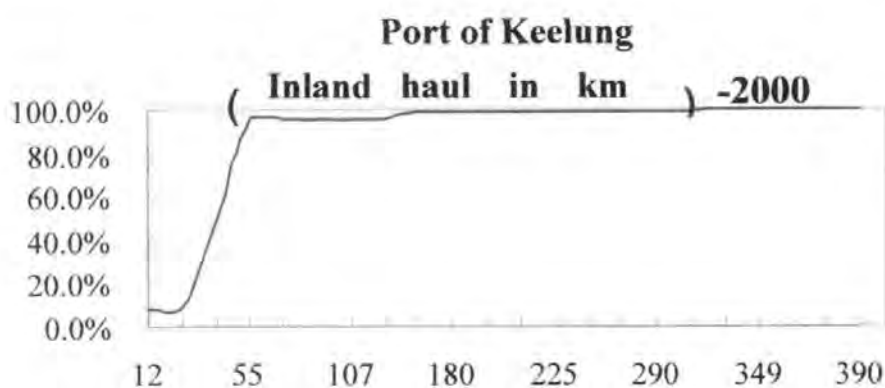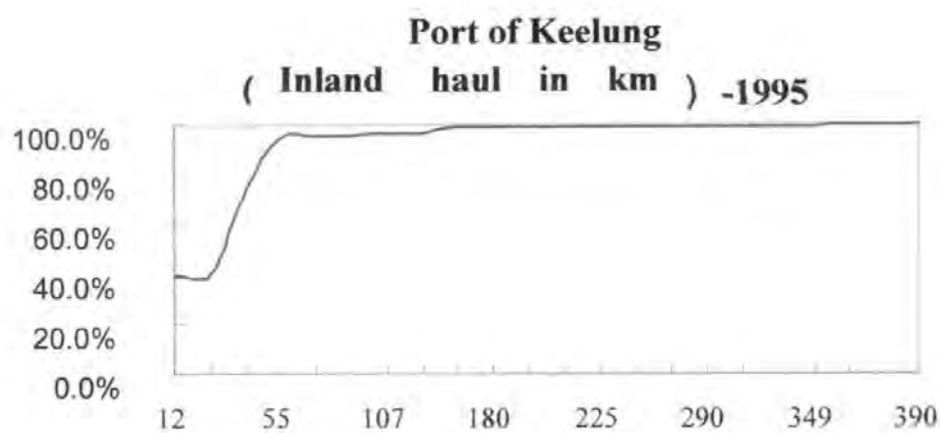
Port of Keelung
(Inland haul in km) -1995

100.0%						
80.0%						
60.0%						
40.0%						
20.0%						
0.0%						
12	55	107	180	225	290	349	390

Port of Keelung
Inland haul in km ( ) -2000

100.0%						
80.0%						
60.0%						
40.0%						
20.0%						
0.0%						
12	55	107	180	225	290	349	390

Port of Keelung
(Inland haul in km) -2005

100.0%						
80.0%						
60.0%						
40.0%						
20.0%						
0.0%						
12	55	107	180	225	290	349	390

(Source: The Ministry of Transportation and Communication annual report: 1991-2007)

Figure 2-6: Length of inland container haul for Port of Keelung
(1995/2000/2005)

2.8: Conclusion

Globalisation has been one of the buzzwords of the 1990's and continues to be a prevalent expression in the new millennium. The speeds by which goods can be transported across vast areas have increased the efficiency of logistical infrastructures in term of economic growth. Since the primary gateways for goods flowing across oceans remain sea ports, the efficiency of ports is central to the economic growth and prosperity of regions that extend beyond the ports themselves. Thus, the effect of port management policy is more than just local: it is national. It affects the efficiency and cost of importing and exporting goods. Intensity of competition can vary from monopolisation to intense, destructive competition. Monopolisation has the negative effect of hampering innovation and reducing efficiency. Infrastructure investment requires a long term commitment. Destructive competition on the other hand, can lead to inefficiencies due to a misallocation of resources and a situation where superfluous infrastructure exists, especially in situations where high capital investments are necessary, such as those in intermodal transport infrastructure. The existence of one type of system in favour of another is due to factors such as geography, the existence of regulatory bodies, and concepts of political economy.

The Taiwanese shipping industry consists of a wide spectrum of economic activities which includes carrier, shipping agent, freight forwarder, terminal operator and port authority. Given the importance of the industry groups to the socio-economic well-being of the country, it is

important to deliver the core services that can support these economic activities in an efficient and cost-effective manner. A national transportation policy for the shipping sector must be drawn in such a way that it provides a structural inter-relationship between these economic activities and the shipping industry. This would help greatly in further developing and promoting shipping activities in the country. Taiwanese shipping transportation policy would take into consideration the activities, infrastructure and system which are involved in the movement of cargos from the point of origin to the point of destination involving the sea mode of transportation. The Taiwanese government has made an effort to plan shipping development policy concentrating on deregulating the barriers to investment and moving them from only public shipping enterprises to public and private shipping. The Ministry of Transportation and Communication had enacted a "cooperative development plan for foreign trade and shipping to draw out fundamental policy guidelines for a cargo reservation system in 1977 (The Institute of Transportation, 2007). It therefore encompasses a broad system linking the ports and shipping groups with a vast network of logistics service providers in the supply chain including transport, distribution, freight logistics and specialist services under private and state ownership. For a trading nation like Taiwan whose economic well-being depends a lot on the efficiency of its shipping industry, it is critical to adjust and respond to fast-changing market conditions. This is important in the light of increasing competition in the shipping sector, especially in the ports and shipping groups, and the increasing demand for efficiency by the industry players.

Port competition can exist in several geographic dimensions: international vs. domestic, and regional vs. local. In the international dimension, ports in different countries can compete to handle the same business, because the similar hinterlands serve as the access points. The fact that neighbouring countries can follow differing policies regarding infrastructure planning is extremely salient with regards to the effect such policies will have on affecting trade volume. In the domestic dimension, ports within the same country compete with each other for business. In regional competition, ports within a region that serve similar hinterlands and/or functions compete for the same cargoes. This can occur domestically or internationally. Finally, there is local competition, a primarily domestic phenomenon that occurs when ports that are close together compete with each other for the same business. The effect of the various types of competition is a warning to refrain from myopic decisions regarding port policy. The increase in globalisation has made more than the closest neighbour a competitor. In fact, in some cases, a neighbour may turn out to be a friend (De Langen and Pallis, 2006).

Changes that affect ports are the increasing temporal and spatial demands of the expanding intermodal freight transportation market, and the increasing number and complexity of environmental regulations that pertain to ports. Therefore, two key areas of competition will be the ability of ports to attract business by seamlessly handling intermodal freight

movements and meeting environmental regulations in a cost-efficient and non-burdensome manner.

In order to be competitive in today's market, a port that wishes to be a major load centre must offer these services, and offer them at a price low enough to retain demand for those services. Because port services are so capital-intensive, it is easy to assume that large economies of scale must be necessary to operate competitively, with economy of scale enjoyed by only large load centres. However, large load centres also have large costs, and economies of scale may not make up for those sizeable costs. Either the large costs have to be made up by some other method, or small ports can take advantage of some of the inefficiencies towards larger ports. However, it is still true that expanding ship sizes, market forces and even geography limit the number of heavily-utilised ports within each geographical region even if there are many good ports to choose from. Thus, the trend today toward larger ships may tend to limit the number of large load centres in any given region. It should be noted that competition between ports is far from perfect in an economic sense. There are barriers to entry, such as the intense capital requirements just mentioned, and there are some ports that enjoy highly monopolistic situations, and therefore face little competition. These factors limit the speed and effectiveness of competitive marketplace forces, producing, in effect, inelastic supply, at least in the short term. Over the long term, this supply becomes more elastic as ports can eventually adjust their ability to compete.

Competition can be more intense between ports that already have made the necessary capital investments in shore-side facilities and that serve similar trades and have overlapping hinterlands. Competition between domestic ports, like Keelung and Kaohsiung in Taiwan gives rise to different policy issues other than international competition between ports. For instance, when competition between domestic ports occurs, it is reasonable to ask who is paying for and benefiting from that competition (Todd, 1990). Since ports are merely one link in the supply chain of transport, the real benefits of port efficiency accrue to the producers and the consumers of the products shipped through the ports, because they enjoy the benefits of low-cost trade. More often than not, these producers and consumers live in areas far removed from the port, and even in other countries. It can thus be argued that increasing port competitiveness through public support should specifically be paid for by the locals. But others enjoy the benefit of port competitiveness. The locals may enjoy the jobs and economic benefits of a port, but those benefits must be carefully weighed against their direct and indirect costs to the local region, as well as the opportunity cost of spending that support elsewhere.

On the national level, competition between domestic ports is of little value, and if it occurs at the cost of financial operating soundness, it is destructive. A national port strategic plan may be a useful tool for limiting or eliminating destructive competition between domestic ports. Such a

plan could benefit a country's producers and consumers by coordinating certain trades with certain ports that are better positioned to capitalize on them and raising the consumer and producer surplus by making trade through ports more efficient and effective. Although some of these issues also apply to competition between ports of different countries, international port competition also gives rise to unique issues. The region that is affected by the growth of a port in a nearby country may in fact need to create a policy by which it must survive.

Inter-port competition results in a reactionary and unguided trade policy in Taiwan. It is not concerned with regional or national trade strategies but with survival and growth of the port itself. It can lead to duplication of effort and low returns on investment of public dollars. The ports have competed in varying degrees because it has been in their own best interests to do so, though perhaps not in the best interests of their public stakeholders, the region, or the nation. Since direct cooperation between the ports is unlikely, a vision benefiting the entire region could most effectively be realized through a development strategy. Such planning could coordinate the public and private sectors for the development of an intermodal transport system in Taiwan that could improve the long-term prospects for trade business. The natural result is competition and lack of coordination. But changes within the transportation industry that have been addressed in this thesis are forcing the ports to look past this myopic paradigm and to realise that they can

face the world and achieve with much greater success together than they

can separately.

CHAPTER THREE
A LITERATURE REVIEW OF THEORY:
MULTIPLE CRITERIA DECISION MAKING MODELS

3.1: Introduction

Decision making has inspired reflection by many thinkers since ancient times. Operations researchers and business decision analysts have undertaken most of the research in general decision making and evaluation. Rigorous quantitative decision modelling seeks to ensure the selection of the best alternative from a set of possible alternatives. These approaches use techniques that resemble those of optimisation because the best decision maximises the benefits for a given decision-maker. Ideally, a decision maker will not be narrowly focused and consider societal benefits when selecting an alternative as opposed to behaving in a selfish manner that only maximizes individual benefits. This chapter provides a review of some of the research in decision theory.

3.2: Decision making models

Many researchers have investigated the role of strategic decision systems on efficiency. Such systems can enhance efficiency by improving methods and capacities for priority setting. More normal approaches can assist data use in priority setting in ways that are internally consistent and thus systematic. In the last decade a growing number of authors have pointed out the crucial role played in supporting

the achievement of the overall strategy. This role has been often summarized in the concept of competitive priorities that represent the deployment of strategic objectives with this concept, classifying competitive priorities into several categories, such as quality, timeliness, flexibility and dependability. Competitive priorities have to be explicitly considered in the design of a performance measurement system, aimed at monitoring the correct implementation of the strategy at all levels of the structure. Hence, the performance measurement system should be able to assess the overall level of support that each department provides to the achievement of the competitive priorities. This study aims to improve decision making towards better efficiency by introducing an effective tool in the strategic decision system.

On the other hand, decision-making is complicated by various factors, including external aspects: the decision maker is faced with a number of possible choices, and must fit together the activities of the enterprise and environmental considerations. Given the complexity of life today, most of our important decisions require a MCDM process. Some decisions may be made considering a single criterion, but these are very limited to the simple and relatively unimportant ones. Almost no decisions of significance can be made based on only one criterion. Given these conditions, the two terms "multiple criteria" and "decision making" are nearly inseparable, especially when making complex decisions that require consideration of all the different aspects that affect the decision.

When making operational decisions a decision maker must take into consideration the operational environment and leadership practices. Decision making is supported by analyses, models, and computer-aided tools and technological advances have an impact on the use of new innovations. These technologies promise better productivity and efficiency through making good decisions and they were enhanced by goal-oriented analytical activity among the users of field technology aimed at maximising the use of technologies. On the other hand, decision-making is complicated by various factors, including external aspects; the decision-maker is faced with a number of possible choices, and must fit together the activities of the environmental considerations. Their classifications will first be discussed, followed by an analysis of how decisions are made, and finally we view various models for decision-making. Decision making is facilitated by an analysis that incorporates a classification of one's own views, calculating the values, translating the analysis results into concrete properties, and a numerical evaluation of the properties.

One method applied for this purpose is the AHP model. This model has many features in common with MCDM, which are also suited for transportation planning decision making that aims at making the correct choices both in the short and in the long term. MCDM has seen a considerable development during the last two decades into a discipline in its own right (Stewart, 1992). Researchers from a wide variety of disciplines have investigated MCDM problems since the eighteenth

century (Iz and Gardiner, 1993). Other general references include Roy (1990), Bell et al. (1988), French (1986), Zeleny (1982), and Stewart (1992). As its name indicates, MCDM aims to provide the decision maker with some tools in order to make advances in solving a decision problem where several, perhaps contradictory, points of view must be taken into account. MCDM is designed to help individuals and organizations make informed inferences and decisions. Ideas have been synthesized from economics, statistics, psychology, operations research, education, and other disciplines in order to give the decision-maker tools to enable and enhance his/her abilities in solving decision problems (Bana, et., al, 1990; Lootsma , 1987; Belton, 1990).

3.3: Multiple Criteria Decision Making (MCDM)

Multiple criteria decision making (MCDM) or multiple attribute decision making (MADM) is an area of decision technology which has seen a considerable development during the last two decades into a discipline in its own right (Stewart, 1992). Researchers from a wide variety of disciplines have investigated multiple decision making problems since the eighteenth century (Iz, 1993). Other general references include Roy (1990), Bell et al. (1988), French (1986), Zeleny (1982), Stewart (1992), and Edwards (1967). MCDM is a critical decision tool. Unlike many other decision theories in the traditional operational research disciplines, MCDM methodologies are controversial and there is not a unique theory accepted by everyone in the field. MCDM models are characterised by the need to evaluate a finite set of alternatives with

respect to multiple criteria. Decision theory provides a logical framework for solving real-life problems. It is a methodology to identify an action that is expected to provide maximum advantages to the decision maker (Stewart, 1996:655).

As its name indicates, MCDM aims to provide the decision maker with some tools in order to make advances in solving a decision problem where several, perhaps contradictory, points of view must be taken into account. MCDM is designed to help individuals and organizations make informed inferences and decisions. Ideas have been synthesized from economics, statistics, psychology, operation research, education, and other disciplines in order to give the decision maker tools to enable and enhance his /her abilities in solving decision problems (See Bana, Costa, and Vincke (1990) for an overview of MCDM, and also Vincke (1992)). Various applications are discussed in Lootsma (1987) and Belton (1990). MCDM is applicable to decisions involving either multiple attributes or multiple objectives, but it may commonly be applied to decisions involving both. The solutions of MCDM are usually designed to connect different decision criteria with each other. Indeed, these vague decision criteria of MCDM are competing with each other in a weighted-sum model. The method does perfectly satisfy all requirements in terms of consistency and stability of the results. The MCDM analysis is considering the complexity and comprehensiveness of the problem in social, political and cultural sectors. The most appropriate procedure for the identification of aggregated criteria is the application of a MCDM model. It was

accomplished in order to make possible the ranking of the alternatives (Triantaphyllou and Lin, 1996). Moreover, it is also a prerequisite problem-solving technique in selecting the best alternative because it satisfies certain criteria despite having an inferior performance. Apparently, compensation becomes the necessary condition for the existence of trade-off with an inferior performance. The ideal situation is unlikely to occur, due to the fact that an alternative may satisfy certain criteria but has an inferior performance in other criteria.

MCDM can be classified as either discrete or continuous. The former refers to MCDM problems which are characterized by a small number of distinct alternatives evaluated on a number of attributes. The continuous type MCDM problems are characterized by a large number of implicit alternatives i.e. alternatives are hidden in the functional forms of the constraints. The objectives are also defined in clear functional form. These types of problems are widely known as multiple objective decision making (MODM) problems. Choo et al. (1999) point out the main purpose of group decision problems in MCDM is to measure the priority of the alternatives on some permissible scale. MCDM is one of the most dynamic areas of research oriented towards the user understanding of the model on a set of alternatives whereas consensus offers a topological measure by using a scale to state preferences between a pair of alternatives. The application of an MCDM technique to a particular problem generally depends on the type of the true meaning and validity of criteria weights and the evaluation on this scale.

Decision makers often deal with problems that involve multiple conflicting criteria. These may range from those affecting common households, such as the purchase of a car, to those affecting entire nations, as in the judicious use of dollars for the preservation of national security. For example, in purchasing a family car, the following multiple attributes may be considered: price, comfort (roominess), fuel economy, safety, maintenance cost, depreciation, appeal, and so on. The job one chooses may depend upon its prestige, location, salary, advancement opportunities, working conditions, and so on (Yoon, 1995). Alternatives are generally first evaluated clearly and fully regarding each of the criteria to obtain some sort of criterion specific priority scores that are then brought together into overall preference values. These criterion specific scores and overall values may be in ordinal, interval, or ratio scales. Ordinal scales on the overall preference values are sufficient if only the best alternative needs to be selected. Interval scales are used in multi-attribute utility theory (MAUT) (Raju and Pallai, 1999) and most explicit multi-attribute value (MAVT) models (Stewart, 1997). Ratio scales are assumed in the AHP. Loetscher and Keller (2002) have reported that MAUT is more favourable than the AHP when a very large number of paired comparisons are needed. One would expect MAUT is suitable for a wider range of applications than AHP because it requires only the construction of an interval scale. However, one could expect that AHP, since it is built on the ratio scale, would be more suitable to some situations in which the subjacent structure had a strong distributive

component, particularly those in which the coefficients of the distribution were not strongly affected by changes in the set of available alternatives (Perez, 1995). MCDM modelling involves an extensive set of activities for a group: problem definition; identification and prioritisation of evaluation criteria by group members; determination of individual preferences; aggregation of individual preferences into group judgements (Moez and Gerardine, 2000). The MCDM methods have three basic types of aggregation operation known from three main steps in utilising a decision making technique involving numerically determining the relevant criteria and alternatives, attaching numerical measures and processing the numerical values (Triantaphyllou and Lin, 1996). In general, the AHP is one of the most popular MCDM methods computed as the average of judgments provided by pair-wise criteria matrix.

The methodology of MCDM can be also divided into three steps (Ozernoy and Vladimir, 1991:162): structuring the decision problem, formulating a preference model, and evaluating and comparing alternatives. Zeleny (1982:86) noted that the more general area of MCDM was the most rapidly growing area of Operation Research / Management Science during the 1970's. The study by Zeleny (1982) shows that work of the 1970's and early 1980's has its roots in earlier times. Complex multi-criteria problems are a key component in organisational life. Ethical choices, trade-offs between cost and quality, and conflicts of preferences are all examples of multi-criteria decisions. MCDM allow decision makers to choose among competing alternatives

by weighing the relative importance of different criteria and then systematically evaluating how well alternative solutions meet these criteria. DeSanctis and Gallupe (1987) define GDSS as interactive computer-based decision support systems that combine communication, computing, and technologies to facilitate formulation and solution of unstructured problems in the group settings, Multiple Criteria Group Decision Support Systems have emerged to meet the needs for appropriate techniques and technologies in support of strategic decision systems. Moreover, program distribution is a serious problem for many types of expert feedback of group meetings. This multiple criteria, decision making method handles subjective or objective data, especially when supported by appropriate technology, and may reduce the problems and raise perceptions of support as facilitating choice. MCDM is generally aimed at supporting non-structured decision making and aimed at better understanding and describing the decision making process (Nazareth, 1993).

MCDM refers to making preference decisions (e.g., evaluation, prioritizing, selection) over the available alternatives that are characterized by multiple, usually conflicting attributes. Despite their potential for improving decision making, MCDM and decision support systems embodying them are not readily applied and used. According to MCDM reviewing research articles from Evans (1984), only two of the studies reviewed observations in the analysis of organisational priority settings. More articles indicated that many multiple criteria problems are

resolved in the group meetings concerning information management and support systems (Desanctis and Gallupe, 1987). Summaries of MCDM methodology available in the research articles are based on empirical research results carried out by using the particular problem. The organisational decision makers need to reassess the special characteristics of the particular focus problem situation in order to use an MCDM approach in the whole planning hierarchy. Ozernoy and Vladimir (1992) also argued that different MCDM methods are suitable for particular application.

MCDM comprises a procedure toolbox-a rich set of resources from which the user must develop a meaningful model and interpret the outputs in light of the problem at hand. The paradox of decision support for MCDM is that the process of applying modelling capability can enhance perceived problem complexity rather than reduce it, thereby lowering comfort with using decision models and reducing decision confidence. Indeed, several studies have found that decision makers avoid the use of MCDM decision aids and, when given a choice, prefer relatively unsophisticated decision models instead. With this conundrum in mind, Dyer et al. (1992) called for researchers to incorporate behavioural and psychological support within MCDM systems. Saaty's AHP and ANP (Analytic Network Process) are examples of the MCDM research from the psychological perspective (Saaty, 2000; Saaty, 2001). The appropriateness of different multi-criteria approaches for a given problem, and the establishment of a unified framework in MCDM that

allows for a better understanding of these techniques, are two of the challenges that remain open in this field (Escobar and Moreno-Jiménez, 2002). The aim of MCDM is to provide support to the decision maker in the process of making the choice between alternatives, and may include the generation of a proposed 'optimal' solution and/or some form of preference ranking (Stewart, 1996).

In MCDM, it is assumed that there exist a number of alternatives between which the decision-maker has to decide, where each alternative is described by its performance on each of a number of criteria, attributes or objectives (Stewart, 1996). MCDM in a complex environment usually requires the aggregation of multiple criteria into a single preference function, and a feasible decision with the highest preference function value is identified as the optimal solution (Choo & Wedley, 1985). Multiple criteria decision-making (MCDM) theory has produced a wide range of techniques suitable to a variety of decision situations and is one of the commonly used mathematical methods for selecting alternatives among a solution set (Dyer and Forman, 1992).

A MCDM model is proposed to facilitate the group's decision making in the selection process. The method allows decision makers to evaluate various competing alternative courses of action to achieve a certain goal. According to the AHP in resolving MCDM problems, especially in the group decision settings, the rationale for MCDM is that decision problems are complex for the well-defined decision maker. To sum up, the main

violations of the MCDM myths were that the decision makers are faced with a multitude of challenges. In business analysis and decision making, there are several MCDM models which use the programmes and prioritise amongst more specific courses of action *and* evaluate strategy value. The presence of the MCDM methods allow decision makers to evaluate various competing alternative courses of action to achieve a certain goal. Often, data in MCDM problems are imprecise and changeable. Therefore, an important step in many applications of MCDM is to perform a sensitivity analysis on the input data (Triantaphyllou, 2000). For many users of a multiple criteria decision analysis, the process of structuring their problems appears as the most valuable part of the whole analysis or should be as important as the development of a formal model, at least.

Computer-aided decision systems are supposed to increase MCDM efficiency. The general challenge of promoting greater user understanding and appreciation of decision aids is a major research issue and it is exaggerated in the case of MCDM, especially in group-settings. Some scholars have called for the development of intelligent interface capabilities that provide explanations to users about how to develop and apply models, and there is a growing line of research that seeks to evaluate alternative approaches for building these capabilities. In a group setting, explanation facilities are decidedly more complex to design than in settings where just one user interacts with the system. For this reason, Group Decision Support System (GDSS) research to date has been

confined largely to design of human interventions to enhance user understanding and appreciation of modelling tools. Here we establish the groundwork for design of intelligent agents for GDSS by exploring the feasibility of providing computer-based system explanations to groups as they use MCDM GDSS. Our goal is to contribute to research on intelligent interfaces for group decision support (Limayem and DeSanctis, 2000).

3.4: Group decision-making

The analytic hierarchy process can be used as a group decision-making process. In fact, brainstorming, or sharing ideas and insights, generally leads to more accurate representation and understanding of the issues than would be possible for a single decision maker. This is because group decision making reduces all the individual preferences and interests to a single decision reached either by conflict or by compromise. The different group decision-making techniques cited in the literature include: brainstorming, nominal group technique, surveys, and the Delphi Method.

Brainstorming is a group decision-making technique through which a group attempts to find a solution for a specific problem by encouraging its members to spontaneously generate unlimited ideas. Brainstorming is based on the presumption that deferring judgment enables the creative part of the mind to generate ideas and evaluate them later, and that the greater the number of ideas generated, the greater the possibility of

reaching an ideal solution (Hwang and Lin, 1987; Iz and Gardiner, 1993). The creative collaboration and large number of ideas are the major advantages of brainstorming. Its disadvantages are that in such an open atmosphere, some group members may monopolize the session, and that the group may become more concerned with reaching an agreement than with reaching a well-thought-out and useful conclusion.

Nominal group technique (NGT): As the term "nominal" (meaning silent and independent) suggests, NGT refers to a process that brings individuals together but does not allow them to communicate verbally. Generating ideas nominally can minimize conforming influences and help maintain social-emotional relationships, both of which can greatly affect the group's final decision. It also provides for equality of participation and for all members to influence the group decision through voting and ordering of priorities (Hwang and Lin, 1987; Limayem and DeSanctis, 2000). NGT's selection process starts with group members silently writing down ideas. One idea at a time is then collected from each member of the group, discussed, defended, and possibly discarded. Ideas are then ranked by vote. NGT's advantages are that it produces accurate judgments (achieved through rank ordering) and helps eliminate conflict among group members. Its disadvantages are that it requires a highly skilled leader who is knowledgeable about the process, and that it limits creativity and diversity with its one-at-a-time approach.

Research surveys are useful when direct interaction among respondents or group members is unnecessary or impossible. With such surveys, the opinions of a chosen group of experts are polled and the results are then analysed. Surveys can take different forms, including face-to-face interviews, phone interviews, and questionnaires. The advantages of surveys are that they typically cover a large geographic area, poll a large number of respondents, and provide respondents with anonymity. The disadvantage of this technique is that respondents may sometimes misinterpret questions, thereby distorting the results (Zahedi, 1986).

The Delphi Method was the name given to USA Air Force study developed by the Rand Corporation in the early 1950s to obtain expert opinion on how many Soviet atomic bombs would be required to do specific damage to the USA. This method has gained wide recognition since then as a powerful technique for group decision-making. The objective of this method is to obtain the most reliable consensus of a group of experts through the use of intensive questionnaires interspersed with controlled opinion feedback (Hwang and Lin, 1987; Saaty, 2003). The special features of the Delphi Method are (1) anonymity, (2) controlled feedback, and (3) statistical group response. Anonymity reduces the effect of dominating individuals. Controlled feedback organizes the exercise into a sequence of rounds and communicates the results to respondents. Statistical group response reduces group pressure for conformity. Another advantage is that the method yields a

wide range of opinions from a wide geographic area. Also, the Delphi Method is continuous, offering different iterations and analyses of responses (Guzzo, 1982). However, with this technique, the decision process is tedious and consumes considerable time and effort. Questions are usually sent to respondents again, allowing them to change their answers after hearing feedback on previous answers. A rational final decision is then possible through consensus or vote. With group decision-making, the group's final decision may be reached through consensus (a solution that satisfies everyone), unanimity (all members of the group agree), majority (the alternative that receives the most votes wins), or a mathematical mean of all judgments (Guzzo, 1982).

3.5: The Analytic Hierarchy Process (AHP)

Strategic decision problems are characterised by multiple criteria with respect to diverging qualitative domains. These strategic decisions are technically and politically complex and require frequent group decision making meetings (Saaty, 1989). Saaty (1980) describes the purpose of the AHP as being to develop a theory and provide a methodology for modelling unstructured problems in the economic, social, and management sciences. Interest in the group decision-making continues to grow. In our view, AHP is a multi-criteria decision-making technique well suited to derive collective judgments in this context in that it facilitates the quantitative comparison of alternatives.

Saaty and Vargas (1991:14) described this methodological tool in the following statement:

" a multi-objective, multi-criteria decision-making approach which employs a pair-wise comparison procedure to arrive at a scale of preferences among a set of alternatives. To apply this approach, it is necessary to break down a complex unstructured problem into its component parts and arrange these parts, or variables, into a hierarchic order."

The AHP has initially been developed for application to a wide range of complex decision problems. A software package called "Expert Choice" is available for the AHP and considerably facilitates its application. However, decision making has to be seen as a process involving discussions, learning and checking the outcome, and AHP is such a process. It provides a consistent framework to formally incorporate subjective judgments. Their elicitation and subsequent discussion is particularly encouraged in group decision making. The AHP is considered as a powerful and straightforward tool to support such group sessions. A unique feature of the approach is the possibility to compute a measure of inconsistency among the decision makers. This enables them to identify 'errors', revise judgments, and improve the quality of the decision. The AHP approach is a decision-making method based on the following principles: decomposition, comparative judgments and synthesis of priorities. The AHP measures the inconsistency ratio, ranking the individual sub-attributes in order to create the principles of

analytical thinking. The AHP is a systematic procedure for representing the elements of any problem in order to build and evaluate the methodology (Saaty, 1980).

The framework of the AHP is a very useful tool for the solution of diverse and numerous application oriented problems. Saaty (1980) defines a hierarchy as a particular type of system. In particular, any system can be divided into two parts: structure and function. Actually, the structure and function of a system cannot be separated. In fact, the structure serves as a vehicle for analysing the function. The functioning modifies the dynamics of the structure. A hierarchy is an abstraction of the structure of a system to study the functional interactions of its components and their impacts on the entire system.

The AHP, a participatory decision-making tool used for prioritising alternatives in complex situations has been used successfully in a variety of fields, including economics and planning, conflict resolution, project selection, education, and politics (Saaty 1980). Application of the AHP for decision-making is very useful when the problem includes qualitative as well as quantitative elements. The strengths of the AHP process include the ability to structure a complex decision into a hierarchy, to incorporate different types of data, and to make decisions based on existing knowledge. Using the Analytic Hierarchy Process in solving a decision problem involves four main steps (Zahedi, 1986:101):

Step 1: Setting up the decision hierarchy by breaking down the decision problem into a hierarchy of interrelated decision elements.

Step 2: Collecting input data by a pair-wise comparison of decision elements, i.e., by comparing the options under each criterion. This method uses a semantic scale and associated 1-9 ratio scale.

Step 3: Using the "eigen-value" method to estimate the relative weights of the decision elements at each level of the hierarchy.

Step 4: Aggregating the relative weights of the decision elements by using the weighted arithmetic mean to obtain the final scores for the decision options.

One of the most important aspects of AHP consists of structuring the problem into a hierarchy, which helps to clarify components of the problem and to identify possible inconsistencies. The hierarchy has several levels reflecting the components of the problem. A simple form of the hierarchy would consist of three levels: a goal, the criteria, and the alternatives. Other possible levels may include objectives, scenarios, events, and outcomes. The second aspect of AHP is to collect data for making pair-wise comparisons. For pair-wise comparisons, participants are asked to determine the relative importance of two criteria. Pair-wise comparisons are made between all possible combinations of criteria. The scale used for comparisons is 1 to 9, where a value of 1 represents items

of equal importance, a value of 3 indicates one item is moderately more important than the other, a value of 5 indicates one item is strongly more important than the other, a value of 7 indicates one item is very strongly more important than the other, and a value of 9 indicates one item is extremely more important than the other. When multiple people are involved in making pair-wise comparisons, it is important to agree upon the rules used to obtain a single judgement, i.e., such as a majority vote or calculating the mean. There should be an opportunity for people to discuss any difference in judgments made for pair-wise comparisons. Using these criteria, the team members make pair-wise comparisons between each of the criteria relative to the importance of the goal. Since there are several people on the recreational team, they decided to use the mean of all individuals' judgment for each pair-wise comparison. Where there were extreme differences in the judgments the group discuss the reasons for differences.

3.6: Decision Support Systems (DSS)

Decision support systems (DSS) are developed to provide the information and analysis necessary for the particular decision that must be made. What makes a DSS unique is its interactive access to data and the models that deals with a specific decision that requires human intervention and that cannot be solved by the computer alone.

In this research, application of the analytical hierarchy process is supported by a DSS, namely the "Expert Choice" software package.

Decision support systems are computer-based systems that provide interactive support to managers during the decision-making process. DSS allows the decision-maker to retrieve data and test alternative solutions during the process of problem solving.

The concept of decision support systems is based on assumptions about the role of computers in effective decision-making. The computer must support the manager but not replace his/her judgment. It should therefore neither provide answers nor impose a predefined sequence of analysis. The main payoff of computer support is for semi-structured and unstructured problems, where the analysis can be systemized for the computer but the decision-maker's judgments are needed to control the process.

Effective problem solving is interactive and is enhanced by dialogue between the user and system. DSS are characterized by flexibility, user initiation, quick responses, ability to operate with little professional involvement, and decision-making at different managerial levels. DSS are also known for offering analytical power because they are equipped with a variety of models to analyse data.

Expert Choice software is a multiple objective decision support system based on the analytical hierarchy process. The Expert Choice software package is intended to make structuring the hierarchy and synthesizing judgments quick and simple, eliminating tedious

calculations. Developed by Forman, Expert Choice has been used in various decision problems and is based on AHP theory; this software accommodates hierarchy structuring, pair-wise comparisons, judgment synthesis, measuring consistency, and sensitivity analysis (Liberatore, 1989).

Some software systems offer user-friendly features including a display that makes decision model-building straightforward and simple. They offer a model view containing either a tree view or cluster view of the decision hierarchy, which does not require numerical judgment from the decision-maker; rather, pair-wise comparisons may be performed numerically, verbally, or graphically. This is because software converts subjective judgments into the one-to-nine scale prescribed by AHP theory, and then into meaningful priority vectors. Expert Choice works by examining judgments made by decision makers, and measures the consistency of those judgments. The software allows for re-examination and revision of judgments for all levels of the hierarchy, and shows where inconsistencies exist and how to minimize them in order to improve the decision.

3.7: Conclusion

The multiple dimensional nature of transportation planning indicates that multiple criteria or multiple objective methods would be more appropriate for sustainability transportation assessments than single criterion or single objective methods. This section first reviews MCDM

methods in general and identifies a number of MCDM applications to transportation planning decision making. MCDM is one of the established branches of Decision Theory, and it is especially useful when making preference-based decisions over available alternatives that are characterized by multiple, usually conflicting, attributes (Hwang and Yoon, 1981; Triantaphyllou, 2000). Unlike single objective decision-making techniques, such as benefit-cost or cost-effectiveness analysis, MCDM approaches can take into account a wide range of differing, yet relevant criteria (Zietsman et al., 2006). Even though these criteria cannot always be expressed in monetary terms, as is the case with many externalities, comparisons can still be based on relative priorities (Nijkamp and Van Delft, 1977).

MCDM methods are generally divided into Multiple Objective Decision-Making (MODM) that studies decision problems with a continuous decision space and Multiple Attribute Decision Making (MADM). In many cases, the terms MADM and MCDM are used interchangeably, and they concentrate on problems with a *discrete* decision space (Triantaphyllou, 2000). MCDM methods are widely diverse. Hwang and Lin (1987) classified a group of MCDM methods according to the type of information and the salient features of information received from the decision maker. The Weighted Sum Model (WSM), the Weighted Product Model (WPM), and the AHP method are the most commonly used MCDM methods.

Because the transportation planning process includes many different objectives and reflects the interests of a wide range of stakeholders, appropriate techniques need to incorporate these multiple and conflicting objectives into the assessment process. Moreover, decision-making in the context of sustainable transportation should involve the evaluation of a discrete set of alternatives while simultaneously considering conflicting objectives. This section identifies relevant international studies that apply different MCDM methods to metropolitan transportation planning and decision-making.

These research trends indicate that MCDM methods have been often applied to transportation planning studies, and MCDM applications to broader scope analyses, such as the evaluation of transportation plans or policies, are more recent research trends. One of the most common methodologies of MCDM is Saaty's AHP developed in the 1970s to provide a systematic approach to setting priorities and decision making based on pair-wise comparisons between criteria (Saaty, 1995). Since Saaty introduced the application of this method in transportation decision-making, the AHP method has been frequently used to incorporate multiple decision criteria in the evaluation of transportation alternatives.

The findings of this literature review of theory indicate that while there is no standard definition of transportation planning, there seems to be emerging consensus that, in order to be effective, it must include impacts on the economy, environment, and social well-being; it must

address the causes of sustainable or non-sustainable trends; it must consider the relative levels of influence that oversight agencies have with respect to implementing policies and procedures that impact sustainability; and it must have a strong stakeholder component. The existing indicator systems reveal that operationally, transportation planning is largely being measured by transportation system effectiveness and efficiency as well as the environmental impacts of the system. At the same time, a growing number of qualitative and quantitative studies on modeling transportation system have been conducted around the world. As with the definitions and performance measures of planning projects, no standard model or evaluation methodology is found. Qualitative planning models include scenario planning approaches that essentially incorporate uncertainties associated with key drivers, such as population, employment, and travel demand, into sustainability planning. System dynamics approaches and influence diagrams are occasionally used to investigate the cause-and-effect relationships within sustainable transportation systems.

In this research, we mainly focus on quantifying transportation planning using an application of a MCDM approach in the development strategies evaluation framework. Most analytical models of planning are based on the multiple dimensional themes of economic, environmental, and social impacts, indicating that a robust method should at the minimum consider these dimensions as decision-making criteria. Thus, multiple criteria and multiple objective methods seem to be better suited

to transportation planning assessments than single criterion and single objective methods. Common MCDM methods were first reviewed in general, and their applications to transportation planning and decision-making identified. This study uses Saaty's AHP model because this model is particularly simple and offers transparency in the interpretation of parameters. The following chapters will demonstrate an application of the MCDM approach for evaluating container ports related to transportation and intermodal system development alternatives.

The AHP technique can evaluate qualitative, quantitative and intuitive criteria comprehensively, and it is possible to raise the level of confidence of it through carrying out consistency testing. The AHP technique resembles the structure of the human brain, and obtains quantitative results by transforming the comparative weight between elements to a ratio scale. The AHP technique is based on three principles; hierarchical structuring, weighting, logical consistency. Pair-wise comparison, homogeneity, independence relation, and expectation are basic assumptions of the AHP technique in strategic planning (Frankel, 1989). They are very important and should be used properly when applied to the AHP technique because they are the fundamental frames of the AHP technique logically and actually. Pair-wise comparison means that a decision maker can not only compare one element of a project or policy with another but also determine the weighted score between them. Homogeneity means that the weighted score can be presented by a settled index in a fixed range, and the independence

relation means that there is no relationship among elements. Expectation means that hierarchical structure logically corresponds to the expectation of every decision maker (Lee and Tseng, 2006).

After considering many factors relative to railroad projects, decision makers calculate the total weighted score sum of each element in each alternative, and then the best alternative can be concluded. Researchers survey citizens, citizen groups, project operators, and government officers who have enough knowledge and experience to judge the public benefit impartially. A consistency test of the questionnaire result is carried out, and applied for calculating the weighted score of the each object. AHP is most commonly used as a supporting system for group decision-making as it is easy to apply and highly respected for its process of measurement and weight calculation according to its hierarchical evaluation structure. In Korea, AHP was used as a multiple criteria analysis method for measuring the competitiveness of container ports when conducting a comprehensive evaluation of the preliminary feasibility study (Yeo, Roe and Dinwoodie, 2008). A participatory decision making tool used for prioritising alternatives in complex situations has been used successfully in a variety of fields, including transhipment port selection and resource management planning (Lirn et al., 2004), conflict resolution, project selection, education, and politics (Baird, 2006; Brooks and Cullinane, 2007). Application of the AHP for decision making is very useful when the problem includes qualitative as well as quantitative elements.

CHAPTER FOUR

CONCEPTUAL MODEL OF THE RESEARCH

4.1: Introduction

This chapter develops a conceptual model of research to provide the way forward for an analysis of an innovation methodology in intermodal transport system development strategies specific to the container port service market. Related reviews of literature regarding container port logistics, intermodal transport system and methodology theory were carried out in the previous chapters enabling the research areas to be narrowed and the research problems to be identified. The research questions and testable hypotheses are considered, described and derived in the following section. This section will focus on the conceptual development of the research model based on the scientific approach, research strategy, and research methods used in this study. This study belongs to the domain of applied research, and its research objectives are reached by using established research methods. This study uses a research strategy incorporating decision-making approaches. The research methods include questionnaires, general analysis and closer study of the selected case study. The conceptual model for research is illustrated in Figure 4.1. The model involves a literature review of the background and theory to the employment of research problem, structure of decision process, an evaluation of the model, and validation of the model.

89

Step one:	**Literature review**
	• **Background review** (Inter-port competition, Inland container transport, Intermodal transport system) • **Theory review**

⬇

Step two:	**Identification of the problem**
	• **Decision process** • **Basic framework** • **Criteria/sub-criteria**

⬇

Step three:	**Structure of the decision process**

⬇

Step four:	**Development of preliminary model**

⬇

Step five:	**Questionnaire survey**

⬇

Step six:	**Analytic Hierarchy Process (AHP) analysis**

⬇

Step seven:	**Validating of the model**

(Source: The author)

Figure 4.1: Conceptual framework of the research

Figure 4-1 presents the conceptual framework of research designs and consists of seven steps:

- Step one: A background literature review concerned with inter-port competition and inland container transport both intensive and comprehensive for the following trends of development strategies regarding an intermodal transport system in Taiwan. A literature review of applications of MCDM processes is included.

- Step two: Identification of the problem including the decision process for selecting the best strategies, basic framework and selection criteria and sub-criteria.

- Step three: Structuring the decision process as a hierarchy.

- Step four: Developing the preliminary model and refining the decision-making procedure.

- Step five: Conducting the questionnaire survey for decision-making procedure.

- Step six: Analyses of the research model using the Analytic Hierarchy Process (AHP) method.

- Step seven: Validation of the model using a case study.

A successful conceptual model of the research will focus on survey design that can be thought of as the main framework of the research. It provides the cohesiveness that brings the thesis together. A design is

used to structure the research, to show how all of the major parts of the research project, the samples, measures, treatments, and methods of assignment will work together in seeking to address the central research questions.

Academics often describe a research design as a concise notation that enables efficient summarisation of a complex design structure (Trochim, 2002). The case study method used here yields both quantitative and qualitative data on real empirical material and facilitates the identification and understanding of the problem. The research process has been greatly helped by extensive cooperation with shipping and port industry specialists in Taiwan. It is very important to understand that the available data is not always of the best quality and some of it is estimated indirectly from company sources available to the public.

Transportation planning development is a complex dynamic process involving various actors with different patterns of behaviour. Modeling a transportation planning development pattern is a prerequisite to understanding the process. A methodology is presented to implement the framework, based on exploratory data analysis, and multiple criteria, where the decision process is carried out by a group of decision-makers. Thus, this research has developed a multiple criteria decision-making model to address this problem.

According to the introduction in chapter one, the research objectives need to be reviewed at this stage. The methodology is based on a theoretical model framework in order to simplify a complex problem of determining critical process. Besides reviewing the relevant literature, the research contains the following objectives. First, this research aims to discover the driving forces, which appear to stimulate intermodal transport service providers to employ the port logistics service concept in their business operations. Discovering these environmental factors can provide a sound starting point for the research. Second, this research aims to investigate the difference between the features of container port service and those of intermodal transport related service. Identifying those differences can help us to establish the underlying reasons why service providers intend to employ the concept of port logistics service. Third, this research aims to analyse carriers' perceptions of intermodal transport service with reference to development strategies' characteristics. For a real user of the service provided, it is vital to analyse the carriers' perception in the first place. Finally, the research aims to analyse the relationship between the preferred strategic planning of intermodal development for the port logistics function and the degree of satisfaction therein.

4.2: Conceptual model

This section aims to define the decision process characteristic of the model. In the MCDM methodology, one compares criteria in the same way as for the attributes of the alternatives. The selection of appropriate

criteria is one of the most critical parts in the design and development of a successful decision making environment. A decision is a choice made from two or more alternatives. Decision making is the process of sufficiently reducing uncertainty and doubt about options to allow a reasonable choice to be made among them. Researchers have addressed a variety of decision making problems by using different decision making methods.

The basic idea behind this weighting procedure is that one has to compare a group of criteria by presenting the decision model for this research from the view of different organisations. The available attributes are related along with the functional requirements of a specific alternative. They are frequently based on multiple criteria for evaluating the performance of projects. The conceptual model provides a framework to assist decision-makers in the selection procedure both qualitative and quantitative, in order to assess transportation system planning. The principles of this research model are to match decision-makers' preferences with MCDM characteristics and assess a number of potential criteria incorporating managerial experiences and judgements in the solution process. It uses the example of a problem to illustrate the solution process and address managerial implications for future research.

After reviewing the relevant literature, a certain degree of judgement may be required to balance the need to show familiarity with the literature of the parent discipline and to focus on the link between the research

problem and its immediate discipline. This section synthesises major emergent methodologies that can be applied for practical modeling of transportation systems within regional development project planning. The literature proposes various tools and methodologies such as scenario planning; economic-based models; integrated transportation and land use models; simulation and decision analysis models; environmental impact analysis; and life cycle assessment. MCDM is a subject that has received great attention among transportation research planners during the last decade. Consequently, development projects need to be allocated in such a way that benefits from research are maximised for a given cost.

MCDM has an economic, analytical dimension that places emphasis on the methodological aspects of measuring the contribution of different research alternatives on pursued objectives, and the systematic comparison of these activities once the measurements have been defined. It may also be viewed from the managerial/institutional dimension placing emphasis on the process of arriving at a best possible set of research activities. In the explored models, a simple AHP method was used that is the most suitable model for this research problem, thereby determining the selection criteria and their relative weights. This is because other MCDM techniques lack AHP's capability to elicit expert judgment and provide consistent feedback to decision-makers.

The judgement of a decision maker can occur in three different ways. Each individual judgment is modelled with a probability distribution. For

example, a decision maker may use the triangular distribution, where only the high, the low and the most likely value are asked. Then the mean of all judgments is estimated and therefore the group value is obtained. All decision-makers are asked for a point-estimation. This assumes that all decision-makers have an equal probability of being correct, as the group decision is derived as the average of all point-judgments. All decision makers are asked to estimate high and low values and their judgment is assumed to possess equal probability within that range.

The issue of transportation planning by using MCDM has been widely discussed in the literature. Saaty and Vargas (2000) have proposed several hierarchies and approaches for that task. Generally, there are two major categories of planning: forward and backward planning. By forward planning is understood a descriptive process that includes all or some actors pursuing certain objectives and implementing certain policies towards a specific objective. This approach leads to a feasible or a likely future. In contrast, backward planning aims at the desired future.

The desired outcome is achieved by applying policies influencing actors. This process is normative. Usually corporations and decision-makers implement a two-stage analysis involving forward and backward planning processes. The first step is to project the likely or feasible future by implementing forward planning. Then a backward process is employed to determine the influences on the actors. In that case the desired future

goal is the outcome of the first step. This process can be repetitive to obtain greater convergence. Practically there are also two limits: one is fixed in the present with actors and the available resources. The other is fixed in the future with the desired objectives. In both cases the preparation of scenarios and their analysis is required. The scenarios must include an adequate account of interaction of the system with relevant factors. The variables are common to all decision processes but the relationship among them is different in projected and desired planning processes.

For projected processes the policies are defined, and the efficiencies are estimated and the outcomes deduced. For the desired process the outcomes are valued, the efficiencies are influenced and the policies are developed. The difference is fundamental due to the different structure of the hierarchy. As stated above, scenario analysis is an indispensable step in the analysis. There are two general kinds of scenarios: exploratory and anticipatory scenarios.

Exploratory scenarios start from present work and go forward to the future illuminating outcomes based on trends or beliefs. Anticipatory scenarios portray feasible and desirable futures; they start from the future and work backwards discovering what alternatives and actions are necessary to attain these futures. Anticipatory scenarios are further broken down to normative and contrast. In normative scenarios the objectives are determined at the beginning. In contrast scenarios,

feasible future scenarios are sketched by using a range of assumptions. The desired future scenario is derived as a combination of contrasting anticipatory ones.

4.3: The proposed Analytic Hierarchy Process (AHP) analysis framework

In this research, we create a conceptual framework for organising and synthesising information for the measurement of transport system development strategies. As discussed in the previous section, the development of a conceptual model should be based on some underlying theoretical assumptions. The testing of the relationship between the variables discovered in the conceptual model can prove whether the underlying theory does exist in the relationship, thus providing a basis for the validation of the model (Aaker et al., 2004). In this section, we address this goal by proposing a framework, which can be expanded to include almost any number of criteria. The framework employs the Analytic Hierarchy Process (AHP) method. In the transport system development strategies project, the researchers challenged the advisory panel members to identify relevant factors that a decision maker should consider when designing transportation systems. One of our primary goals was to provide a list of people's preference weightings for all these criteria. AHP fits our needs for two reasons: first, it is a powerful tool developed for calculating criteria's priorities and, second, through the first two stages it is easy to set up a basic hierarchy structure.

Another important consideration when applying AHP is that the alternatives or choices that decision makers are comparing are indeed comparable. If the magnitudes of the choices are not clear, it will be impossible for the decision maker to express meaningful preferences. For example, it is impossible to accurately compare apples with oranges. The quantity, size, quality, and characteristics of the choices must be explicit to assure meaningful weights. Group decision-making is more common than individual decision-making, especially at the level of public investment decisions. In the transportation system development project, a framework was developed that will enable representatives of all stakeholders to express their preferences. A decision-making AHP model is very similar to the individual one. The most important difference between individual and group decision-making is that a group AHP exercise must combine each person's weight, on each indicator, into a final one. In other words, it must average individuals' weights. Empirically, several ways of averaging have been used, in particular, arithmetic means, geometric means, and weighted arithmetic means.

4.4: Research hypotheses

During the information acquisition phase and the actual research, the hypotheses have been formulated based on the discussion in the literature review and the conceptual model. The three categories of model used in the analysis of the research hypotheses associated with the decision-making process are as follows:

Hypothesis one:

- **H1: The specific features of all transportation planning research require the definition and incorporation of special criteria into the multiple criteria decision-making approach.**

The first main hypothesis has been formulated based on the relevant literature review. The main objective of hypothesis one is to investigate the different features of decision-makers and end users' knowledge, and the clear need that understanding of transportation planning must be increased. The existing transportation planning research must be interoperable, interchangeable and possible to be used across the same systems. Transportation planning requires the definition and incorporation of special criteria into the multiple criteria decision-making approach with its own specific devices and accessories to improve transportation planning management.

Hypothesis two:

- **H2: The sources of uncertainty regarding the success of transportation planning research and the successful adoption of the results by end users have to be carefully identified and included in the approach.**

The uncertainty, complexity and flexibility of transportation planning work must be coordinated on a case-by-case basis. Correct coordination to improve the planning process is complex, and the use of development

strategies in a planning procedure should involve decision-makers and end users who have a need for innovations to facilitate the introduction of the new transport system. Decision-making in transportation planning can be improved by applying the principle of case studies. The main decision-makers must share the responsibility for success and satisfactory operation of the entire transportation planning system.

Hypothesis three:

● **H3: The development strategies of intermodal transport system research should be explicitly assessed.**

After reviewing various multiple criteria decision making approaches, the Analytic Hierarchy Process (AHP) is selected as the methodological basis for this study. The AHP hierarchically structures multiple criteria decision problems and employs pair-wise comparisons to determine preferences among a set of alternatives. It is adapted in order to deal with the issues stated in the working hypothesis. The decision-making support model for the development strategies of the intermodal transportation system enhances the design and implementation of transportation planning projects. Participatory planning and multiple criteria decision-making tools should be used in decision making. The AHP is selected as the methodological basis for the choice of the Multiple Criteria Decision Making (MCDM) approach related to transportation planning in order to improve the decision-making process. The use of the AHP method

employs a set of alternative solutions for the transportation planning researcher in order to provide more knowledge and greater accuracy.

4.5: Model formulation

The framework of the innovation strategy model that we construct is as shown in Table: 4.1. As a first step, we confirm the contents of the decision including the scope of the plan and the appropriateness of the objectives. As a second step, we analyse the objectives. Thirdly, we analyse the internal and external criteria (Godet, 1987; Wernerfelt, 1984; Amit and Schoemaker, 1993; Hamel & Prahalad, 1994). Fourthly, we evaluate the development strategies by using the AHP approach (Saaty, 1980). Finally, we produce the strategic plan of the model. The Analytic Hierarchy Process (AHP) is used to describe the structure of the planning and decision-making process involving development strategies' selection. The appeal of AHP as a method of decision making in a wide variety of applications is the accuracy of the predictions and decision outcomes that turn out to be true when events become known later. Thus, there is a growing interest in AHP as a predictive as well as multiple criteria decision analysis method used in transportation planning among many applications. The AHP application in this research provides a further test of the method in the prediction of development strategies' selection decision outcome.

Table 4.1: Structure of the strategic plan model

Process phases	Contents
First phase	Definition of objectives
Second phase	Analysis of objectives
Third phase	Analysis of internal and external criteria
Fourth phase	Evaluation of strategy
Final phase	Building a Strategic Plan

(Source: The author)

The AHP model used in this research describes a framework of the actual planning process implemented in Taiwan. AHP informs as well as is informed by the decision making and planning processes. Viewed methodologically, the procedure is intended to facilitate the public transportation decision-making process generically, providing reflective guidelines as well as local priorities and preferences for multiple participant groups. Instead of being viewed as yet another AHP application in transportation, this research is intended as a contribution

toward the development of a streamlined and unified procedural framework for the purposes of transportation planning decision making with a potential for systematic comparison of similar experiences in different fields.

Thus, this research is a case analysis with a general procedural implication for public transportation decision-making. A brief description of AHP follows with particular reference to applications in transportation planning projects. The research concludes with reflections on the case-specific planning process. Planners confront complex multiple criteria decisions related to alignment alternatives, different development strategies choice, and environmental impacts. The decisions commonly involve various interest groups as well as elected officials, governmental agencies, and the general public. The decision criteria can be mixed with tangibles and intangibles. Commentators have observed public transportation decision making as both a technical and political process. Transportation decision-making is also characterized as a process involving multiple participants or "stakeholders" (Hall 1980; Levin et al. 1999). AHP has emerged as a versatile decision support and evaluation methodology with wide-ranging applications. Transportation planning applications are equally as prolific and diverse: stakeholder preference assessment in transportation planning (Levin et al. 1999), development strategies priority analysis, transportation system improvement projects (Tabucanon and Lee 1995), and carrier selection (Bagchi 1989).

In this section, we tried to explain structural links in real-life interventions that are too complex for the survey method or for experimental strategies. According to Yin (1994), the case study methodology in logistics is the preferred strategy in exploratory research, because: ``how" questions are posed to identify operational links, which have to be traced over time; the investigator has little control over events (unlike in an experiment); and the focus is on a contemporary phenomenon within some real-life context. Yin (1994) adds that the results of case studies can be generalized to support theoretical propositions, but they do not apply automatically to populations or universes and the quality of a research project and its case study design can be tested in four areas. To assist in answering these questions, two methods were applied in the case studies: process mapping techniques and cause-effect modelling. To redesign chain processes, one has to describe them thoroughly and analyse their relationships with other processes and chain performance. Methodology reviews in logistics use an increasingly frequent adoption of case studies as a method within which to frame data gathering in logistics research, because case study methods are versatile and accepted within different paradigms (Dinwoodie and Xu, 2008).

AHP is a tool to help planners structuring a complex, multifaceted decision-making process. In contrast to multiple criteria or multiple attribute evaluation methods, AHP is a hierarchic, systems-oriented or holistic methodology useful in defining a characteristically multiple

layered public transportation problem. A typical AHP hierarchy is structured by the relationship of the elements in various levels. The overarching goal is stated at the first level, followed in subsequent levels by the criteria and alternatives. When group participation is essential, the participant groups are specified explicitly as described below. A versatile ratio scale is used to compare elements pair-wise for all the levels of the hierarchy and systematically comparing the elements of a level with each of the elements of the previous level, starting with each level subsequent to the goal and ending with alternatives in order to compute a composite score of the alternatives.

For a thorough account of the underpinning philosophy, measurement theory, and methodology of AHP, see Forman (1993), and Saaty and Vargas (2000). The criteria to assess development strategies are varied, and thus the measurement of the intensity of the multiple criteria involves different rating, step, and utility functional types that are supported by the software and shown later in this research. A simple example of the rating methods of AHP is given to determine the best development strategies alternative. In Figure 4.2, three objectives and ten criteria are used to decide three types of development strategies alternative, and the relative importance of the criteria is determined. A rating scale is then developed to evaluate alternatives. The relative importance of the criteria is determined through the paired comparison method of AHP.
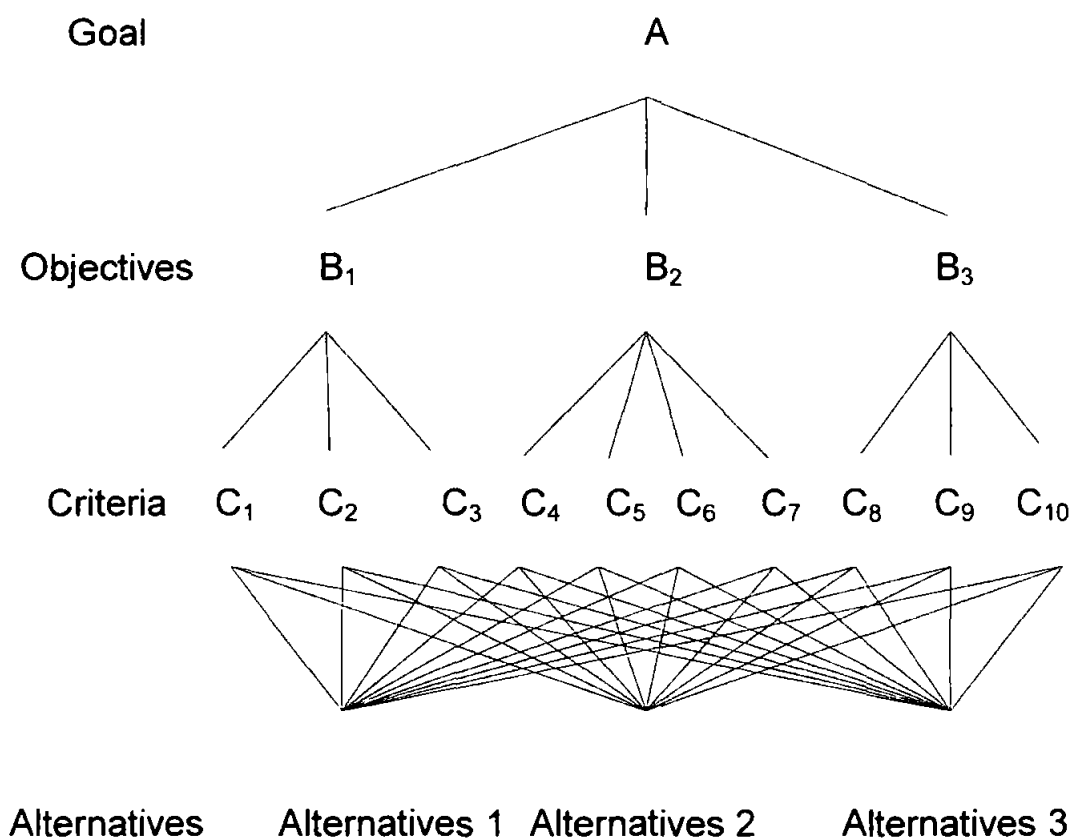
Figure 4.2: Basic structure of the hierarchy

4.6: Conclusion

The conceptual model of research developed in this chapter will be empirically elaborated through both the methodologies' exploratory and explanatory aspects. A suitable way of combining methodologies will be

considered and discussed. This chapter has focused on the scientific approach, research strategy, and research methods used in the present study. The study belongs to the domain of applied research, and its research objectives are reached by using established research methods. The empirical material facilitates the identification and understanding of the problem.

The experience and feedback from people involved in the case study has suggested that the AHP is an appropriate tool to manage development strategies selection problems in this study. It is an easy communication method and, thus, allows the participation of virtually everybody who has a stake in the decision. Its simplicity and intuitive logic also facilitates interaction with stakeholders and the broader public not directly involved in the exercise. The AHP provides detailed information that permits a thorough analysis on the strength and weakness of the alternatives. The rigorous structure of AHP models improves collective thinking, reasoning, and the efficiency of group discussions.

The AHP is very flexible in terms of the degree of detail in structuring the decision problem, accuracy of data used in the evaluation, and intensity of stakeholder involvement. As a consequence, it can be adapted to almost any budget. The analytical rigour and the transparency of the AHP increases trust in the process of multiple criteria analysis and the need for trust is a common element in public decision making.

The purpose of this section is to describe the model within the research framework for the MCDM methodology. It is based on the AHP that has been identified as a suitable method to select transportation planning projects under a set of multiple criteria decision processes. As set out above, the AHP meets the key requirements of participation and transparency and has a convincing procedure to compare and aggregate various kinds of project impacts. For the development of the model, particular attention has been paid to the issues raised in the working hypotheses.

We start with structuring a hierarchy that reflects the basic problem of the MCDM process for transportation planning projects. The goal appears at the top of the hierarchy. The different levels consist of the corporate objectives, criteria, sub-criteria and alternative activity. Details on the structuring process and the individual elements included are reported in the following chapters. The separate analysis of uncertainties and preferences is a common approach for choosing under uncertainty. In the second working hypothesis, we argued that uncertainty is of particular relevance in transportation planning research evaluation and, therefore, warrants more careful scrutiny. Accordingly, we formulate two additional hierarchies, one for the evaluation of the chances of research success and one for the chances of successful adoption of the research results.

In conclusion, the model developed for MCDM methodology in transportation planning research is based on the AHP method. The specific features of transportation planning have accordingly been included on the decision process level of the different hierarchies. The strategic component is considered by adding a criterion level of development strategies hierarchy. The chances of success are selectively multiplied by the potential impacts of the projects on the individual decision process.

CHAPTER FIVE

THE ANALYTIC HIERARCHY PROCESS

5.1: Introduction

The basic model of the methodological framework for the proposed project is AHP. A decision making choice for the purpose of setting priorities for different alternatives in order to attain a goal was the core subject. The method is described by Saaty and Vargas (1991, p.14) as a "...multiple objective multiple criteria decision making approach which employs a pair-wise comparison procedure to arrive at a scale of preferences among a set of alternatives. To apply this approach, it is necessary to break down a complex unstructured problem into its component parts and arrange these parts, or variables, into a hierarchic order." The AHP was initially developed by Saaty (1980). It has been applied to a wide range of complex decision problems. The numerous applications have been surveyed by Zahedi (1986), Golden et al. (1989), and Vargas (1990). Special issues of several journals have been devoted to the AHP. For instance, Ramanujam and Saaty (1981) used the AHP to deal with technological choice in developing countries.

The AHP method was developed by Thomas L. Saaty in the 1970's to provide a flexible and easily understood way to analyse and deconstruct the decision problem. It is a multiple criteria decision making methodology that allows subjective as well as objective factors to be

considered in the evaluation process. AHP is a method that can be used to establish and connect both physical and social measures, including cost, time, public acceptance, environmental effects, and so on. In its general form, it is a framework for performing both deductive and inductive thinking. Saaty's AHP is a technique for multiple criteria decision analysis with a systematic procedure that organises the basic rationale of the decision problem by breaking it down into smaller constituent parts and then calling for only one simple pair-wise comparison of judgments to develop priorities within each hierarchy. AHP was designed as a scaling procedure for measuring priorities in a hierarchal goal structure. It requires pair-wise comparison judgments of criteria in terms of relative importance. These judgments can be expressed verbally and enable the decision-maker to incorporate subjectivity, experience and knowledge in an intuitive and natural way (Saaty, 1980). This technique aims to support the analysis of complex decisions. It facilitates a quantitative comparison of how effective decision alternatives are in fulfilling multiple criteria relevant to the objective. Since this research uses this method, in this section we will illustrate the methodology underlying the AHP by means of an example.

5.2: The Analytic Hierarchy Process (AHP) structures

AHP requires the decision maker to first represent the problem within a hierarchical structure. However, decision making has to be seen as a process involving discussions, learning and checking the outcome, and

AHP is such a process (P = Process). It provides a consistent framework to formally incorporate subjective judgments. Their elicitation and subsequent discussion is particularly encouraged in group decision making. The AHP is considered as a powerful and straightforward tool to support such group sessions. A unique feature of the approach is the possibility to compute a measure of inconsistency of the decision makers. This enables them to identify 'errors', revise the judgments, and improve the quality of the decision. The procedure of the AHP is based on three principles: 1. decomposition of a complex unstructured problem; 2. comparative judgments about its components; 3. synthesis of priorities derived from the judgments. The purpose of constructing the hierarchy is to evaluate and prioritize the influence of the criteria on the alternatives to attain or satisfy overall objectives. To set the problem in a hierarchical structure, the decision-maker should identify his/her main purpose in solving a problem. In the most elementary form, a hierarchy is structured from the top level with goals/objectives, through intermediate levels (criteria/sub-criteria on which subsequent levels depend) to the lowest level (which is usually a list of alternatives). The AHP structures a decision into a hierarchy of factors. Criteria are then chosen and weighted according to the priority of their importance to the decision-makers. The different alternatives are then evaluated based on those criteria, and the best one is chosen. This is through the construction of a ratio scale for the priorities associated with the alternatives of the problem, by means of hierarchical modelling and pair-wisely comparing each decision criterion, sub-criteria, and alternative (Aguarón and Moreno-Jiménez, 2000).

AHP's power has been validated in empirical use, extended by research, and expanded by new theoretical insights as reported in a series of annual international symposia on AHP. AHP has been widely used as a powerful multiple-criteria decision-making tool. It has been applied to solve highly complex decision problems, in planning and resource allocation as well as conflict resolutions (Saaty, 2000). In essence, the hierarchical levels represent the objective of the decision, the criteria and the alternatives. The number of levels in the structure depends upon the complexity and the degree of detail in the problem. The main goal/objective of the problem is represented at the top level of the hierarchy. Then each level of the hierarchy contains criteria or sub-criteria that influence the decision. A simple example will illustrate the methodology of the AHP in Figure 5-1. In this example, the goal or objective is to choose out of four criteria, containing ten sub-criteria. The main criteria for this objective are assumed to be: criteria 1, criteria 2, criteria 3 and criteria 4. Ten sub-criteria will be compared according to these criteria (adapted from Zahedi, 1986 in Figure 5-1). The AHP method is based on a basic set of axiomatic foundations that correspond to hierarchic structures of the AHP (Saaty, 1986). Zahedi (1986) comments that the structure of the hierarchy depends upon the nature of the pair-wise comparisons resulting in a (N × N) positive reciprocal matrix A, where the diagonal $a_{ij} = 1$ and reciprocal property $a_{ji} = (1/a_{ij})$, i, j = 1. Consider where a decision maker is making inter-comparisons of the weights of alternatives, the rest of the matrix is defined by the reciprocal

property of A. It is obvious that similar relationships can be obtained with any other pair of rows. It must satisfy the reciprocal property. Zahedi, (1986) points out a both positive and reciprocal relationship in a survey model of the AHP method. The application of this method was not only contending that AHP's axioms are simpler and maintain the reciprocal property of the pair-wise comparison. The pair-wise evaluations require redundant comparisons in the random consistency checking from the weights obtained. The basic principle of AHP procedure is neither assumed the stronger condition of consistency nor overtaken by strong assumptions of the usual notions of rationality in the combined comparison (Zahedi, 1986; Vargas, 1990). In addition to reducing the effect of the usual type of errors in measurement, this procedure also reduces the effect of the fuzzy nature of the ordinal scale and different interpretations of the scale by different decision makers.

Figure 5-1: The example of AHP methodology

Constructing the hierarchical structure is the most important step in AHP. There is no specific procedure for constructing a hierarchy, and the approach depends on the kind of decision to be made. The hierarchy should be constructed so that elements at the same level are of the same order of magnitude and must be capable of being related to some or all elements in the next higher level. In its general form, the AHP is a nonlinear framework for carrying out both deductive and inductive thinking by taking several factors into consideration simultaneously and allowing for dependence and making numerical tradeoffs to arrive at a synthesis or conclusion. AHP is a mathematical algorithm based on priority and simple linear algebra.

The AHP method involves the following steps: The overall goal or objective is identified, and the issue is clearly defined. After finding the objective, the criteria used to satisfy the overall goal are identified. Then the sub-criteria under each criterion must be realised so that a suitable solution or alternative may be specified. The hierarchical structure is constructed. Pair-wise comparisons are constructed; elements of a problem are paired and then compared. Weights of the decision elements are estimated by using the eigen-value method. Consistency of the judgments is checked. The initial version of the AHP consisted of three steps (Saaty, 2001: 45).

The first step involves setting up a problem as a hierarchy. This is an efficient and intuitive way of dealing with complexity and identifying the relevant components of the problem. Evaluation of the pair-wise comparison matrix through eigenvector scaling yields a set of uni-dimensional priorities for the elements of the pair-wise comparison matrix. One such matrix must be generated for each group of elements which need to be further evaluated by the decision maker on how strongly one member of a set belongs to that set. The entries in this matrix reflect the pair-wise comparison. The method was also evaluated in terms of a pair-wise matrix, and when the relative priorities are derived by using the eigen-vector the principal problem is decomposed into a hierarchy. Each level of the hierarchy consists of an efficient and intuitive way of dealing with complexity and identifying the relevant components

of the problem. At the lowest level are the alternatives to be evaluated for the relevant elements by solving for the principal eigen-vector of the matrix. The weights derived from a pair-wise comparison matrix are called "local weights". The local priorities for the set of the elements are immediately calculated and displayed.

The AHP pair-wise comparison matrix shown in Table 5-1, represents a 9-point scale implying that, to recover the scale from the matrix of ratios, one must solve the problem using different matrices at the sub-criteria level. The weights were evaluated in relation to the weights of each criterion estimated using an eigen-vector approach. Such a scale is nothing but a one-to-one mapping between the set of discrete linguistic elements. The items can be evaluated through visual inspection. The next step is to form the pair-wise comparison matrix for the eigen-vector solution to the paired comparison matrix, a measurement implicitly adjusted to a common dimension by the scaling level. The next step is to establish priorities by the relative importance weights for each set of elements at each level. Such a hierarchy can aid management in identifying their relevant problem. State the question for pair-wise comparisons clearly above each matrix. Calculate priorities by adding the elements of each column and transpose the vector of weights of the characteristics. This yields a dimensional discrete scale of 1-9 which has the advantages of simplicity and ease of use. The AHP method is also known as an eigen-vector method which reflects a vector of weights obtained from the pair-wise comparisons matrix. With

118

counting numbers we can say how many times one set of elements is a multiple of another and by the comparisons one derives a scale of priorities, which are in relative values.

AHP offers an approach to estimate the weights of the criteria and the priorities of the alternatives. This quantification is derived from a matrix of pair-wise comparisons of two criteria or alternatives. The pair-wise comparisons of the criteria indicate the relative importance of the criteria with respect to the objective, the comparisons of the alternatives, and the relative preference for the alternatives with regard to a criterion. They are based upon an ordinal scale. This scale ranges from the numerical value 1 reflecting equal importance or preference up to and including 9 reflecting extremely greater importance or preference. An example of a pair-wise comparison of the importance of two criteria using Table 5-1 will be:

1: equally

3: moderately

5: strongly

7: very strongly

9: extremely

2, 4, 6, 8: Intermediate values

The AHP provides a fundamental scale of relative magnitudes expressed in dominance units to represent judgments in the form of paired comparisons. The comparison matrix can capture the importance of these influences by making pair-wise comparison judgments expressed using the AHP fundamental scale in Table 5-1 shown as following:

Table 5-1: Fundamental scale of the AHP

1	Equal
2	Between Equal and Moderate
3	Moderate
4	Between Moderate and Strong
5	Strong
6	Between Strong and Very Strong
7	Very Strong
8	Between Very Strong and Extreme
9	Extreme
	Decimal judgments, such as 3.5, are allowed for fine-tuning, and judgments greater than 9 may be entered, though it is suggested that they be avoided.

(Source: Saaty, 2001)

The two criteria can be reversed, if criteria 1 is more important than criteria 2 as shown in Table 5-2 to provide the matrix of pair-wise comparisons of n criteria: A is a matrix in which n is the number of elements being compared. Entries of A were the judgments or the relative scale of alternative i to alternative j. is the entry from the i th row and the j th column of A.

Table 5-2: The sample matrix A

A = (aij).

	Criteria$_1$	Criteria $_2$		Criteria $_n$
Criteria $_1$	a_{11}	a_{12}	...	a_{1n}
Criteria $_2$	a_{21}	a_{22}	...	a_{2n}
......	...	...	...	...
Criteria $_n$	a_{n1}	a_{n2}	...	a_{nn}

(Source: adapted from Saaty, 2001)

The general steps of AHP involves transforming the structure of the problem into a hierarchy in order to obtain the global weights that measure the importance of each node in the total hierarchical levels. Each node is calculated by multiplying the local group priority of the node by the matrices to establish local and global priorities and calculate local and global weights for the higher-level nodes (Saaty, 2001). Each function can be looked on as a separate, a more complex AHP hierarchy, with local and global default priorities, the initial global priorities are calculated by the priorities for all perspectives. We can use the AHP to investigate individual priorities which were calculated with

pair-wise comparisons between the global and local priorities and weights of each alternative based on judgment weights of criterion. Elements of a problem on each level are paired and then compared. For each level, starting from the top of the hierarchy and going down, the pair-wise comparisons are reduced in the square matrix form. Breaking a complex system into a set of pair-wise comparisons is a major feature of AHP.

A measurement theory can establish the priorities of the hierarchy and the consistency of the judgmental data provided by the group of respondents to calculate the priorities. The basic premise of the AHP is that the measurement evolves from pair-wise comparisons. The matrix is constructed by using the relative importance of the alternatives in terms of each criterion. The best alternative is the one that satisfies the structure of an m x n matrix constructed by using the relative importance of the alternatives in terms of each criterion. It was constructed using the relative importance of the alternatives demonstrating that an inconsistency can occur when the AHP is used to model the alternatives in terms of each criterion involved in a given decision making problem. Therefore, the actual value of the alternative in terms of decision criteria is constructed using a scale of relative importance in each column of the normalised decision matrix. In order to obtain the consistency index of judgment, we carry out the critical points of the process and the construction of the most outstanding characteristics of the AHP. Consistency of stability intervals for a judgment was important in a

hierarchical decision support system for the facilities layout design problem (Aguarón et al., 2003). The procedure exploits the characteristics of AHP in the possibility of measuring consistency in judgment elicitation. The average random consistency index of different sample size matrices was shown in Table 5-3. The inconsistency ratio, which is the matrix's mean inconsistency divided by the mean random inconsistency, should also be less than 10% according to Saaty's (1980) measure. He suggests these hypotheses regarding AHP matrices: where the Average Consistency Ratio is the average index of randomly generated weights. Saaty (1980) proposes the rule of thumb, where a CR of 10% or less is considered acceptable. If this is not the case, then the pair-wise comparison of the value of Average Consistency Ratio depends upon the size of the matrix.

Table 5-3: Table of random consistency for different size matrices

n	1	2	3	4	5	6	7	8	9	10
Random Consistency Index (R.I.)	0	0	0.52	0.89	1.11	1.25	1.35	1.40	1.45	1.49

Note: Saaty (2000) shows the value of the random consistency
index (RI) for matrices of order 1 to 10.
Source: (Forman and Selley, 2001; Atthirawong and MacCarthy, 2002).

5.3: The advantages of Analytic Hierarchy Process (AHP)

AHP has many advantages over other multiple attribute decision models and is an appealing methodology to evaluate qualitative criteria and quantitative criteria systematically. Like all modelling methods, the

AHP has advantages and disadvantages. The main advantage of the AHP is its ability to rank choices in the order of their effectiveness in meeting conflicting objectives. If the judgements made about the relative importance of, in this example, the objectives of expense, operability, reliability and flexibility, and those about the competing machines' ability to satisfy those objectives, have been made in good faith, then the AHP calculations lead inexorably to the logical consequence of those judgements. It is quite hard − but not impossible − to 'fiddle' the judgements to get some predetermined result. The further strength of the AHP is its ability to detect inconsistent judgements.

The limitations of the AHP are that it only works because the matrices are all of the same mathematical form − known as a positive reciprocal matrix, so we will simply state that point. To create such a matrix requires that, if we use the number 9 to represent 'A is absolutely more important than B', then we have to use 1/9 to define the relative importance of B with respect to A. Some people regard that as reasonable; others are less happy about it. In less clear-cut cases, it would be no bad thing to change the rating scale and see what difference it makes. If one option consistently scores well with different scales, it is likely to be a very robust choice. In short, the AHP is a useful technique for discriminating between competing options in the light of a range of objectives to be met. The calculations are not complex and, while the AHP relies on what might be seen as a mathematical trick, you don't need to understand the maths to use the technique. Do, though, be

aware that it only shows relative value for money. AHP has many advantages over other multiple attribute decision models and is an appealing methodology to evaluate qualitative criteria and quantitative criteria systematically. A great advantage of the AHP method is that by structuring the function of a system hierarchically in multiple objective frameworks, the fuzziness of imprecise phenomena can be measured in a meaningful way. The AHP method's comparative advantage lies in dealing with areas too fuzzy, too unstructured, or too political for traditional techniques require that the measurement scale be made explicit. The AHP calculates three kinds of priorities (local, global and total) which are organised in a systematic way to combine the priorities associated with the different decision making problems. The method identifies both tangible and intangible properties in order to measure their interrelations. Basically, the ratio scale of the AHP model structures a set of priorities associated with the alternatives of the problem. The ratio scale can combine the individual pair-wise comparison matrix to obtain a consistency ratio and measure the consistency of judgments for a decision problem to obtain the set of overall priorities for alternatives. In doing this, participants explore the aspects of the problem from different levels. Priorities are numbers associated with the nodes of an AHP hierarchy. The AHP method enables the decision maker to develop the trade-off and analyse the multiple criteria pair-wise comparison matrices. The structure family can evaluate alternatives against their covering criteria in any order. To sum up, the main advantages of AHP are that it can effectively manage qualitative and quantitative decision making for

complex multiple player and multiple dimensional problems. Other advantages of the AHP are (Saaty, 2001: 52):

- It provides a single, easily understood model for unstructured problems.

- It enables decision-makers to refine their definition of a problem and improve judgment and understanding by repeating the process.

- It agrees well with the behaviour of decision-makers, since decision-makers base judgments on knowledge and experience and then make decisions accordingly (Skibniewski, 1992).

- It helps the decision makers not only to set the relative order of importance of different criteria or projects, but also to indicate how much importance one may have over the other.

- It does not require consensus, but rather produces a representative outcome based on diverse judgments.

- It leads to an overall estimate of the desirability of each alternative.

- It can deal with the interdependence of elements in a system.

- It reflects the natural tendency of the human mind to sort elements of a system into different levels and to group like elements within each level.

- It tracks the logical consistency of judgments used in determining priorities.

The aim of this study is to assist a strategic decision by using Saaty's AHP in order to evoke logical foundations based on an acceptable compromise. Modelisation, prioritisation and valuation are three basic useful components of the AHP in a decision problem. The decision makers' subjective judgments can be quantified by assigning corresponding results

126

based on the relative importance of factors under consideration. The AHP structural hierarchy includes the interdependence of characteristics among elements and components. The AHP method is based on a basic set of the components of each index which were first scaled to lie on the establishment and the valuation of priorities and measurement in terms of consistency (Atthirawong and MacCarthy, 2002). The AHP method takes into account the motives for the choice of a strategic decision structure. Also, the mathematical process of AHP can be applied in computer software to make it simple and accurate (Partovi and Hopton, 1994).

The AHP has been popularly used for multiple criteria decision analysis. Sun, Hoffman, and Newton (1996) compiled about 480 AHP-related articles covering the years 1990-1996, and Gloden et al. (1989) found the AHP has been applied in hundreds of areas. Ra (1999) quoted Zanakis et al. (1995) and indicated the AHP has been employed to analyse over 100 applications in the service and government sectors alone.

5.4: Conclusion

The purpose of this section is to describe the model within the research framework for the MCDM methodology. It is based on the AHP, which has been identified as a suitable method in transportation planning under a set of decision criteria. As set out above, the AHP meets the key requirements of participation and transparency and has a convincing procedure to compare and aggregate various kinds of project impacts.

For the development of the model, particular attention has been paid to the issues raised in the working hypotheses. In the next chapter, we start with structuring a hierarchy that reflects the basic problem of decision-making processes as for a research project. This preliminary research project has the goal appearing at the top level of the hierarchy. The second level consists of the corporate objectives, the third consists of criteria, the fourth level consists of sub-criteria and the fifth level consists of alternative activity. For the study we have identified scientific capacity building as a critical benefit of development strategies of research projects and an additional criterion to capture this impact is incorporated into the levels.

The hierarchy serves to assess the project impacts. However, this will only yield the potential impacts, i.e. without taking into account the uncertainty regarding the success of the research and adoption process. The simultaneous evaluation of the impacts and their occurrences would be too complex a task for decision makers. The chances of success of the research projects have to be estimated separately. The separate analysis of uncertainties and preferences is a common approach for choosing under uncertainty. In the second working hypothesis, we argued that uncertainty is of particular relevance in transportation planning project evaluation and, therefore, warrants more careful scrutiny. The strategic component is considered by adding the level of development strategies to the potential impacts of the transportation planning projects for individual consideration.

CHAPTER SIX

STRATEGIC PLANNING FOR INTERMODAL

TRANSPORT SYSTEM DEVELOPMENT

6.1: Introduction

Containers as transport cargo units improve intermodality so that it becomes common for different ports to share the same hinterland, creating port competition (Hoare, 1986). The rise of intermodal transport has resulted in dramatic changes in the pattern of freight transport and port competition in worldwide shipping (Hayuth, 1987). The intermodal system affords exporters and importers impressive opportunities for saving money, expanding markets, and increasing the value added related to distribution, but by far the greatest benefit they afford is the minimization of intermodal transfers. There will be a renewed focus on intermodal freight transportation driven by the changing requirement of global supply chains.

Extension of worldwide transportation needs to avoid the high cost of non-movement, even briefly at the point of interchange between modes. To achieve optimum transportation returns, goods in transit should move forward in a continuous manner. Industry and government are concerned about the capacity of ports to handle steadily increasing volumes of intermodal containerised traffic, and the ability of ports to develop an intermodal freight transport system.

Planning for global logistics management centres implies a demand for good quality logistics services. Major enterprises assume the greatest competitive advantage when they are appropriately supported through key value-added logistics activities. Short-term challenges to intermodal links in container ports need to be overcome to approach the long-term vision of establishing port intermodal transport systems and appropriate management. In this chapter, we will discuss strategic planning for the intermodal transport system of container ports, taking into account both interior and exterior environmental factors for intermodal development. A decision support methodology to evaluate the alternatives known as Analytic Hierarchy Process (AHP) is used to identify appropriate strategies.

6.2: Development of an analytical framework for intermodal supply chains

Many countries seek to have a global logistics management centre, since it is assumed to boost trading activities with other countries. Poor logistics support is one of the major reasons for the failure to attract foreign investors. Many actors in the supply chain have responded by providing value-added services in an integrated logistics package (Hastings, 1994), and many container lines have transformed themselves into logistics management organizations. Logistics has the potential to become the next governing element of strategy as an inventive way of

creating value for customers, a source of savings, and an important discipline in providing production flexibility.

The fact that a growing number of ocean carriers expand their role by controlling the total logistics chain including inland transport, storage and distribution implies that the criteria for port selection are related to the entire transportation journey and thus no longer restricted to maritime transport alone (Rodnikov, 1994).

Under these circumstances, carriers choose a network in which the port is merely one node, though an important one. Consequently, if a seaport does not succeed in attracting some of the carriers, it will be exposed to high risk of substantial loss of container traffic. There are two distribution strategies in a priority hierarchical process of this type during which strategic operating alternatives are evaluated to determine the most cost-effective way of providing the required service level. They are optimal size and the number of transportation facilities.

The fundamental decisions forming the basis of logistics system planning are inventory policy, facility location and transport routing. These developments force ports to make every effort to be competitive in terms of cost and quality of services and to develop the port area into a logistics park and distribution service centre. Logistics is marketing oriented and it plays a key role in satisfying the companies' customers, and achieving a profit for enterprises (Rao et al, 1994). The expanding literature on

intermodalism in developed countries stresses the importance of the process to their economies, and knowledge of their intermodal transport systems is useful in attracting international investors (Rodnikov, 1994).

6.3: Characterisation of decision making with Analytic Hierarchy Process (AHP)

This section deals with the problem of investment evaluation and selection of an intermodal transport system, and assumes a complex multi-criteria decision for several reasons. Among these reasons are the low degrees of experience of the decision maker with respect to the intermodal transportation infrastructure to be purchased, the high number of both qualitative and quantitative attributes that have to be considered in the selection process, and the number and variety of the alternative intermodal transport systems available on the market. Many studies have used Analytic Hierarchy Process (AHP) in transportation projects: Saaty (1988) formulated the AHP model to select alternatives as a decision, Sharp (1987) applied AHP in haulier's selection. Bagchi (1989) used it to construct a maritime carrier selection model. The AHP method is a relatively new technique in some of the topics that concentrate on economic-management problems, political problems, social problems and technological problems (Vargas, 1990). It can deal with a variety of problems (Saaty, 1980) and combine qualitative and quantitative criteria (Wedley, 1990). In this research, an attempt to develop a decision-making model for the selection of intermodal transport systems by using AHP is presented.

The Analytical Hierarchy Process (AHP) (Saaty, 2001) is a decision approach designed to aid in the solution of complex multiple criteria problems in a number of application domains. This method has been found to be an effective and practical approach that can consider complex and unstructured decisions (Partovi, 1994). The AHP is proposed in this research in order to handle both tangible and intangible factors and sub-factors affecting international location decisions. The selection of the methodology is based on the characteristics of the problem and the consideration of the advantages and drawbacks of other methodologies.

The decision maker judges the importance of each criterion in pair-wise comparisons. The outcome of AHP is a prioritised ranking or weighting of each decision alternative. However, the concepts of the development and the structure of the model will be similar and can be applied to strategies selected within a particular country. Basically, there are three steps for considering decision problems by AHP: constructing hierarchies; comparative judgement; and synthesis of priorities. The objective of this work is to develop a dynamic and adaptable model for the selection of intermodal transport systems. The task is difficult because of the various attributes involved, the most important of which include cost, flexibility, complexity and the fact that many purposes and motivations have to be considered. The selection of an appropriate intermodal transport system might urge managers to face fairly

complicated multi-criteria decision problems, due to the complexity both of available alternatives or selection criteria, and of the prevailing qualitative nature of many of the latter.

A sound weighting of the importance placed on the different criteria therefore becomes a critical task in the selection process. Problems are also associated with the possibility of selecting a sub-optimal transport system that performs well with respect to a few criteria and does not compromise good overall practices. Most of the existing decision support systems related to transportation are a direct or indirect application of operational research techniques. Many hidden assumptions and simplifications are behind the output, which may be the optimal solution from a mathematical point of view but, in many cases, is not useful from the point of view of the decision maker. This is why the AHP technique was used in this research. This is also why concrete transport system evaluation algorithms were considered a less critical issue than the structure of the model and the approach in facilitating the interaction between the user and the model. Algorithms for transport system selection and evaluation are well established in the academic world. Once the model's framework was established, the integration of calculation algorithms would be simple and without any true innovative value.

Therefore, the final prototype only integrated one particular evaluation algorithm as an example. The objective or the overall goal of

the decision is represented at the top level of the hierarchy. The criteria and sub-criteria contributing to the decision are represented at the intermediate levels. Finally, the decision alternatives or selection choices are laid down at the last level of the hierarchy. This step allows a complex decision to be structured into a hierarchy descending from an overall objective to various 'criteria', 'sub-criteria', and so on until the lowest level. According to Saaty (2001), a hierarchy can be constructed by using creative thinking, recollection and people's perspectives. He further notes that there is no set of procedures for generating the levels to be included in the hierarchy.

Zahedi (1986) comments for the structure of the hierarchy which depended upon the nature or type of managerial decision. Also, the number of the levels in a hierarchy depends on the complexity of the problem being analysed and the degree of detail of the problem that an analyst requires to solve (Zahedi, 1986). As such, the hierarchical representation of a system may vary from one person to another. Once the hierarchy has been structured, the next step is to determine the priorities of elements at each level. A set of comparison matrices of all elements in a level of the hierarchy with respect to an element of the immediately higher level are constructed so as to prioritise and convert individual comparative judgements into ratio scale measurements.

The matrices are illustrated in Figure 6-1. The pair-wise comparisons are given in terms of how much element A is more important than

element B. As the AHP approach is a subjective methodology, information and the priority weights of elements may be obtained from a decision-maker of the company using direct questioning or a questionnaire method.
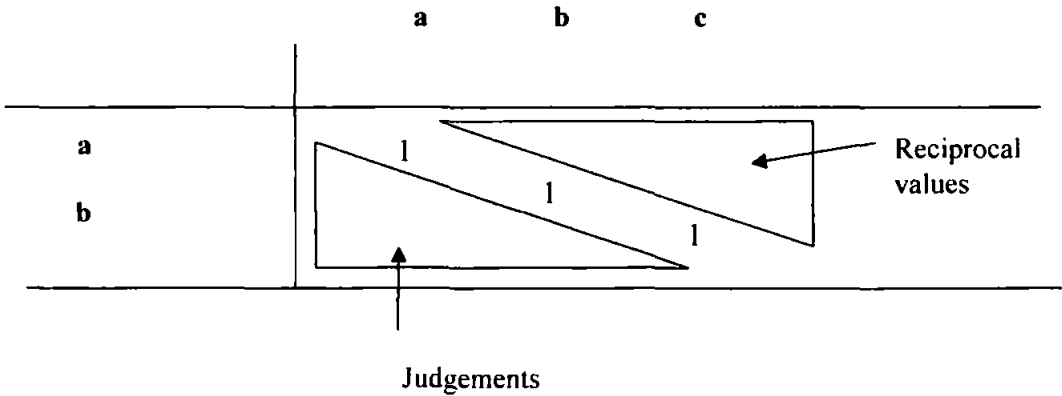
Figure 6-1: An illustrative data matrix

6.4: Working definition of Analytic Hierarchy Process (AHP)

AHP helps us choose one of several options effectively based on certain criteria. In the AHP hierarchical structure that we call an AHP template, there are several criteria and decisions that were made by the following procedure:

1. The weighting of each criterion is calculated by giving a weighting to every pair of criteria.

2. Total score (1 point) is divided among criteria according to the weighting of each criterion (score of each criterion).

3. For each criterion, the weighting of each alternative is calculated by giving a weighting to every pair of alternatives.

4. The score of each criterion is divided among alternatives according to the weighting.

5. The score of each alternative is calculated by adding the scores of every criterion.

A measurement methodology is used to establish priorities among the elements within each level of the hierarchy. In this study, the number of alternatives considered in a selection of the intermodal transport system may be viewed as indefinite and the decision making is usually multi-objective. Generally, a decision maker constructs the hierarchy and criteria. The subjective point of view of the decision maker is a weakness for every methodology. Usually methodologies demand a certain level of expertise from the decision-maker. The hierarchy of the criteria reflects also the understanding of the decision-maker of the problem and of the parameters affecting the final judgment. In some cases, the relative comparisons are part of the procedure for their perception tends to improve the outcome. It has to be noted that decisions will also reflect personal and subjective perceptions in many cases as well and objectivity is desired only when the decision maker is neutral or indifferent, when selecting the alternative.

In this research, the highest goal in the hierarchical structure is the selection of an intermodal transport system, followed by the corporate objectives for development of an intermodal transport system, which are market share, logistics process and diversification. The criteria in the hierarchical structure are reliability, flexibility and strategic compatibility. The sub-criteria under the major frame of criteria are location convenience, access to infrastructure development, access to finance and integrated transportation. The most important alternative activities divide into three: port service in the transportation performance; customer service and marketing strategy; and the logistics channel. All problems, from the simplest to the most complicated, can be represented in a multilevel structure, a hierarchy, whose first level is the goal followed by levels of factor, criteria, sub criteria and so on. Its representation can be used in order to describe how changes, at upper levels, can affect the priority at lower levels. Hierarchical representation gives a clear picture to the decision-maker about the structure and functions of the system in its lower levels and provides an overview of the actor and their purposes in the upper levels.

There are several key points in the evaluation framework, such as deciding alternative activities, selecting evaluation criteria, constructing a hierarchical structure for this framework, questionnaire design and survey, the AHP analysis, synthesis evaluation, and so on. After alternative activities are decided, relevant statistical data are collected, and then evaluation criteria are proposed. AHP starts by decomposing a complex

problem into a hierarchy, each level consisting of a few manageable elements. Each element is decomposed into another set of elements by the process of descending to the most specific elements of the problem, typically the specific courses of action that are represented at the lowest level of the hierarchy. An example is the simple five level hierarchies of environmental scenarios: goal, corporate objectives, criteria, sub-criteria and alternative activity. Such a hierarchy can aid management by identifying their relevant objectives, and forcing them to explain the environmental scenarios most likely to affect their planning decisions and most likely to be creative in generating specific courses of action.

AHP is based on the concept of having n alternatives and their relative pair-wise comparisons and a_{ij} is an approximation to the ratio of w_i / w_j which is the weight of alternative i to alternative j. The decision maker does not know in advance the value w_i / w_j. The hierarchy normally consists of a top node – the goal, then the second layer is the criteria level, and finally the third layer is the alternatives level. The basis of the AHP is the completion of an $i \times j$ matrix at each level of the decision hierarchy. This matrix A is of the form $a_{ij} = 1/a_{ji}, a_{ij} > 0$; i.e. A is a positive, reciprocal matrix. The basic theory is based on the fact that a_{ij} is an approximation to the relative weights (w_i / w_j) of the n alternatives under consideration; the value assigned to a_{ij} is typically in the interval [1/9, 9]. The estimated weight vector w is found by solving the following eigen-vector problem:

$$Aw = \lambda_{max} w$$

139

whereλmax is the principle eigen-vector value of A.

$$
A = \begin{array}{c} A_1 \\ \vdots \\ A_n \end{array} \quad \begin{pmatrix} A_1 \ldots\ldots\ldots A_n \\ w_1/w_1 \ldots\ldots w_1/w_n \\ \vdots \qquad\qquad \vdots \\ \vdots \qquad\qquad \vdots \\ \vdots \qquad\quad \vdots \\ w_n/w_1 \ldots\ldots w_n/w_n \end{pmatrix}
$$

Therefore, Let us suppose that we have *n alternatives* A1 ... A_n whose vector of corresponding weights $w=(w_1, ..., w_n)$ is know. Let us formulate the matrix of pair-wise comparisons of weights. As an example, assume that one is given three machines of different criticality according to their downtime failures. These machines are a, b, and c of criticality 3, 5, and 7 hours respectively, taking downtime as a criterion. Suppose that a matrix of pair-wise ratios is formed whose rows give the ratios of the downtime of each machine with respect to all others. Thus one has the equation:

$$
Aw = \begin{array}{c} \\ a \\ b \\ c \end{array} \begin{array}{ccc} a & b & c \\ \begin{pmatrix} 3/3 & 3/5 & 3/7 \\ 5/3 & 5/5 & 5/7 \\ 7/3 & 7/5 & 7/7 \end{pmatrix} \end{array} = nw
$$

Where *A* has been multiplied on the right by the vector of weight w, the result of this multiplication is *n*w. Thus, to recover the scale from the matrix of ratios, it is necessary to solve the problem *Aw* = *n*w. This is a system of homogeneous linear equations. It has a nontrivial solution if

and only if the determinant of A-n I vanishes, that is, n is an eigen-value of A.

6.5: The strategic planning of an intermodal transport system: preliminary study for container ports

In this study, the number of alternatives considered in selection of an intermodal transport system may be viewed as indefinite and the decision-making is usually multiple objectives. A positive attitude toward intermodal transport is built on a level playing field of successful intermodal development. So, the top target of goal in the hierarchical structure is the selection of an appropriate intermodal transport system. As noted earlier, the corporate objectives of development for an intermodal transport system are market share, logistics process and differentiation. The criteria in the hierarchical structure will be selected as reliability, flexibility and strategic compatibility. The sub-criteria under the major frame of criteria will be selected as location convenience, access to the infrastructure development, access to finance and integrated transportation. Finally, the most important alternative activity will be divided into three parts: port service, marketing and logistics. There are several key points in the evaluation framework, such as deciding the alternative activities, selecting evaluation criteria, constructing the hierarchical structure for this framework, questionnaire design and survey of the AHP analysis, synthesis evaluation, and so on. After alternative activities had been decided, we must collect the relevant data and then propose evaluation criteria. The determinants of intermodal transport system selection are

141

divided into internal and external parts. In an evaluation hierarchical structure each criterion is assessed by questionnaire survey. Experts judge the indices of relative importance in the evaluation procedure.

Competitive strategy has become an important management idea. In the past, scholars have found that competitive strategy is very useful in planning and increasing efficiency across organizations. Strategic planning is about decision-making and developing an effective competitive strategy. Strategic planning is a tool that assists the management in defining the future direction and developing a plan for its future development. Strategic planning is used to explore future opportunities and to reduce the risks associated with market and political uncertainties. Some researchers have also found that strategic planning can be used to give clear direction in planning. In order to achieve the strategic planning for an intermodal transport system, a preliminary study of container ports was conducted aiming to shed light on the quantitative elements analysis from the global carriers' perspective. The following study applies the theory structure of Analytic Hierarchy Process (AHP) and the analysis is based on the characteristic of the multiple goals and the practicable issues of strategy analysis. With the hierarchy, the corporate objectives are first compared in a pair-wise fashion in respect of the goal. Then the criteria, sub-criteria, alternative activity and strategies for the selection of an intermodal transport system are compared pair-wise in respect of each preceding level. In the classical weightings and scores approach, the ratings are

determined by a questionnaire aimed at industrial, governmental and academic experts. This strategic planning process is shown in Figure 6-2.

```
                              ┌──────────────────────────┐
                              │   Background reviews     │
                              └──────────────────────────┘
┌──────────────────┐                      │
│  Brainstorming   │─────────────────────►│
│     method       │                      ▼
└──────────────────┘         ┌──────────────────────────┐
                             │  Determinants of decision │
                             └──────────────────────────┘
┌──────────────────┐                      │
│ Preliminary study for │──────────────────►│
│     experts      │                      ▼
└──────────────────┘         ┌──────────────────────────┐
                             │   Hierarchical structure  │
                             └──────────────────────────┘
┌──────────────────┐                      │
│    AHP survey    │─────────────────────►│
│                  │                      ▼
└──────────────────┘         ┌──────────────────────────┐
                             │   Weighted for criteria   │
                             └──────────────────────────┘
```
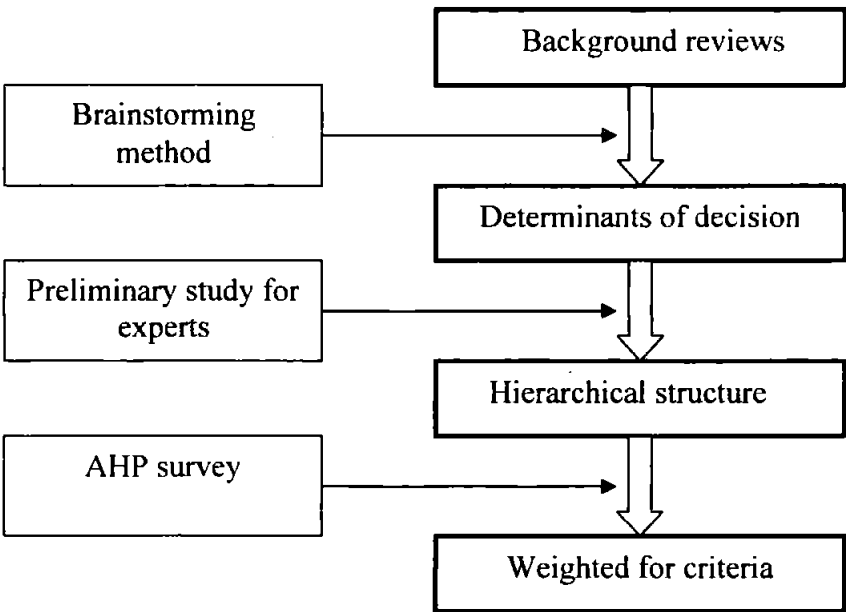
(Source: adapted from Saaty, 2001)

Figure 6-2: The strategic planning process

6.6: Conclusion

Intermodal transport is also known as door-to-door transport, and it is a derivative of containerisation. To increase service quality by through transport, the carriers are forced to integrate all their available resources to provide road, rail, freight forwarding, container leasing and port operations (King, 1997). The ocean transportation cost is less than 50% of shippers' total freight cost, and it is about 2~3% of cargoes' average Cost, Insurance and Freight (CIF) value. However, freight transport is a

key element in supply chains. It adds the value of cargoes through the space displacement by moving cargo to where its utility is perceived higher by consumers. Freight transport plays a major role in current merchandise value-added processes.

Strategic planning for selecting an intermodal transport system is gaining more importance. In this research, it is proposed to approach an intermodal transport system as an integrated aspect of the strategic management process. This approach is a systematic and continuous procedure for fast response to trends and events both internal and external to container ports. In the strategic management process, decisions are usually based on qualitative judgments, and thus the process is a potential application area for decision support systems. In the Analytic Hierarchy Process (AHP), as described in this research, a complex, multiple criteria problem is broken down into a hierarchy, and the priorities of the elements at each level of the hierarchy are determined. These tools address major problems and issues in teamwork, as well as promote organizational learning, in producing a group decision.

CHAPTER SEVEN

VALIDATING THE MODEL WITH AN EMPIRICAL CASE STUDY

7.1: Introduction

The purpose of this chapter is to present the design of research methods involved in this research relating to the selection of development strategies of an intermodal transportation system in Taiwan. As we have seen, the problem addressed in this research involves multiple criteria, and the decision process is carried out by a group of decision makers. Thus, this research has developed a multi-criteria decision making model to address this problem. We concluded that the AHP is the most suitable method for this research problem, thereby determining the selection criteria and their relative weights. This MCDM technique by using AHP has the capability to elicit expert judgment and provide consistent feedback to decision makers. The previous chapter has discussed the classification and analysis of a strategic decision model for developing an intermodal transport system. This chapter will present the development of the decision making model and criteria with an empirical case study for the purpose of the current research when applied to transportation planning issues of practical applications of this technique in Taiwan. The evaluation of research alternatives in the public sector requires a multiple criteria

approach since they generally pursue multiple objectives that can hardly be expressed in a single criterion.

Over the past two decades, a discipline called Multiple Criteria Decision Making (MCDM) has been developed to assist in managerial planning and decision making. Stewart (1992) draws on the results of this research to give implications for the future research needs for MCDM. It includes research experiences from a review of applications in the transportation planning area and looks at methodological issues that need to be addressed and overcome while suggesting future research possibilities. Some of the key issues that are covered include: the problems of choosing and defining research design for the decision-makers who will be involved in the analysis, interacting with groups of decision-makers with multiple weights and how to address this within the MCDM framework for the applications; the need for validation of results and the need for much greater consistency in the meaning of terms used for a strategic decision system based on a multiple criteria decision-making approach. The basic research design has focused on the multiple criteria decision-making model shown in Table 7-1. This study included the design and preparation of multiple-choice questionnaires for decision-making criteria, and charting forms for the study of the example and case processes.

Table 7-1: Basic research design for the multiple criteria decision making model

Research design steps	Components for multiple criteria decision making model
Step one	Multiple criteria decision making model
Step two	Multiple criteria decision making methodology and case study
Step three	Multiple criteria decision making in transportation planning

(Source: the author)

7.2: Research design:

Research design can be thought of as the main framework of the research thesis. This chapter concentrates on the research design for a multiple criteria decision making model based on the case of AHP application. The applied model includes goal, corporate objectives, criteria, sub-criteria, alternative activity and strategies of the study to support decision making in transportation planning. As we have seen, the problem addressed in this research involves multiple criteria, and the decision process is carried out by a group of decision makers. Thus, this research has developed a multiple criteria decision making model to address this problem. This is because other multiple criteria decision-making techniques lack AHP's capability to elicit expert judgment and provide consistent feedback to decision makers. As described in the following sections, the model of this research consists of the following steps: (1) identifying evaluation goal, corporate objectives, criteria, sub-

147

criteria, alternative activity and strategies of the case study; (2) structuring the hierarchy; (3) enabling the group's decision making process and (4) selection of the best alternatives and strategies.

As maintained earlier, the evaluation process is one of the crucial parts of the planning project. This process should have precise criteria that cover all aspects of the process. This research, by contrast, aimed to establish general criteria which could meet the different needs of each project and/or country. And given the capability of the "Expert Choice" software, the decision makers can suspend any criteria which do not comply with their needs and can select the most suitable weight for each criterion. The criteria developed by this research should help to enable clear and fair evaluation, which will help achieve a win-win outcome for both private and public interests.

The generation of criteria is most critical and time consuming. It starts with the national development goals from which more specific sector objectives can be derived. The specification of these goals is a first step to give the decision criteria a more operational meaning. The relevant goals and objectives are arranged in a hierarchy. The real contributions of the research activities to the objectives are subject to considerable uncertainty inherent in the research process and the diffusion of the results. The degree of uncertainty depends on the constraints imposed by the available resources and the prevailing conditions of the research system and the related environment. Consequently, additional criteria have to be

considered in order to take into account the determinants of uncertainty. The generation of criteria results in an initial list of possible criteria. Any evaluation of transportation planning activities has to address the areas of national concern. They can be expressed in terms of national development goals. The goals provide the foundation for addressing public decision problems. Therefore, they are the logical point of departure for the development of decision criteria. National development goals in Taiwan can be broadly defined as economic growth, balanced social development, and efficient and effective public institutions (Wang, 1998). The public sector becomes more demand-oriented by bringing the user's perspective into the picture. Various methodological approaches have been developed to involve user's perspective into the process.

Before discussing it in more detail, some comments are made on the generation of alternative activity. The aim of this research must be to capture as much as possible the relevant aspects of the decision problem with the lowest possible number of criteria. Using dozens of criteria would certainly represent a complete picture of the situation but would be of no use for decision makers. The decision to exclude a criterion from the initial list is based on the extent to which it can discriminate between alternatives. A criterion may have no discrimination potential because it is irrelevant for the research alternatives at hand. Furthermore, the analysis of the desirable and undesirable aspects of alternatives stimulates thinking about further criteria not yet included in the list. Suppose an alternative leads to the establishment of a processing industry with positive overspill

for the infrastructure in the region. It may be well justified in this situation to include a criterion to capture this potential impact.

Reviewing the list regarding the discrimination potential of the criteria requires a pragmatic approach. Those insignificant relative to others should be eliminated to bring the list down to a manageable size. In case the final result does not indicate clear priorities, we can still revise the decision by including some of the criteria previously dropped. In the last phase of the conceptual framework, the applicability of the criteria regarding the data availability is evaluated. In the previous two lists we always used the term 'possible criteria' to indicate that only the necessary data will enable decision makers to effectively apply these criteria.

Data availability is critical in every decision-making exercise. It will influence the choice of the most appropriate method and define the degree of detail and accuracy of the decision process. To a certain extent, weak data might be compensated by expert's judgement. However, even experts depend on some kind of information if their judgements are to be more than pure speculation. In addition, the involvement of experts in the process was restricted by the resource which was available for the exercise, including skilled individuals. In a group setting, the number of participating experts is limited to ensure the practicability of the process.

This approach, in order to generate decision criteria, used a recent application in the intermodal transport system development program of

Taiwan. The context of the exercise is briefly described followed by a discussion of the six criteria lists. As mentioned earlier, the procedure is based on the AHP. Applications of the AHP have been reported for a wide range of MCDM problems (Zahedi 1986; Golden et al. 1989; Vargas 1990). The AHP technique is used to evaluate the decision support system for strategic planning of an intermodal transport system, based on the views elicited from a structured survey of industrial, governmental and academic experts for the preliminary study. The resulting list and its hierarchical structure are presented in Figure 7-1 and Table 7-2. The list is divided into six hierarchies: goal, corporate objectives, criteria, sub-criteria, alternative activity and strategies. However, because of the importance of this element it was agreed to consider it as far as possible in the context of the distribution between expert groups. We will briefly discuss the indicators used in the hierarchy of potential impacts to give an idea on how the criteria were operationalised, what information was required, and what concessions had to be made in practice.
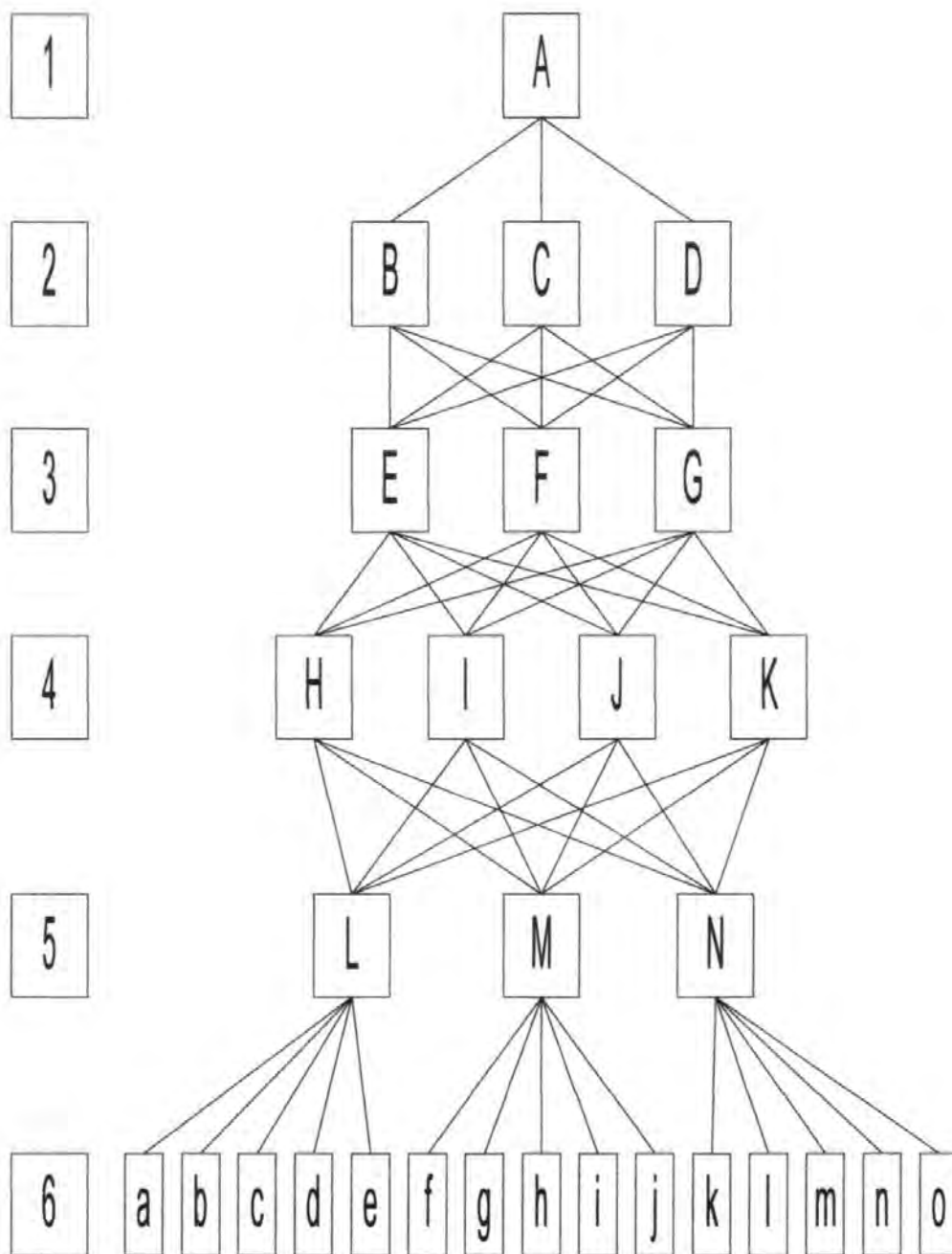
Figure 7-1: Intermodal transport system planning hierarchical structure

Table 7-2: Hierarchical structure list

1. Goal:	A. Selection intermodal transport system
2. Corporate objectives:	B. Market share C. Logistics process D. Diversification
3. Criteria:	E. Reliability F. Flexibility G. Strategic compatibility
4. Sub-criteria:	H. Location convenience I. Access to infrastructure development J. Access to finance K. Integrated transportation
5. Alternative activity:	L. Port service M. Marketing N. Logistics

6. Strategies:

a.	Improve quality of port management
b.	Improve service of the people who assign in-port operations
c.	Improve efficiency of loading and discharging
d.	Establish service system of ship berthing
e.	Increase management of berth scheduling
f.	Industrialize port management
g.	Establish national trade centre
h.	Develop recreation area
i.	Decrease port expense
j.	Develop tourism
k.	Simplify management of customs
l.	Format intermodal links
m.	Improve the system of transportation for exterior
n.	Set up the port flow area
o.	Establish check area for container depot

(Source: adapted from Saaty, 2001)

An AHP pilot survey was undertaken in Taiwan for this research. As the pilot survey population was small, a high response rate was important for the survey's success. Therefore, 15 participants were contacted and asked to fill in the questionnaire. A total of 12 questionnaires were returned, representing 5 expert academic scholars, 5 for container carriers and 2 for port operators. The total response rate was 80 %.

Perry (1995) argues that a pilot survey in a survey process is crucial, especially when it comes to PhD dissertation level. First, it is expected to achieve a detailed scrutiny of the survey. Second, the researcher can predict the percentage of response. Third, there is a possible improvement in terms of contents of questionnaire. The approach was adopted to ensure personal networking within the shipping industry in Taiwan and also prior-survey telephone contact with persons in charge in order to increase participants' willingness to respond to the survey. The criteria for the AHP questionnaire were mainly derived from the relevant literature and brainstorming outcomes. In order to verify whether these criteria were valid for this pilot survey, a preliminary study was organised as described in the previous study. The results of the preliminary study have been presented at the 2002 IAME conference proceedings (Juang and Gray 2002). Upon successful completion of the preliminary study, the author proceeded to form the main survey for the container carriers and port operators in 2005. The main survey finding indicated interviewees seemed unable to easily compare pair-wise over five factors at a time without substantial consistency. Thus, reducing the numbers of factors to fewer

154

than five by combining similar criteria through a brainstorming session was desirable before carrying out the main research survey (Nijstad et al., 1999).

The proposed decision support approach for this study is based on the AHP or expert choice methodology developed by Saaty (1980, 1986). It has been used in resolving a variety of complex, multi-criteria business problems. It provides a logically consistent and highly useful framework for business decision making especially when intangible judgments are involved in the process. The advantages of the AHP approach include flexibility and logical consistency in determining priorities. The relatively simple methodology involves modelling a complex problem in a hierarchical structure showing the relationships of the goal, the general criteria, secondary sub-criteria and tertiary sub-criteria followed by the alternatives. The decision-maker then ranks alternatives according to the importance of the criteria and the extent to which they are met by each alternative. The use of paired comparisons helps the decision-maker to concentrate on only two factors at any one time of the whole process. The user must be asked to evaluate a set of elements at one hierarchy level in a pair-wise fashion regarding the relative importance with respect to each of the elements at the next higher level of the hierarchy.

This research has been enhanced and has resulted in the development of a multiple objective decision model for the intermodal transportation system which can help shippers make trade-offs among a variety of objectives and incorporate uncertainty into the decision making

process. In particular, the following results have been achieved. A review of the relevant literature in this area has been conducted. Key uncertain elements and risk-based performance measures associated with intermodal transportation have been identified. A multiple objective decision model has been built. A results analysis based on experimental design methodology was performed to evaluate the influence of the model factors on the decision results.

Traditional AHP is carried out in three stages once the overall goal is established. During the first stage, the defining decision criteria are identified in the form of a hierarchy of objectives or general criteria. Typically, this entails having clearly defined primary goals. The evaluation criteria that influence each of the general criteria are placed at the next level of the hierarchy and the sub-criteria related to the second level are placed at the tertiary level. During the second stage of the analysis, paired comparisons are made at each level of the hierarchy, giving value judgments and establishing priorities among the elements within each level of the hierarchy. The third stage involves a paired comparison of the chosen alternatives with each of the sub-criteria. As we explained the problem is identified and the decision's goal and evaluation criteria recognized, and the decision can be structured as a hierarchy.

7.3: Strategic decision-making system with a case study

After the research model was formulated through hypothetical investigation to identify the determinants for goal, corporate objectives,

criteria, sub-criteria and the alternative activity by developing a framework for the selection process, the case study was validated for available development strategies of the intermodal transport system proposals. Case study research is very useful in the research areas where there is little control of the event such as occurs with the evaluation of transportation planning proposals. This research used Kaohsiung port in Taiwan as a case study for the validation of the research model. A few other cases were found that included just one criterion and one alternative. However, use of this research model requires multiple criteria and more than one alternative. The objectives of this model were to validate the model in terms of its objective, to identify the Taiwanese container port case study decision output when all the criteria had been used, and to define how to limit the criteria. The Kaohsiung port is one of the top ten largest container ports in the world. While its volume and the value of its cargo have declined relative to some other ports over the past ten years it is still the largest container port in Taiwan. In order to cope with the trend toward super large containerships, the Taiwanese government has decided to build the new Kaohsiung intercontinental container terminal. This project includes the construction of 9 container berths. The port is located on the Southwest coast of Taiwan and enjoys a particularly good physical facility with easy access to the sea and to the downtown of the Kaohsiung city. The port is linked to the national transportation infrastructure by rail and road and Kaohsiung International Airport is located nearby (Figure 2-1, 2-3).

The case study conducted a mail list survey with the questionnaire in order to comprehend the degrees of internal situation and external information of variables from the container carriers and port operators in Taiwan. The process to determine questionnaire items is crucial to ensure the validity of their content, which is an important measure of a survey instrument's accuracy (Cooper and Schindler, 2001). Content validity refers to the extent to which a test measures what we actually wish to measure. The assessment of content validity typically involves an organized review of the survey's content to ensure it includes everything it should and does not include anything it should not. The determinants of criteria for the AHP questionnaire were mainly derived from relevant literature. The assessment of questionnaires for the container carriers and port operators were based in Taiwan. The questionnaires were written in both English and Chinese. Therefore, participants from container carriers' and port operators' managers were selected in this case study. The main research survey was a cross sectional study. Respondents were requested to provide feedback within three months as explained in an explanatory note attached to the questionnaire conducted between April and August in 2005. Respondents' answers were calculated and checked by both AHP software named Expert Choice 2000, and Microsoft Excel spread sheet. A strategic decision making system was developed and is shown in Figure 7-2 which formulated the most properly objective strategic determinants by goal, corporate objectives, criteria, sub-criteria and the alternative activity constructed in order to achieve the intermodal transport system development strategies in Taiwan. It provides a descriptive

summary for the current model, as well as discussion for the development of system contents. We conclude the analytical model of a strategic decision-making system requires the identification of components: (i) formulating the system; (ii) developing the system; and (iii) building the system. It is important to select the "right" model that highlights those dimensions of the entire structure that are the most relevant to the prospective design process.

The developments of intermodalism which are taking place use resources and markets which are becoming increasingly connected through total supply chains. National development no longer depends solely on the ways in which productive sectors operate but also on their ability to distribute their products which also requires national transportation systems with sophisticated port and other infrastructures. On the passenger side, developments of intermodalism resulted in an explosive growth in tourism. In the process, modal integration lags well behind developments in the freight sector and stands in sharp contrast to the Taiwanese scene. The anticipated system will be based on a high-speed rail network that is linked to other transportation modes through intermodal terminals that provide travelers with easy access to several modes.
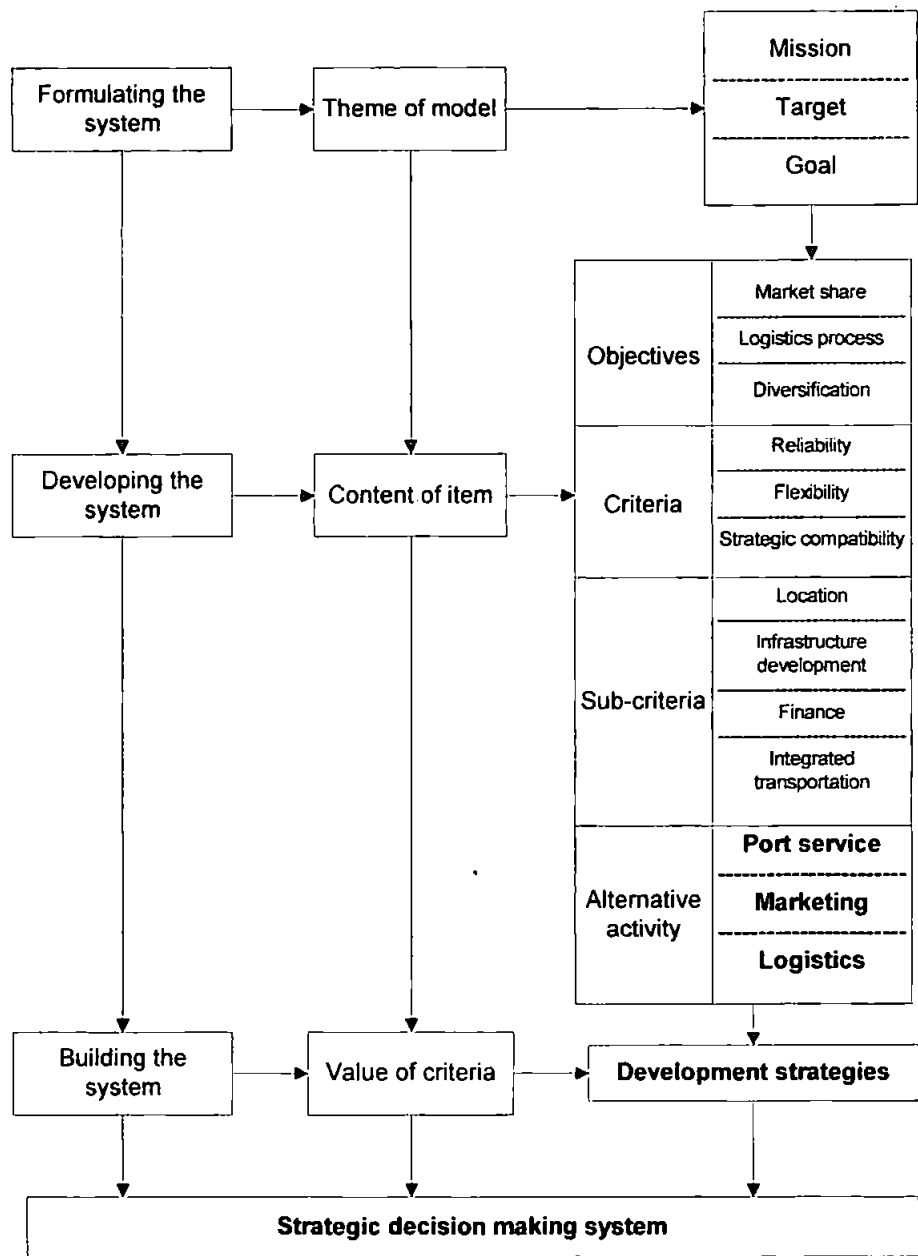
(Source: Adapted from Saaty and Vargas , 2000 and reformed by the author*)*

Figure 7-2: Strategic decision making system.

Multiple objective optimization and decision analysis provide the tools and effective methods to deal with such elements. The first step for the decision maker is to identify the decision situation and understand what their objectives are. There are many uncertain elements that exist in an intermodal transportation system which involved the decision making process. When the decision maker schedules a transport task, input variables must be specified. Now that the problem has been formulated, the next issue is how to handle the multiple criteria measures. The power of AHP lies in its ability to structure a complex, multi-attribute, and multi-period problem hierarchically. Applying the AHP to solve the path alternative decision problem consists of five stages (Saaty, 1980).

- Decision hierarchy construction;
- Attribute priority determination;
- Alternative weight determination;
- Consistency computation, and
- Overall weighted performance determination.

Once the hierarchy is established, priorities should be established for each set of elements at every level of the hierarchy.

7.4: The case study survey procedure of the AHP approach

The procedure which was followed in the case study survey exercise using the AHP approach is depicted in Figure 7-3. The main survey for the decision process was carried out in a participatory way and included container carriers and port operators as described in previous section. The research survey design of the first round questionnaire focuses on

161

acquiring the weighting values of the selection factors. The data collected from the first round questionnaires are explained in Table 7-3. The questionnaires were mailed with a cover letter (Appendix A and C). A sample of 29 participants (17 carriers, 12 port operators) container carriers and port operators was surveyed taken from the 2005 edition of Taiwanese Shipping Directory. A stamped envelope was also sent for easy return of the completed questionnaire. A total of 22 participants (12 carriers, 10 port operators) responded to the questionnaire, giving a response rate of 75.9 per cent. Four major ocean container carriers listed on Taiwan's Stock Exchange were invited to participate in the study through the author's personal networking. Eight general agents represented as the ocean carriers were reported as being among the top 30 leading container carriers in the world in 2005. Two of the carriers are global carriers, and the other two are mainly niche container carriers focusing on intra-Asia regional markets. Ten port operators were major container terminal handling companies in Kaohsiung port. Moreover, as the survey questionnaires were delivered in person to participants by the author, this allowed for explanation of queries in person , ensuring a valid response.

Table 7-3: Profile of the first round questionnaire

Objective	Calculating the relative weighting values
Methods	Mail delivery questionnaire
Retrieve	22 copies
Reliability validity	Consistency (C.I./C.R.) reliability test

(Source: the author.)

162
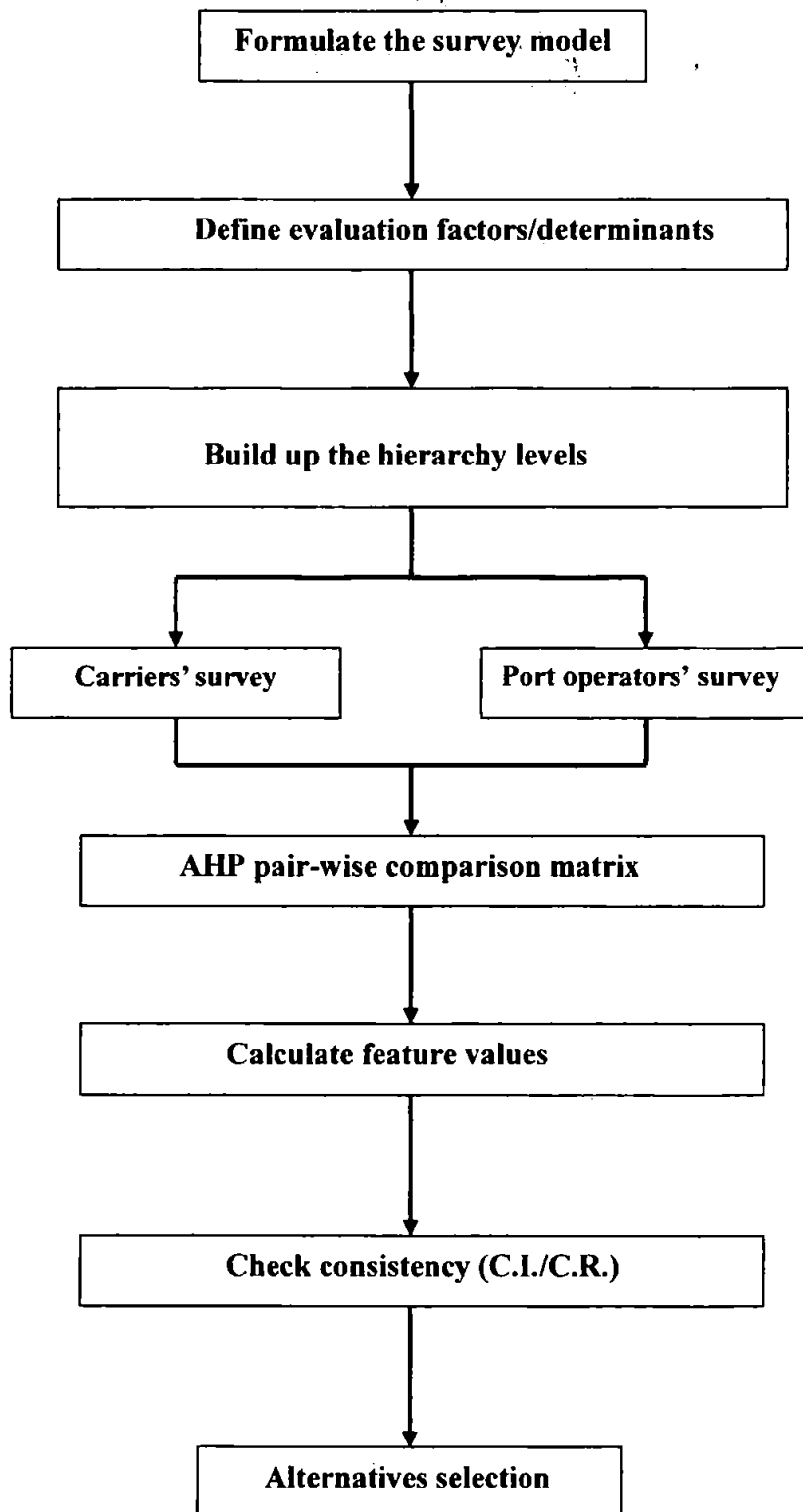
(Source: the author.)

Figure 7-3: Procedure of AHP survey

163

According to the AHP level structure design, the questionnaire used in this study was generalized into five levels: the goal, the corporate objectives, the criteria, the sub-criteria and the alternative activity. Based on the AHP analysis, the variables were compared in pairs. Most criteria from the literature review were fully supported and validated by industry experts and academicians in the interview survey. The top level of the goal was to select the best intermodal transport system.

The evaluation results and the analysis of the measurement in the second level include market share, logistics process and diversification representing the determinants of corporate objectives. They show the competitive nature of the maritime environment and suggest the key factors influencing the industry's corporate objectives and how their decisions are made. The AHP weighted values and the rankings are shown in Table 7-4, Table 7-5 and suggest that the "logistics process" is the most important factor for both carriers and port operators for the corporate objectives of Taiwanese container transportation business.

A supply chain is not a series of links forged together for a common purpose. That is a nice image. However it minimises the reality of the chain and how each link in that chain must design its own logistics process to function within the warehousing, information system and transportation chains. As a result, there are supply chains within each supply chain. With supply chains, the emphasis is on logistics process because that is the vital driver of the supply chain (Mentzer, Stank and Esper, 2008).

Table 7-4: AHP weighted values and ranking of the second level factors

Factors/Determinants	Weighted values		Ranking	
Corporate objectives	Carriers	Port operators	Carriers	Port operators
Market share	0.295	0.295	3	2
Logistics process	0.394	0.423	1	1
Diversification	0.311	0.281	2	3

(Source: the author.)

Table 7-5: AHP weighted values of the second level factors

		Weighted values					
		(B) Market share	(C) Logistics process	(D) Diversification	λ_{max}	C.I.	C.R.
Container carriers	1	0.091	0.818	0.091	3.000	0.000	0.000
	2	0.333	0.333	0.333	3.000	0.000	0.000
	3	0.327	0.260	0.413	3.217	0.109	0.187
	4	0.097	0.701	0.202	3.136	0.068	0.117
	5	0.196	0.311	0.493	3.054	0.027	0.046
	6	0.747	0.119	0.134	3.013	0.006	0.011
	7	0.143	0.714	0.143	3.000	0.000	0.000
	8	0.747	0.204	0.049	3.436	0.218	0.376
	9	0.223	0.127	0.651	3.295	0.147	0.254
	10	0.637	0.105	0.258	3.039	0.019	0.033
	11	0.105	0.637	0.258	3.039	0.019	0.033
	12	0.111	0.111	0.778	3.000	0.000	0.000
Effective average weight *[2]		*0.295*	*0.394*	*0.311*			
Average weight		0.313	0.370	0.317			
Port operators	1	0.200	0.600	0.200	3.000	0.000	0.000
	2	0.069	0.582	0.348	3.032	0.016	0.028
	3	0.793	0.131	0.076	3.022	0.011	0.019
	4	0.143	0.429	0.429	3.000	0.000	0.000
	5	0.089	0.588	0.323	3.009	0.005	0.008
	6	0.203	0.742	0.055	3.436	0.218	0.376
	7	0.068	0.695	0.238	3.295	0.147	0.254
	8	0.714	0.143	0.143	3.000	0.000	0.000
	9	0.060	0.730	0.210	3.305	0.153	0.263
	10	0.059	0.490	0.451	3.007	0.004	0.006
Effective average weight		**0.295**	**0.423**	**0.281**			
Average weight		0.240	0.513	0.247			

(Source: the author.)

*[2] "Effective average weight" means (C.I.) and (C.R.) <0.1 of surveyee's average weighted values (Source: Forman and Selly, 2001; Atthirawong and MacCarthy, 2002).

166

The evaluation results and the analysis of measurement at the third level of the criteria include reliability, flexibility and strategic compatibility. The assessment of these factors will be useful in providing an insight into how the effective criteria should be incorporated into plans at the port planning stage. These qualitative factors include subjective influences on the port's strategic planning. The AHP weighted values and the rankings are shown in Table 7-6 and Table 7-7 and suggest that "flexibility" is the most important criteria for both carriers and port operators.

Table 7-6: AHP weighted values and ranking of the third level factors

Factors/Determinants	Weighted values		Ranking	
Criteria	Carriers	Port operators	Carriers	Port operators
Reliability	0.213	0.178	3	3
Flexibility	0.484	0.587	1	1
Strategic compatibility	0.303	0.235	2	2

(Source: the author.)

Table 7-7: AHP weighted values of the third level factors

		Weighted values			λ_{max}	C.I.	C.R.
		(E) Reliability	(F) Flexibility	(G) Strategic compatibility			
Container carriers	1	0.203	0.055	0.742	3.436	0.218	0.376
	2	0.091	0.818	0.091	3.000	0.000	0.000
	3	0.079	0.659	0.263	3.032	0.016	0.028
	4	0.153	0.777	0.070	3.104	0.052	0.090
	5	0.311	0.493	0.196	3.054	0.027	0.046
	6	0.249	0.594	0.157	3.054	0.027	0.046
	7	0.550	0.210	0.240	3.018	0.009	0.016
	8	0.200	0.200	0.600	3.000	0.000	0.000
	9	0.236	0.682	0.082	3.108	0.054	0.093
	10	0.117	0.268	0.614	3.074	0.037	0.063
	11	0.143	0.143	0.714	3.000	0.000	0.000
	12	0.177	0.519	0.304	3.295	0.147	0.254
Effective average weight		**0.213**	**0.484**	**0.303**			
Average weight		0.209	0.451	0.339			
Port operators	1	0.184	0.584	0.232	3.054	0.027	0.046
	2	0.136	0.238	0.625	3.018	0.009	0.016
	3	0.258	0.637	0.105	3.039	0.019	0.033
	4	0.097	0.202	0.701	3.136	0.068	0.117
	5	0.166	0.761	0.073	3.074	0.037	0.063
	6	0.808	0.062	0.130	3.136	0.068	0.117
	7	0.605	0.105	0.291	3.136	0.068	0.117
	8	0.143	0.714	0.143	3.000	0.000	0.000
	9	0.726	0.198	0.076	3.436	0.218	0.376
	10	0.048	0.191	0.761	3.704	0.352	0.607
Effective average weight		**0.178**	**0.587**	**0.235**			
Average weight		0.317	0.369	0.313			

(Source: the author.)

The evaluation results and the analysis of the measurement in the fourth level of the sub-criteria include location convenience, access to infrastructure development, access to finance and integrated transportation. These determinants will be the main factors influencing greater frequency of ship visits. This will translate into more choices for cargo owners in scheduling their shipments and selecting a shipping service for the transportation of their cargoes, and hence resulting in more competitive carrier costs. The AHP weighted values and the rankings are shown in Table 7-8 and Table 7-9 and suggest that "integrated transportation" is the most important sub-criteria for port operators but "access to infrastructure development" is the most important sub-criteria for container carriers.

Table 7-8: AHP weighted values and ranking of the fourth level factors

Factors/Determinants	Weighted values		Ranking	
Sub-criteria	Carriers	Port operators	Carriers	Port operators
Location convenience	0.255	0.321	3	2
Access to infrastructure development	0.280	0.148	1	4
Access to finance	0.194	0.197	4	3
Integrated transportation	0.271	0.334	2	1

(Source: the author.)

Table 7 -9: AHP weighted values of the fourth level factors

		Weighted values						
		(H) Location convenience	(I) Access to infrastructure development	(J) Access to finance	(K) Integrated transportation	λ_{max}	C.I.	C.R.
Container carriers	1	0.212	0.637	0.075	0.075	4.246	0.082	0.091
	2	0.321	0.036	0.321	0.321	4.000	0.000	0.000
	3	0.606	0.058	0.198	0.138	4.152	0.051	0.056
	4	0.549	0.031	0.279	0.142	4.345	0.115	0.128
	5	0.400	0.200	0.200	0.200	4.000	0.000	0.000
	6	0.167	0.500	0.167	0.167	4.000	0.000	0.000
	7	0.250	0.250	0.250	0.250	4.000	0.000	0.000
	8	0.110	0.540	0.145	0.205	4.183	0.061	0.068
	9	0.165	0.064	0.293	0.479	4.034	0.011	0.013
	10	0.091	0.142	0.239	0.529	4.087	0.029	0.032
	11	0.196	0.076	0.182	0.546	4.075	0.025	0.028
	12	0.283	0.580	0.068	0.068	4.073	0.024	0.027
Effective average weight		**0.255**	**0.280**	**0.194**	**0.271**			
Average weight		0.279	0.259	0.201	0.260			
Port operators	1	0.236	0.167	0.199	0.398	4.060	0.020	0.022
	2	0.147	0.089	0.213	0.551	4.201	0.067	0.074
	3	0.500	0.167	0.167	0.167	4.000	0.000	0.000
	4	0.070	0.100	0.593	0.237	4.309	0.103	0.114
	5	0.682	0.061	0.098	0.159	4.085	0.028	0.031
	6	0.041	0.721	0.080	0.158	4.345	0.115	0.128
	7	0.051	0.630	0.206	0.114	4.299	0.100	0.111
	8	0.321	0.036	0.321	0.321	4.000	0.000	0.000
	9	0.048	0.564	0.259	0.130	4.390	0.130	0.145
	10	0.037	0.369	0.186	0.408	4.068	0.023	0.025
Effective average weight		**0.321**	**0.148**	**0.197**	**0.334**			
Average weight		0.213	0.290	0.232	0.264			

(Source: the author.)

The evaluation results and the analysis of the measurement in the fifth

level of the alternative activity include port service, marketing and logistics.

Perception of these factors can be more important in this research survey.

Port service, marketing and logistics efforts by port authorities to highlight

the port's positive characteristics and accomplishments could improve the

port's reputation. A record of accomplishments and achievements gives

assurance to customers in terms of quality and reliability. The AHP

weighted values and the ranking are shown in Table 7-10 and Table 7-11

and suggest that "port service" is the most important alternative for port

operators and container carriers.

Table 7-10: AHP weighted values and ranking of the fifth level factors

Factors/Determinants	Weighted values		Ranking	
Alternative activity	Carriers	Port operators	Carriers	Port operators
Port service	0.372	0.437	1	1
Marketing	0.264	0.209	3	3
Logistics	0.364	0.354	2	2

(Source: the author.)

Table 7-11: AHP weighted values of the fifth level factors

		Weighted values			λ_{max}	C.I.	C.R.
		(L) Port service	(M) Marketing	(N) Logistics			
Container carriers	1	0.072	0.114	0.814	3.054	0.027	0.046
	2	0.818	0.091	0.091	3.000	0.000	0.000
	3	0.772	0.173	0.055	3.208	0.104	0.180
	4	0.672	0.265	0.063	3.029	0.015	0.025
	5	0.196	0.493	0.311	3.054	0.027	0.046
	6	0.123	0.170	0.707	3.136	0.068	0.117
	7	0.333	0.333	0.333	3.000	0.000	0.000
	8	0.049	0.309	0.642	3.136	0.068	0.117
	9	0.791	0.151	0.058	3.181	0.091	0.156
	10	0.143	0.286	0.571	3.000	0.000	0.000
	11	0.060	0.193	0.747	3.197	0.099	0.170
	12	0.519	0.177	0.304	3.295	0.147	0.254
Effective average weight		**0.372**	**0.264**	**0.364**			
Average weight		0.379	0.230	0.391			
Port operators	1	0.540	0.297	0.163	3.009	0.005	0.008
	2	0.550	0.240	0.210	3.018	0.009	0.016
	3	0.157	0.249	0.594	3.054	0.027	0.046
	4	0.693	0.220	0.087	3.217	0.109	0.187
	5	0.696	0.229	0.075	3.076	0.038	0.066
	6	0.791	0.151	0.058	3.181	0.091	0.156
	7	0.500	0.250	0.250	3.000	0.000	0.000
	8	0.143	0.143	0.714	3.000	0.000	0.000
	9	0.248	0.064	0.688	3.356	0.178	0.307
	10	0.474	0.053	0.474	3.000	0.000	0.000
Effective average weight		**0.437**	**0.209**	**0.354**			
Average weight		0.479	0.190	0.331			

(Source: the author.)

The weighted values of the pair-wise comparison data indicated the best selection option for an intermodal transport system in Taiwan. In this study's analysis, the "port service" factor was the most important alternative activity compared with the other two dimensions for both container carriers and port operators.

7.5: Conclusion

In this chapter we validated the case study based on the main survey of Kaohsiung port in Taiwan to test the AHP approach. The main part of the chapter is devoted to the procedure that begins with the formulation of the research survey and ends with the discussion on the final survey results. The outcome of the exercise encompasses a structured list of weighted decision criteria and a rank order of the evaluated determinants. This assessment of more practical aspects of the procedure allows a favourable judgment on the basic functioning of the approach. The exercise also produced benefits beyond the mere rank order of other research surveys. Various information sources including the extensive use of subjective judgments were tapped to obtain the necessary information. The decision to work with a strategic and a technical group was correct given the different kind of judgements that were expected from the experts.

The case study produced meaningful surveys and other results from the exercise provided a good basis for resource allocation assessment.

The most important result from this case study was the large variation in the different group experts' weighting of the criteria. Those responsible for the container transport industry need to follow-up this case study and assess the respective requirements for future applications. Regarding information collection and processing, the importance of fine-tuning the sequence of the different steps has been highlighted. More subject matter experts have to be involved in order to meet specific information needs. It is clear that the interaction between the members of the strategic group was deficient. In future applications, more attention has also to be paid to the communication between the two groups. Most important, representatives of end users (shippers) in particular have to directly participate in the process. The results for development strategies is analysed in the next chapter and final survey results assessed.

Testing the validity of a proposed or developed model is an extremely important issue. In this study, the issue of validity of the proposed AHP model is considered. In the next chapter, it was noticed that validation tests for the models developed with AHP are based on factor analysis with Cronbach's alpha reliability approaches. The survey results analysis in chapter 8 compares the priority vector obtained from carriers and port operators, with the actual relative weights vector from shippers to analyse validation of the research.

CHAPTER EIGHT

SURVEY RESULTS ANALYSIS

8.1: Introduction

This chapter aims to test the survey results and analyses the research findings. We will focus on the survey assessment of results as well as on methodological aspects. The main part of the research is a study using the Multiple Criteria Decision Making (MCDM) model based AHP methodology to quantify the importance of various criteria for intermodal transport system development strategies in Taiwan. We discussed this pilot application of the MCDM model approach in a previous chapter. In this section, the evaluation data are examined to test the validity of the overall criteria using the second round questionnaire survey from shippers in Taiwan. The research measures the validity of the overall development strategies and the test shows that the overall development strategies have high reliability validity. From the perspective of the research project, the main purpose of this study was to evaluate the decision support tool. The evaluation aimed to test the suitability of the tool to cope with the strategic component of research activities, major uncertainty, and the specific characteristics of transportation planning. More generally, its relevance and practicability to tackle real-world decision problems, particularly regarding group decision-making is to be examined.

Having obtained a good understanding of the data acquired, this section aims to test the model developed for the research. Firstly, shippers' perceptions of container transportation and port service are analysed by performing cross-tabulations together with the statistical techniques of factor analysis and then a one-way analysis of variance (ANOVA) analysis. The statistical techniques of factor analysis and ANOVA were utilized for analysing the data in order to analyse the relationship between the service purchase behaviour and the degree of satisfaction, factor analysis is employed for the purpose of data reduction and, subsequently, ANOVA is also employed for analysing the data.

8.2: Methods of data collection

Transportation planning project selection is of critical importance to container carriers, port service providers and shippers in terms of achieving high customer service level, cost savings and efficiency in the overall supply chain. On the other hand, providers of transportation services have been interested in finding out the salient freight transport selection factors in order to be competitive within the freight transport markets. These facts have directed the attention of transport and logistics researchers towards the problem of freight transportation selection and as a result of this many empirical researches and reviews have been realised. A field survey was conducted within the framework of this study and after reviewing the attributes used in transportation planning project selection

criteria research. This survey assesses three category factors comprised of 15 development strategies with 1 to 5 importance ranking range in order to investigate the attributes of container port operation. A 15 development strategies item importance scale was developed in order to measure the perception of Taiwanese shippers. The questionnaires in this research are carried out twice. The first one focuses on acquiring the weighting values of the selection factors we have surveyed in the previous chapter. The second round questionnaires aim to test the reliability effectiveness of this research. The data collected from the second round questionnaires are explained in Table 8-1 as follows:

Table 8-1: Profile of the second round questionnaires

Objective	Testing the effectiveness of the factors
Methods	Mail delivery questionnaire
Retrieve	248 copies
Reliability validity	Cronbach's alpha (α) reliability test

(Source: the author.)

The second round questionnaires were mailed with a cover letter to the shippers (Appendix B and D). A sample of 1,000 shippers of various sizes ranging from small to large was surveyed from the 2005 edition of the Taiwanese Shipping Directory by mailing questionnaires. The questionnaires designed for the study were pre-tested on a small group of

177

shippers and finalised before it was utilised for the survey. In addition to the general questions on the nature and performance of each firm, respondents were asked to indicate their perceptions on each of these strategies according to a five-point Likert scale. The scale for each factor ranged from 1 = Least important to 5 = Most important. The questionnaire and the letter of request were provided in both Chinese and English. A stamped envelope was also sent for easy returning of the completed questionnaire. A total of 262 shippers responded to the questionnaire, giving a response rate of 26.2 per cent. Since 14 responses were not useable due to incomplete data, 248 responses were utilised for the study. The statistical techniques of strategy analysis and ANOVA were utilised for analysing the data. A profile of these firms is displayed in table 8-2. All groups were fairly well represented by the sample shippers, while the electronic and computer equipment group accounted for nearly 50 per cent of all shippers, indicating its dominance in the current manufacturing industry as a shipper in Taiwan. The results of the strategies analysis show a set of three separately identifiable alternative activities as factors that have positive and significant impact on the success of the sample shippers.

The sample shippers will fight for international trade; especially, when confronting large corporations with significant influence on trade route shipping and competitive modes of delivery and work within their firms to determine which one might be able to establish international trade and might exercise spheres of influence in developing new, alternative trade routes. Shippers move international shipments via container using

sequential transportation modes (water, air and land) while making use of

the most efficient cost-effective methods to move goods. An entire new set

of terms have developed around this concept of intermodalism.

Table 8-2: Profile of the sample shippers (part-one)

Type of Industry	Shippers	%
Food, and beverages products	36	14.5
Electronic and computer equipment	121	48.9
Paper products	18	7.3
Chemical, petroleum, rubber and plastics products	45	18.1
Basic metal products	20	8.0
Manufactured products not elsewhere specified	8	3.2
All shippers	248	100.0

(Source: the author's survey data, April-August 2005.)

The majority of shippers showed 87.1 per cent were private limited

companies, sole proprietorships were 7.3 per cent and partnerships were

5.6 per cent (Table 8-3). The numbers of small, medium and large

shippers included in the sample were 40.3 per cent, 27.4 per cent and

32.3 per cent respectively. Thus, 67.7 per cent of shippers in the sample

belonged to the small and medium enterprise (SME) category. This

classification was based on a widely used criterion of defining shippers

with 1-100 employees as a small-scale industry, and those with 101-300

employees as medium-scale industry. When the shippers' size was

measured in terms of annual sales, 18.1 per cent of firms had sales less

than 10 million New Taiwanese Dollars (NTDs) while the majority of

shippers (73.8 per cent) had sales ranging from 11 million to 1,000 million

NTDs. Only 8.1 per cent of firms had an annual sales turnover exceeding

1,000 million NTDs. Most of the sample shippers (64.5 per cent) were engaged in export trade while only 35.5 per cent confined their sales to local customers. Most of the firms that sold their products only to overseas customers were in the electronics and computer industry.

Table 8-3: Profile of the sample shippers (part-two)

Forms of Organisation	Shippers	%	Employees	Shippers	%
Sole proprietorship	18	7.3	1 – 100	100	40.3
Partnership	14	5.6	101 – 200	40	16.1
Private limited company	216	87.1	201 – 300	28	11.3
			> 300	80	32.3
All firms	248	100	Total	248	100
Sales (Millions of NTDs)	Shippers	%	Nature of Sales	Shippers	%
< 10	45	18.1	Both local and overseas	1880	75.8
11 – 100	88	35.5	Overseas only	60	24.2
101 – 1000	95	38.3			
> 1000	20	8.1			
Total	248	100	Total	248	100

(n=248)

(Source: the author's survey data, April-August 2005.)

8.3: Results of the Statistical Analysis

The statistical analysis of data was carried out in three stages. Firstly, the technique of factor analysis was utilised to reduce the number of variables to meaningful factors, each representing separately identifiable characteristics that could be considered as a set of principal components or determinants of success for shippers. Factor analysis has the ability to

produce descriptive summaries of data matrices, which aid in detecting the presence of meaningful patterns among a set of variables (Dess and Davis, 1984).

The correlation matrix produced by SPSS software showed a considerable number of correlations exceeding 0.3. Furthermore, the anti-image correlation matrix revealed that all of the measures of sampling adequacy were well above the acceptable level of 0.5, confirming the suitability of our data for a factor analysis. The descriptive statistics were used for ranking the alternative activities in their order of importance. An analysis of variance (ANOVA) was utilized to determine whether the respondents' perceptions on the importance of each factor varied between firms of different sizes. When the original 15 variable strategies were analysed by the principle component factor analysis, a three-factor solution with an eigen-value of ≥ 1 resulted. The analysis of the remaining 15 variables strategies yielded three significant factors which explained 61.1 per cent of the total variance.

These factors were also considered satisfactory according to the reliability test of Cronbach's alpha with a value greater than 0.6 (Cronbach, 1951). These three alternative activities factors and the 15 strategies variables loaded against each, along with the relevant statistical values, are given in Table 8-4. The factor loadings ranged from 0.787 to 0.450. The higher a factor loading, the more its test reflects or measures a factor. The literature on factor analysis shows that loadings

equal to or greater than 0.40 are considered large enough to warrant interpretation (Kerlinger, 1979). These factors, when ranked in their order of importance ranking are the same as the AHP reported in the previous chapter and as follows: strategies of port service, marketing, and logistics. The relevant statistical values and ranking order also are given in Table 8-5.

Table 8-4: Principal components factor analysis

Variables (Strategies)	Factor 1: Port service	Factor 2: Marketing	Factor 3: Logistics
Improve quality of port management	0.728		
Improve service of the people who assign in-port operations	0.708		
Improve efficiency of loading and discharging	0.703		
Establish service system of ship berthing	0.702		
Increase management of berth scheduling	0.657		
Industrialise port management		0.533	
Establish national trade area		0.507	
Develop recreation area		0.761	
Decrease port expense		0.731	
Develop tourism		0.614	
Simplify management of customs			0.569
Format intermodal links			0.786
Improve the system of transportation for exterior			0.758
Set up the port flow area			0.472
Establish check area for container depot			0.450
Eigen-value	3.99	2.88	2.66
Proportion of Variance explained	24.4%	19.3%	17.4%
Cumulative Variance Explained	24.4%	43.7%	61.1%
Alpha (α)	0.85	0.75	0.77

(Source: the author.)

Table 8-5: Ranking of factors according to their importance

Factor	No. of variables	Mean	Standard Deviation	Rank
Factor 1: Port service	5	4.4781	0.6487	1
Factor 2: Marketing	5	4.3264	0.6418	2
Factor 3: Logistics	5	4.2777	0.6491	3

(Source: the author.)

In order to examine possible differences in the perceived importance of factors according to the sizes of the respondent shippers, the mean values of factors were further analysed into three groups of firm size as shown in Table 8-6. Sample shippers are classified into three groups by the number of employees: small shippers (S1) with less than 100 employees, medium shippers (S2) with 101 to 300 employees, and large shippers (S3) with over 300 employees. Accordingly, the three groups consisted of 100 small shippers with a mean of 49.6 employees, 68 medium firms with a mean of 183.7 employees, and 80 large firms with a mean of 1151.6 employees. As for the statistical analysis, one-Way ANOVA was utilized to determine whether there was a statistically significant difference between the means of factors among the above three groups of firms. In addition to determining the differences between means, one-way ANOVA post hoc multiple comparisons were also used to identify the means that would differ. The ANOVA results are shown in Table 8-6.

Table 8-6: ANOVA results of group differences between means of factors

	(S1) Small shippers	(S2) Medium shippers	(S3) Large shippers	Significance
	Mean	Mean	Mean	
Factor 1: Port service	4.32 ^{a*,b*}	4.57 ^{a*}	4.59 ^{b*}	0.008 **
Factor 2: Marketing	4.18 ^{b**}	4.34	4.50 ^{b**}	0.006
Factor 3: Logistics	4.11 ^{b**}	4.31	4.46 ^{b**}	0.001 **

Notes:
a = S1 different from S2; b = S1 different from S3;
Significance levels: * $P<.05$; and ** $P<.01$

(Source: the author.)

Ranking of the above three factors in order of their importance, along with mean and standard deviation, is shown in Table 8-7. The importance of these factors, as perceived by the respondents has been ranked on the basis of their mean values. The closer the mean to 5, the greater the importance indicated by the factor. Accordingly, the ranking using their means ranged from 4.638 to 2.642.

Table 8-7: Intermodal transport system development strategies

Development strategies	Ranking	Mean	Standard Deviation
Improve efficiency of loading and discharging	1	4.638	0.44
Improve quality of port management	2	3.993	0.47
Decrease port expense	3	3.921	0.63
Simplify management of customs	4	3.897	0.53
Improve service of the people who assign in-port operations	5	3.801	0.55
Industrialise port management	6	3.748	0.77
Format intermodal links	7	3.579	0.77
Improve the system of transportation for exterior	8	3.500	0.77
Establish service system of ship berthing	9	3.475	0.93
Develop recreation area	10	3.385	0.87
Increase management of berth scheduling	11	3.365	0.87
Establish check area for container depot	12	3.345	0.86
Develop tourism	13	3.073	0.72
Set up the port flow area	14	2.740	0.79
Establish national trade area	15	2.642	0.90

Note: 1= Lowest Importance; 5=Highest Importance

(Source: the author.)

8.4: Results for development strategies

The Cronbach Alpha coefficients (α) of the selection criteria constructs for shippers' range from 0.85 to 0.77 reported in Table 8.4 for the three factors group and indicates the reliability with high internal

consistency of the construct. The survey results indicated some significant differences between the three groups of shippers in respect of three factors:

Factor 1: Port service:

- Improve quality of port management

- Improve service of the people who assign in-port operations

- Improve efficiency of loading and discharging

- Establish service system of ship berthing.

- Industrialise port management

Factor 2: Marketing:

- Establish national trade centre

- Develop recreation area

- Decrease port expense

- Develop tourism

- Increase management of berth scheduling

Factor 3: Logistics:

- Simplify management of customs

- Format intermodal links

- Improve the system of transportation for exterior

- Set up the port flow area

Overall mean scores and standard deviations are ranked in order from highest importance to lowest importance in Table 8-7. 'Improve efficiency of loading and discharging' ($\mu=4.638$), 'Improve quality of port management' ($\mu=3.993$), 'Decrease port expense' ($\mu=3.921$) 'Simplify

management of customs' (μ=3.897) and 'Improve service of the people who assign in-port operations '(μ=3.801) were determined as the most important top five development strategies of intermodal transport system selection criteria with respect to the perceptions of shippers' respondents.

Factor analysis and principal components analysis was applied for the determination of the main components of development strategies of intermodal transport system selection criteria. Table 8-4 reveals the three sets of factors obtained through the factor analysis of the strategies variable concerning the selection criteria. These factor analysis results are stated as follows:

Factor 1: Port service: This factor was represented by 5 variables with factor loadings ranging form .728 to .657 (Cronbach's alpha = 0.85).

Factor 2: Marketing: Five variables with loadings ranging from .761 to .533 (Cronbach's alpha =0 .75).

Factor 3: Logistics: This factor comprised five variables with loadings ranging from .786 to .450 (Cronbach's alpha = 0.77).

8-5: Conclusion

The results of the factor analysis show a set of three separately identifiable alternative factors that have positive and significant impact on the success of intermodal transport system development strategies in Taiwan. The empirical survey results reveal that there exist significant differences, especially regarding three alternative activities factors: "port

service", "marketing" and "logistics". Firstly, "port service" activity gives more weight to efficiency and quality for port operation. Secondly, "marketing" activity was not seriously considered by shippers' perception to decrease port expenses. In addition, logistics operation factors such as management of customs, intermodal links and accessibility to the port are not seriously considered. These findings indicate that container port operators should place more importance on "port service". The survey results indicate that shippers have specific interest in these factors. (Malchow and Kanafani, 2001).

In addition, the current study shows that shippers and container carriers possess similar perspectives regarding the importance of container operations in port, which is considered less by terminal operators. Therefore, it is recommended that terminal operators make greater effort to reinforce their capabilities accommodating and supporting container carriers' operations and strategies in order to obtain and maintain their competitive advantage and position. It has been a long controversial argument about "who" has more influential power in the transhipment decision of container ports between carriers and shippers. For instance, Slack (1985) argued that liners are the most significant actor in the development strategies of the port. According to D'Este and Meyrick (1992), a port selection shifted from the shipper to the carriers since the shipping lines grew larger in their scale of operations. They take a similar view of Hayuth (1987), Hayuth and Fleming (1994), and Malchow and Kanafani (2001). On the contrary, Tiwary et al. (2003) argues that shippers

now possess stronger bargaining and influencing power against container carriers and over their service design. According to them, the organization of global strategic alliances of shipping lines has redesigned liner service routes in response to economic growth and shippers' needs. These arguments can be compromised by the finding of recent research that shipping lines select their calling ports directly considering shippers' requirements and shippers realise their preference for a port by the choice of a line providing a service route passing through that port (Malchow and Kanafani, 2004).

In conclusion, ports, particularly container terminal operators, should focus their attention on the "port service" factors on which shippers and liners are commonly placing high priorities, when the terminal operators formulate, implement and evaluate their terminal management policy and operating strategy, as well as their marketing plan. The current study concentrated mainly on different perspectives and priorities about port development strategy factors among shippers, carriers and terminal operators. It will be a meaningful future study to test the explanation power of the port choice factors and real influences of major market players on container port development strategies factors. For instance, it would be possible to collect the scores of various container terminals for each port development strategies factors and run a regression model examining the influences of these factors upon ports' market share and/or throughputs. In addition, a structural equation model could be employed to explore some

direct and indirect relationships among port selection factors and port

operational indices in further research.

CHAPTER NINE

CONCLUSIONS AND DISCUSSIONS

9.1: Introduction

The main objectives of this research have been to understand the detail of development strategies for an intermodal transport system in Taiwan in order to identify the multiple criteria and variables related to this research, and develop an integrated decision making process model as a framework to help the public sectors make quality decisions in selecting the best development strategies. This chapter presents a summary of the research conclusions as well as a discussion drawn from those findings of hypotheses. Conclusions and limitations of the research will be stated with a suggestion for future research.

The decision problem was structured as a hierarchy that included, at the top level the goal; the second level the corporate objectives; on the third and fourth levels, respectively, the criteria and sub-criteria; fifth the alternative activity; and finally, on the bottom level, all of the strategies. This research defined the framework for the decision process and highlighted the process completed by a group of decision makers. The model was validated by the case study in Taiwan and the analysis and limits of the model were discussed. This research developed a framework that will enable the public sectors to make better decisions and will save decision-makers time and effort.

The model developed by this research study focused on the steps of their selection process. The field of development strategies is growing all around the world, and there is currently a lack of evaluative criteria and decision-making tools to help the public sectors select the best proposals. There are many criteria and variables that affect development strategies and these should be considered in the evaluation process. This research shows that the consideration of all these criteria could help produce better decisions. Decision-makers within the public sector need a practical and simple tool that can be implemented easily. This research developed a systematic approach that includes all the criteria and can accommodate subjective judgments. The decision process in this model involves group decision making, and since the model is Multiple Criteria Decision Making (MCDM) based on AHP, it helps the decision makers to accommodate diverse judgments. It also permits the decision makers to check their judgments through consistency ratios. This model tool is based on a simple yet powerful technique named AHP. AHP is the most suitable technique for public sectors to use because it is easily implemented. It helps decision-makers to understand the problem by structuring the hierarchy, and it transfers their subjective judgments into meaningful weights and ratios that represent their priorities.

9.2: Findings of hypotheses

This research developed three working hypotheses that have been tested. The following were the working hypotheses and test findings.

Hypothesis one:

- **H1:** **The specific features of all transportation planning research require the definition and incorporation of special criteria into the multiple criteria decision-making approach.**

Finding:

Transportation planning research concerning the intermodal transport system for container port operation in Taiwan is heavily constrained by factors that are related to transport infrastructure, the transport decision-maker, and the transport service offered. Table 9-1 classifies factors that affect the selection of intermodal transport system in Taiwan into five main categories. In this study, the transportation planning features in the framework were the five main categories: goal; corporate objectives; criteria; sub-criteria; alternative activity. The last criterion (alternative activity) was included to capture the 15 development strategies which are shown in Table 9-2.

Table 9-1: Factors related to specific features of intermodal transport planning

Hierarchies/Features	Indicators/Factors
1. Goal:	A. Selection intermodal transport system
2. Corporate objectives:	B. Market share C. Logistics process D. Diversification
3. Criteria:	E. Reliability F. Flexibility G. Strategic compatibility
4. Sub-criteria:	H. Location convenience I. Access to infrastructure development J. Access to finance K. Integrated transportation
5. Alternative activity:	L. Port service M. Marketing N. Logistics

(Source: the author.)

Hypothesis two:

- **H2:** **The sources of uncertainty regarding the success of transportation planning research and the successful adoption of the results by end users have to be carefully identified and included in the approach.**

Finding:

The research finding in hypothesis two has revealed a clear conceptual separation between potential impacts and the chances to effectively realise them, on the one hand, and between the two major areas of uncertainty for the transportation planning process and project proposals adoption. On the other hand, it is necessary to elicit meaningful judgments. Methodologically, the separation was achieved by employing three different hierarchies. The selective combination of the projects' outcome from each hierarchy is an innovative approach that allows the capturing of the impacts of projects in the process of their formation over time in a more realistic manner. The field of transportation planning is growing all around the world, and there is currently a lack of evaluative criteria and decision-making tools to help the public sectors' selection of the best proposals. There are many criteria and variables that affect the evaluation process. This research shows that the consideration of all these criteria could help produce better decisions. Decision-makers within the public sectors need a practical and simple tool that can be implemented easily. The decision process in this model involves group decision-making since the MCDM model is based on the AHP. Future applications need to enhance the decision framework to allow for potential effects of a rapidly

changing environment. With scenarios based on time-series analysis, economic forecasts can be made, thus improving the accuracy of the evaluation. Once the scenarios are defined, they can be embodied in the AHP. Two ways are suggested to assess their likelihood of occurrence by means of the AHP. Different scenarios can be weighted through the pair-wise comparison process directly to the main hierarchy by adding a further level (Dyer and Forman 1992). For a more detailed evaluation, a separate hierarchy is constructed for the scenarios (Ramanujam and Saaty 1981). The use of scenarios may lead to a different type of outcome of the decision making process. Rather than providing a 'best' choice the evaluation would come up with a set of options.

Hypothesis three:

- **H3: The development strategies of intermodal transportation system research should be explicitly assessed.**

Finding:

In Table 9-2, we classify variables that affect intermodal transport planning into 15 development strategies. It is a fact that the nature of freight transport will have an impact on shippers' selection of intermodal service in a container port. In Taiwan, the shippers considered that 'improve efficiency of loading and discharging', 'improve quality of port management', 'decrease port expense', 'simplify management of customs' and 'improve service of the people who assign in-port operations' were the most important top five development strategies of intermodal transport

197

system selection criteria with respect to the perceptions of their respondents. The findings of this research could be put forward to the Taiwanese government to promote the usage of intermodal transport system for transit inland container cargoes.

Table 9-2: Development strategies of an intermodal transport

system

Development Strategies:	
(i)	Improve quality of port management
(ii)	Improve service of the people who assign in-port operations
iii)	Improve efficiency of loading and discharging
(iv)	Establish service system of ship berthing
(v)	Increase management of berth scheduling
(vi)	Industrialize port management
(vii)	Establish national trade centre
(viii)	Develop recreation area
(ix)	Decrease port expense
(x)	Develop tourism
(xi)	Simplify management of customs
(xii)	Format intermodal links
(xiii)	Improve the system of transportation for exterior
(xiv)	Set up the port flow area
(xv)	Establish check area for container depot

(Source: the author.)

9.3: Conclusions and limitations of the research

It has been clear that the demand for transportation infrastructure is growing, and governments have found the need for a development strategies approach in particular to be a viable solution to this problem. The objective of this study was to develop a tool to support decision

makers of development strategies in Taiwan. Decision makers face increasingly complex decision problems when scarce resources need to be efficiently allocated and accounted for. The Multiple Criteria Decision Making (MCDM) approach had facilitated the decision choice of best development strategies of an intermodal transport system. In this study, in order to aim at developing such an approach for transportation planning projects the Analytic Hierarchy Process (AHP) was identified as an appropriate methodological tool. Both the public and private sectors recognise that the evaluation process is a crucial part of the implementation of this approach. The strong movement toward the expanded use of development strategies projects requires governments to have a rational and comprehensive selection process that addresses all of the issues affecting the selection of proposals. The model developed by this research is expected to provide some important contributions including the development strategies proposal selection guide that helps the public sector select various criteria that should be considered in evaluating and selecting the best proposals. It is a decision making tool that provides the decision-makers with steps to help them structure the decision problem and drive their judgments in a systematic way. The uses of this model will save decision makers within the public sector a great deal of time and effort. This research introduces to decision makers in this field a powerful and simple tool named AHP which has been used widely in the transportation planning research. The incorporation of decision criteria has reflected the specific transportation planning features. The public acceptance required collaboration of decision-makers from different fields

in order to enable more realistic management of public-sectors decision problems.

In the case study application, their significance in terms of criteria weights differed widely. But even the most relevant ones had only a marginal influence on the final ranking. This research has made significant contributions, but there are several limitations as well. The test data are relatively limited, but the case study in Taiwan provided a good validation test. More cases would enable a comprehensive analysis for further research. This limitation resulted from two main factors: the field of development strategies for intermodal transport system is relatively new in many countries, so there are limited implemented cases; and within this field, data from the public sector is considered sensitive and confidential. As a result it was difficult to survey the full picture of the industry. This research focused on the stages of the development strategies selection process and considered all of the steps of the process. However, it did not integrate the entire process into the model, especially the stage following the evaluation stage. This research defined and explained all evaluation criteria but did not include exact values or limits for each one because the factors indicate the nature of development strategies projects and the values or weights for the criteria differ from one project to another in different countries. There is a lack of data and information about previous cases; and this field is relatively new, so there are few existing projects or cases about developing the intermodal transport system available to study.

The AHP provided a suitable basis for the methodological framework of the approach. It has confirmed its potential to cope with multiple criteria decision problems. The flexibility in modeling the problem allowed the accommodation of the working hypotheses. The AHP also met the requirements regarding participation, transparency, and standardised measurement scale. Because it is simple and intuitively logical, the AHP does not require particular analytical skills and virtually everybody can participate. The way of structuring and visualizing complex decision problems is straightforward and appealing in the AHP. The use of pair-wise' comparisons to produce relative preferences of alternatives is particularly attractive for assessing qualitative impacts. This research developed a model for the different stages of the evaluation process. It will be good for future researchers to develop other models to integrate this model with risk analysis. In the future, with increased implementation of development strategies projects, there will be more information and data available and additional work will be done to provide reference values for the criteria.

For further applications, it would be interesting to analyse the benefits of clearly dividing the procedure into two parts: a pre-selection process and a more detailed evaluation with a shortlist only. This would greatly reduce the set of alternatives and permit considerable time saving. In addition, it would provide information on the relevant issues to be focused on in the main evaluation. More generally, it should be examined how to reduce the time requirement of the participatory process. Efficiency gains

can be expected from improved techniques to elicit judgments, better

moderated group sessions, timely provided and properly processed data,

and a sharper focus on the most pertinent parts of the evaluation.

APPENDICES

203

Appendix A:

Questionnaire for container carriers and port operators

Invitation Letter

Mr. Yih-Ching Juang
PhD Researcher
Institute of Marine Studies
University of Plymouth
Drake Circus, Plymouth
Devon, PL4 8AA
United Kingdom
Email:
yjuang@plymouth.ac.uk
Tel: +44 - 01752-232467
Fax: +44- 01752-232406

Dear Sir or Madam

As part of my PhD research, I am investigating the decision process for strategic intermodal transport developments. In order to complete this work, I am seeking the views of experts from various related fields regarding the relative importance of decisions associated with intermodal transport.

I would be most grateful if you would complete the attached questionnaire that should only take several minutes of your time. Please return the questionnaire in the reply paid envelope. All replies will be treated in the strictest confidence and it will be impossible to identify individual respondents in any published results. If you would like to receive the general results of the survey, please enter your name and address at the end of the questionnaire.

If you have any question about this research please do not hesitate to contact me or my supervisor Dr. Richard Gray at the above address.

Yours sincerely,

Yih-Ching Juang

QUESTIONNAIRE

This study of the selection of an intermodal transport system for container port planning requires you to make specific choices as shown in the example below using the following scale.

Scale of relative importance

Intensity of relative importance	Definition
1	Equal importance
3	Slight importance
5	Moderate importance
7	Strong importance
9	Extreme importance

Example

If you think factor A is 5 times more important than factor B then please tick as follows:

Factor A	Intensity of relative importance									Factor B
Scales	9	7	5	3	1	3	5	7	9	Scales
Market share			✓							Logistics process

This means that in your opinion factor A (market share) is moderately important compared with factor B (logistics process) when deciding to select an intermodal transport system.

The survey of factor comparison : please tick the appropriate answers

A. First tier comparison: the relative importance of each major factor for the choice of goal tier (selection of intermodal transport system)

Factor A	Intensity of relative importance									Factor B
Scales	9	7	5	3	1	3	5	7	9	Scales
Market share										Logistics process
Market share										Diversification
Logistics process										Diversification

B. Second tier comparison: the relative importance of each major factor for the choice of corporate objectives tier (market share, logistics process, diversification)

Factor A	Intensity of relative importance									Factor B
Scales	9	7	5	3	1	3	5	7	9	Scales
Reliability										Flexibility
Reliability										Strategic compatibility
Flexibility										Strategic compatibility

C. Third tier comparison: the relative importance of each major factor for the choice of criteria tier (reliability, flexibility, strategic compatibility)

Factor A	Intensity of relative importance									Factor B
Scales	9	7	5	3	1	3	5	7	9	Scales
Location convenience										Access to infrastructure development
Location convenience										Access to finance
Location convenience										Integrated transportation
Access to infrastructure development										Access to finance
Access to infrastructure development										Integrated transportation
Access to finance										Integrated transportation

D. Fourth tier comparison: the relative importance of each major factor for the choice of sub-criteria tier (location convenience, access to infrastructure development, access to finance, integrated transportation)

Factor A	Intensity of relative importance									Factor B
Scales	9	7	5	3	1	3	5	7	9	Scales
Port service										Marketing
Port service										Logistics
Marketing										Logistics

If you wish to receive the general results of the survey, please enter your details and return with questionnaire.

Name:

Title/Position:

Organization/Company:

Address:

Telephone No:

Fax No:

E-mail:

Tel: 886-6-9264115 ext 3203

300 Liu-Ho Road, Makung, Penghu, Taiwan 880

National Penghu Institute of Technology

Department of Shipping and Transportation Management

Mr. Yih-Ching Juang

Appendix B:

Questionnaire for shippers

Invitation Letter

Mr. Yih-Ching Juang
PhD Researcher
Institute of Marine Studies
University of Plymouth
Drake Circus, Plymouth
Devon, PL4 8AA
United Kingdom
Email:
yjuang@plymouth.ac.uk
Tel: +44 - 01752-232467
Fax: +44- 01752-232406

Dear Sir or Madam

As part of my PhD research, I am investigating the decision process for strategic intermodal transport developments. In order to complete this work, I am seeking the views of experts from various related fields regarding the relative importance of decisions associated with intermodal transport.

I would be most grateful if you would complete the attached questionnaire that should only take several minutes of your time. Please return the questionnaire in the reply paid envelope. All replies will be treated in the strictest confidence and it will be impossible to identify individual respondents in any published results. If you would like to receive the general results of the survey, please enter your name and address at the end of the questionnaire.

If you have any question about this research please do not hesitate to contact me or my supervisor Dr. Richard Gray at the above address.

Yours sincerely,

Yih-Ching Juang

QUESTIONNAIRE

This study of the development strategies selection of an intermodal transport system for container port planning requires you to make specific choices below using the following scale.

Scale of relative importance

Intensity of relative importance	Definition
1	Equal importance
2	Slight importance
3	Moderate importance
4	Strong importance
5	Extreme importance

Part One:
The evaluation of different alternative activity of intermodal transport system

Please tick one of the five ratio scale _1, 2, 3, 4, 5_ for each item to show the relative importance for the development strategies of alternative activity of intermodal transport system _(5 is the most important and 1 is the least important)_.

Alternative activity of intermodal transport system	Scales
L. Port service	1 2 3 4 5
M. Marketing	1 2 3 4 5
N. Logistics	1 2 3 4 5

Part Two:
The evaluation of different development strategies

A. Please tick one of the five ratio scale *1, 2, 3, 4, 5* for each item to show the relative importance for the development strategies of port service *(5 is the most important and 1 is the least important)*.

Development strategies of port service	Scales
a. Improve quality of port management	1 2 3 4 5
b. Improve service of the people who assign in-port operations	1 2 3 4 5
c. Improve efficiency of loading and discharging	1 2 3 4 5
d. Establish service system of ship berthing	1 2 3 4 5
e. Increase management of berth scheduling	1 2 3 4 5

B. Please tick one of the five ratio scale *1, 2, 3, 4, 5* for each item to show the relative importance for the development strategies of marketing *(5 is the most important and 1 is the least important)*.

Development strategies of marketing	Scales
f. Industrialize port management	1 2 3 4 5
g. Establish national trade centre	1 2 3 4 5
h. Develop recreation area	1 2 3 4 5
i. Decrease port expense	1 2 3 4 5
j. Develop tourism	1 2 3 4 5

C. Please tick one of the five ratio scale *1, 2, 3, 4, 5* for each item to show the relative importance for the development strategies of logistics *(5 is the most important and 1 is the least important)*.

Development strategies of logistics	Scales
k. Simplify management of customs	1 2 3 4 5
l. Format transfer process	1 2 3 4 5
m. Improve the system of transportation for exterior	1 2 3 4 5
n. Set up the port flow area	1 2 3 4 5
o. Establish check area for container depot	1 2 3 4 5

End of the questionnaire

If you wish to receive the general results of the survey, please enter your details and return with questionnaire.

Name:

Title/Position:

Organization/Company:

Address:

Telephone No:

Fax No:

E-mail:

Tel:886-6-9264115 ext 3203

300 Liu-Ho Road, Makung, Penghu, Taiwan 880

National Penghu Institute of Technology

Department of Shipping and Transportation Management

Mr. Yih-Ching Juang

Appendix C:

Questionnaire for container carriers and port

operators

(Chinese version)

『貨櫃港埠複合運輸系統發展策略之研究』問卷調查

敬愛之專家、先進您好,

　　本問卷是針對「貨櫃港埠複合運輸系統發展策略之研究」計劃案而設計, 希望能藉由航商 (carriers) 及貨櫃碼頭經營業者 (port operators) 之意見調查而發現各項重要評估選擇準則, 進而改善台灣各港口之服務品質與提昇各貨櫃港之競爭力。 煩請 您以個人之觀點填寫此問卷, 本問卷只供本研究參考、採隱匿名稱方式撰寫使用且不會對其他第三者公開。 您寶貴之批評、意見對本研究具有極高之價值。 謝謝您對本問卷調查之回覆與支持。

敬頌時棋

　　英國朴里茅司大學(University of Plymouth)航運管理研究所
　　聯絡人：莊義清
　　聯絡電話：06-9264115 轉 3203 分機
　　或 行動電話 0929330102　傳真：06-9265760

A. 問卷解釋:

圈選出不同倍數的數值代表著下列之意義:
- 9: 極端重要（extremely important）
- 7: 非常重要（very important）
- 5: 強烈重要（strongly important）
- 3: 稍微重要（weakly important）
- 1: 同等重要（equally important）

設若您認為 A 評估準則較 B 評估準則具有 5 倍數之重要性, 則請圈選型式如下：

評估準則 (A)	偏好重視數目尺度								評估準則(B)
市場佔有率	9	7	⑤	3	1	3	5	7	9	*運籌流程*

此答案表示：市場佔有率(A)因素相對於運籌流程(B)因素是具有「極端之重要性」。

B. 問卷

（1） 第一層面比較

評估準則	偏好重視數目尺度									評估準則
市場佔有率	9	7	5	3	1	3	5	7	9	*運籌流程*
市場佔有率	9	7	5	3	1	3	5	7	9	*組織多樣化*
運籌流程	9	7	5	3	1	3	5	7	9	*組織多樣化*

（2） 第二層面比較

評估準則	偏好重視數目尺度									評估準則
可靠程度	9	7	5	3	1	3	5	7	9	*彈性程度*
可靠程度	9	7	5	3	1	3	5	7	9	*策略適應程度*
彈性程度	9	7	5	3	1	3	5	7	9	*策略適應程度*

(3) 第三層面比較

評估準則	偏好重視數目尺度									評估準則
地理區位方便程度	9	7	5	3	1	3	5	7	9	*設施發展配合度*
地理區位方便程度	9	7	5	3	1	3	5	7	9	*財務調配程度*
地理區位方便程度	9	7	5	3	1	3	5	7	9	*轉運整合運輸系統鄰近度*
設施發展配合度	9	7	5	3	1	3	5	7	9	*財務調配程度*
設施發展配合度	9	7	5	3	1	3	5	7	9	*轉運整合運輸系統鄰近度*
財務調配之程度	9	7	5	3	1	3	5	7	9	*轉運整合運輸系統鄰近度*

219

(4) 第四層面比較

評估準則	偏好重視數目尺度								評估準則
港埠服務便利性	9	7	5	3	1	3	5	7	9	*港埠行銷積極性*
港埠服務便利性	9	7	5	3	1	3	5	7	9	*港埠運籌發展性*
港埠行銷積極性	9	7	5	3	1	3	5	7	9	*港埠運籌發展性*

C.、基本資料

(以下資料僅供整體分析之用，不做個別探討，敬請安心填答，謝謝！)

姓　　名：

服務單位：

職　　稱：

性　　別：□男　□女

年　　齡：□25 歲以下　□26~30 歲　□31~35 歲　□36~40 歲

　　　　　□41~45 歲　□46~50 歲　□51~55 歲　□56 歲以上

連絡電話：

傳真　　：

Tel: 06-9264115 轉 3203

澎湖縣馬公市六合路 300 號

國立澎湖技術學院

航運管理學系

莊義清 老師

Appendix D:

Questionnaire for shippers

(Chinese version)

『貨櫃港埠複合運輸系統發展策略之研究』問卷調查

敬愛之專家、先進您好,

　　　本問卷是針對「貨櫃港埠複合運輸系統發展策略之研究」計劃案而設計, 希望能藉由託運人(shippers)之意見調查而發現各項重要發展策略選擇準則, 進而改善台灣各港口之服務品質與提昇各貨櫃港之競爭力。 煩請 您以個人之觀點填寫此問卷, 本問卷只供本研究參考、採隱匿名稱方式撰寫使用且不會對其他第三者公開。 您寶貴之批評、意見對本研究具有極高之價值。 謝謝您對本問卷調查之回覆與支持。

敬頌時棋

　　　英國朴里茅司大學(University of Plymouth)航運管理研究所
　　　聯絡人：莊羲清
　　　聯絡電話：06-9264115 轉 3203 分機
　　　或 行動電話 0929330102　傳真：06-9265760

壹. 問卷解釋:

貨櫃港埠複合運輸系統發展策略之選擇方案

*(一) 請圈選 **1, 2, 3, 4, 5** 以決定發展策略選擇方案之相關重要性.*

貨櫃港埠複合運輸系統發展策略之選擇方案	程度
L. 港埠服務便利性	1 2 3 4 5
M. 港埠行銷積極性	1 2 3 4 5
N. 港埠運籌發展性	1 2 3 4 5

*(二) 請圈選 **1, 2, 3, 4, 5** 以決定港埠服務便利性之發展策略相關重要性.*

港埠服務便利性之發展策略	程度
a. 改善港埠管理之品質	1 2 3 4 5
b. 改善港區人員營運之服務	1 2 3 4 5
c. 改善港區裝卸之效率	1 2 3 4 5
d. 建立船舶靠泊服務系統	1 2 3 4 5
e. 增進靠泊排程之管理	1 2 3 4 5

*(三) 請圈選 **1, 2, 3, 4, 5** 以決定之港埠行銷積極性之發展策略相關重要性.*

港埠行銷積極性之發展策略	Scales
f. 產業化之港埠管理	1 2 3 4 5
g. 建立國家貿易中心	1 2 3 4 5
h. 發展休閒活動特區	1 2 3 4 5
i. 降低港埠費率	1 2 3 4 5
j. 發展觀光活動	1 2 3 4 5

*(四) 請圈選 **1, 2, 3, 4, 5** 以決定之港埠運籌發展性之發展策略相關重要性.*

港埠運籌發展性之發展策略	Scales
k. 簡化關稅管理作業	1 2 3 4 5
l. 標準化轉運作業程序	1 2 3 4 5
m. 改善對外交通聯絡系統	1 2 3 4 5
n. 建立港區作業專業區域	1 2 3 4 5
o. 建立貨櫃檢驗專業區域	1 2 3 4 5

End

貳..基本資料

(以下資料僅供整體分析之用，不做個別探討，敬請安心填答，謝謝！)

(一):
姓　　名：
服務單位：
職　　稱：
性　　別：□男　□女
年　　齡：□25 歲以下　□26~30 歲　□31~35 歲　□36~40 歲
　　　　　□41~45 歲　□46~50 歲　□51~55 歲　□56 歲以上
連絡電話：
傳真　　：

(二):
此部份是個人及企業組織基本資料：

1.貴公司目前員工人數為？

　　□10 人以下 □10-20 人 □20-30 人 □30-50 人 □50-100 人□100 以上

2.貴公司目前資本額？

　　□1000 萬以下 □1000-5000 萬 □5000-1 億 □1 億-10 億 □10 億-50 億
　　□50 億以上

3.請問貴公司成立有幾年？

　　□10 年以內 □11-20 年 □21-30 年 □30 年以上 □其它＿＿＿＿＿

4.請問貴公司近年來的年貨櫃託運裝卸量大約為？(Teus)

　　□100 以下 □101-250 □251-500 □501-1000 □1001-2000□ 2001-3000
　　□3001 以上

6.請問貴公司主要的貨櫃託運航線為何？

　　□歐洲 □美國 □亞洲 □其它＿＿＿＿＿＿＿＿＿＿＿

本問卷填答至此，非常感謝您的配合。

225

Tel: 06-9264115 轉 3203

澎湖縣馬公市六合路 300 號

國立澎湖技術學院

航運管理學系

莊義清 老師

- -

REFERENCES

Aaker, D.A., Kumar, V. and Day, G.S. (2004). *Marketing Research* (8th Edition), John Wiley & Sons, New York, U.S.A.

Aguarón J. and Moreno, J.J.M. (2000). Local stability intervals in the Analytic Hierarchy Process. *European Journal of Operational Research*, 125(1): 113-132.

Alix, Y., Slack, B. and Comtois, C. (1999). Alliance or acquisition?: strategies for growth in the container shipping industry, the case of CP ships. *Journal of Transport Geography*, 7(1): 203-208.

Ambrosini, C. and Routhier, J.L., (2004). Objectives, methods and results of surveys carried out in the field of urban freight transport: an international comparison, *Transport Reviews*, 24 (1): 57-77.

Amit, R. and Schoemaker, P.J.H. (1993). Strategic assets and organizational rent, *Strategic Management Journal.* 14(1): 33-46.

Ashar, A. (1999). The fourth revolution, *Containerisation International*, December: 57-61.

Atthirawong, W. and MacCarthy, B. (2002). An application of the Analytical Hierarchy Process to international location decision-making, *The 7th Annual Cambridge International Manufacturing Symposium*, 12th-13th September 2002, Moller Centre, Churchill College. Retrieved 07/02/2007, From: http://www.ifm.eng.cam.ac.uk/cim/imnet/symposium2002/papers/Atthira wong.pdf.

Bagchi, P.K. (1989). Carrier selection: the Analytic Hierarchy Process. *Logistics and Transportation Review* 25 (1): 63-73.

Baird, A.J. (2001). *Scapa Flow Container Transhipment Terminal: Plans For An Innovative New Container Transhipment Terminal For Northern Europe At Scapa Flow.* Occasional paper No. 12 of scottish transport studies group, Napier University, Edinburgh.

Baird, A.J. (2006). Optimising the container transhipment hub location in northern Europe, *Journal of Transport Geography*, 14(3): 195-214.

Bana, E., Costa,C.A. and Vincke, P. (1990). Readings in multiple criteria decision aid, Bana, E. and Costa, C.A. (eds), *Multiple Criteria Decision Aid: An Overview*, Springer, Berlin, Germany.

Barros, C.P. and Athanassiou, M. (2004). Efficiency in Europe seaports with DEA: evidence from Greece and Portugal. *Maritime Economics and Logistics*, 6: 122-140.

Barton R.F. (1981). An MCDM approach for resolving goal conflict in MBO. *The Academy of Management Review*, 6(2): 231-241.

Bell, D.E., Raifa, H., and Tversky, A. (1988). *Descriptive, Normative, and Prescriptive Interactions in Decision Making*, Cambridge University Press, England, U.K.

Belton, V. and Viclers, S. (1990). Use of a simple Multi-Attribute value function incorporating visual interactive sensitivity analysis for multiple criteria decision making. *Reading in Multiple Criteria Decision Aid*, Bana, E. and C. A. Costa (eds), Springer, Berlin, Germany.

Brooks, M.R. (1992). Issues in North American container port competitiveness. *Journal of the Transportation Research Forum*, 32(2): 333-343.

Brooks, M.R. and Cullinane P.K. (2007). *Devolution, Port Governance and Performance*. Elsevier, London, UK.

Bryson, N. and Mobolurin, A. (1994). An approach to using the analytic hierarchy process for solving multiple criteria decision-making problems. *European Journal of Operational Research* 76: 440-454.

Choo E.U., Schoner B. and Wendley W.C. (1999). Interpretation of criteria weights in multi-criteria decision-making. *Computers and Industrial Engineering*, 37: 527-541.

Choo E.U. Wedley, W.C. (1985). Optimal criterion weights in repetitive multi-criteria decision-making. *The Journal of the operational research society*, 36(11): 983-992.

Colson, G. and De Bruyn, C. (1989). Models and methods in multiple criteria decision making. *Mathematical and Computer Modelling* 12: 1011-1032.

Comtois, C. (1994). The evolution of containerisation in East Asia. *Maritime Policy and Management*, 21(1):195-205.

Containerisation International Yearbook (2001-2008), Emap Business Comminications, Ltd., London, U.K.

Cooper, D. R. and P. S. Schindler (2001). *Business Research Methods*, McGraw-Hill, New York, U.S.A.

Coyle, J., Bardi, J. and Langley, J. (1996). *The Management of Business Logistics*, 6th Edition, West Publishing, St. Paul, MN, USA.

Cronbach, L.J. (1951). Coefficient alpha and the internal structure of tests, *Psychometrika*, 16(3): 297-334.

Cullinane, P.K. and Khanna, M. (2000). Economies of scale in large containerships: Optimal size and geographical implications. *Journal of transport geography*, 8(1): 181 -195.

Davey, A. and Olson, D. (1998). Multiple criteria decision making models in group decision support. *Group decision and negotiations* 7(1): 55-75.

D'Este, G.M. and Meyrick, S. (1992). Carrier selection in a RO/RO ferry trade Part 1: Decision factors and attitudes, *Maritime Policy and Management*, 19 (2): 115-126.

De Langen, P.W. and Pallis, A.A. (2006). Analysis of the benefits of intra-port competition, *International Journal of Transport Economics*, 33(1): 69-85.

Desanctis, G. and Gallupe, B. (1987). A foundation for the study of group decision support systems. *Management Science*, 33(5): 589-609.

Dess, G. and Davis, P. (1984). Generic strategies as determinants of strategic group membership and organisational performance, *Academy of Management Journal*, 27: 46-482.

Dinwoodie, J. and Xu, J. (2008). Case studies in logistics: a review and tentative taxonomy, *International Journal of Logistics Research and Applications*, 11(5):393-408.

Drewry Shipping Consultants. (1997). *World Container Terminals:Global Growth and Private Profit*, Drewry Shipping Consultants, London, U.K.

Dyer, J.S., Fishburn, P.C., Steuer, R E., Wallenius, J. and Zionts, S. (1992). Multiple criteria decision making, multi-attribute utility theory: The next ten years. *Management Science*. 38(5): 645-654

Dyer, R.F. and Forman, E.H. (1992). Group decision support with the analytic hierarchy process. *Decision Support Systems* 8: 199-124.

Fawcett, S.E., Birou, L. and, Taylor, B.C. (1993). Supporting global operations through logistics and purchasing, *International Journal of Physical Distribution & Logistics Management*, 23: 3-11.

European Conference of Ministers of Transport (2001). *Land Access to Seaports*, OECD Publications Service, Paris, France.

229

Escobar M.T. and Moreno-Jiménez J.M. (2002). A linkage between the Analytic Hierarchy Process and the compromise programming models. *Omega*, 30(5): 359-365.

Evans G.W. (1984). An overview of techniques for solving multi-objective mathematical programs. *Management Science*, 30(11): 1268-1282.

Fleming, D.K. (2000). A geographical perspective of the transshipment function, *International Journal of Maritime Economics* 2(3): 163–76.

Fleming, D.K. and Hayuth, Y. (1994). Spatial characteristics of transportation hubs: Centrality and intermediacy. *Journal of Transport Geography*, 2(1): 3-18.

Foggin, J.H. and Dicer, G.N. (1985). Disappearing hinterlands: the impact of the logistics concept on port competition. *Journal of the Transportation Research Forum*, 26(1): 385-391.

Forman, E.H. and Selley, M.A. (2001). *Decision by Objectives*, Retrieved 23/8/2006, From: http://www.expertchoice.com/dbo/chapter4.pdf

Frankel, E.G. (1989) Strategic Planning Applied to Shipping and Ports. *Maritime Policy and Management*, 16(2): 123-132.

French, S. (1986). *Decision Theory An Introduction to the Mathematics of Rationality*, John Wiley & Sons, London, U.K.

Godet, M. (1987). *Scenarios and strategic management*, Butterworths, London, U.K.

Golden, B.L., Wasil, E.A. and Harker, P.T. (eds.) (1989). *The Analytic Hierarchy Process: Applications and Studies*, Springer Verlag, New York, U.S.A.

Gouvernal, E., Debrie, J. and Slack, B. (2005). Dynamics of change in the port system of the Western Mediterranean. *Maritime Policy and Management*, 32(2): 107-121.

Goss, R.O. (1986). Seaports should not be subsidized. *Maritime Policy and Management*, 13(2): 85-104.

Gouliemos, A.M. and Pardali, A.I. (2002). Container ports in the Mediterranean sea: A supply and demand analysis in the age of globalization. *International Journal of Transport Economics*, 29(1): 91-117.

Guy, M. (1991). Spatial interaction modelling in retail planning practice: the need for robust statistical methods, *Environment and Planning B: Planning and Design*, Volume 18(1): 191-203.

Guzzo, R.A. (1982). *Improving Group Decision Making: In Organizations: Approaches From Theory And Research*, Academic Press, New York, U.S.A.

Hall, P. (1980). *Great planning disasters*. University of California Press, Berkeley, CA, U.S.A.

Harker, P.T. (1987). Alternatives modes of questioning in the analytic hierarchy process. *Mathematical Modelling* 9(3-5): 353-60.

Hamel, G. and Prahalad, C.K. (1994). *Competing for the future*, Harvard Business School Press, Boston, MA, U.S.A..

Hastings, P. (1994). Logistics in a bear hug, *Purchasing and Supply Management*, Supplement: 14-15.

Hayuth, Y. (1987). *Intermodality: Concept and Practice*, Lloyd's of London Press, London, U.K.

Hayuth, Y. (1988). Rationalization and deconcentration of the U.S. container port system. *Professional Geographer*, 40(3): 279-288.

Hayuth, Y. (1991). Load centering: Competition and modal integration, *Coastal Management*, 19(3): 297-311.

Hayuth, Y. and Fleming, D.K. (1994), Concepts of strategic commercial location: the case of container ports, *Maritime Policy and Management*, 21(3): 187-193.

Heaver, T.D. (1993). Rail freight service in Canada: restructuring for the North American market. *Journal of Transport Geography*, 1(1): 156-166.

Helling, A. and Poister, T.H. (2000). US maritime ports: trends, policy implications, and research needs. *Economic Development Quarterly*, 14(1): 298-315.

Henig, M. and Katz, H. (1996). R& D project selection: A decision process approach. *Journal of Multi-Criteria Decision Analysis*, 5: 169-177.

Henig, M.I. and Buchanan, J.T. (1996). Solving MCDM problems: process concepts. *Journal of Multi-Criteria Decision Analysis*, 5(1): 3-21.

Hensher, D. and Puckett, S. (2005). Refocusing the modeling of freight distribution: Development of an economic-based framework to evaluate supply chain behaviour in response to congestion charging, *Transportation*, 32(6): 573-602.

Hess, M. and Rodrigue, J.P. (2004). The transport geography of logistics and freight distribution, *Journal of Transport Geography*, 12: 171-184.

Hoare, A.G. (1986). British ports and their export hinterlands: a rapidly changing geography, *Geographiska Annaler,* 68B(1): 29-40.

Holguín-Veras, J. and Thorson, E. (2003). Practical implications of modeling commercial vehicle empty trips, *Transportation Research Record,* 1833: 87-94

Hwang, C.L. and Lin, M.J. (1987). *Group Decision Making Under Multiple Criteria,* Spring-Verlag, Berlin, Germany.

Hwang, C.L. and Yoon, K.P. (1981). *Multiple Attribute Decision Making: Methods and Applications,* Springer-Verlag, Berlin, Germany.

Iz, P.H. and Gardiner, L.R. (1993). Analysis of multiple criteria decision support systems for groups, *Group Decision and Negotiation,* 2(1): 61-79.

Jauernig, C. and Roe, M. (2000). International freight transport in Lithuania. *Transport Reviews,* 20(1): 447-468.

Juang, Y.-C. and Gray, R. (2002). Challenges to Intermodal Ports: a Strategy for Container Ports. *Proceedings of 2002 Annual Conference for the International Association of Maritime Economists,* Panama City, Panama, 13-15 November 2002. (CD-ROM).

Keeney, R.L. and Raiffa, H. (1976). *Decisions with Multiple Objectives: Preferences and Value Tradeoffs,* John Wiley & Sons, New York, U.S.A.

Kerlinger, F.N. (1979), *Behavioural Research: A Conceptual Approach,* Holt, Rinehart and Winston, Inc., New York, U.S.A.

Khorramshahgol R. and Steiner H.M. (1988). Resource analysis in project evaluation: a multi-criteria approach, *Journal of Operation Research Society,* 39 (9): 795-803.

King J. (1997). Comment: globalization of logistics management: present status and prospects. *Maritime Policy and Management,* 24(4): 381-387.

Kite-Powell, H.L. (2001). Marine policy: shipping and ports. In: Steele, J., Thorpe, S. and Turekian, K. (eds)., *Encyclopedia of Ocean Sciences,* Academic Press, London, U.K.

Kuby, M. and Reid, N. (1992). Technological change and the concentration of the U.S. general cargo port system: 1970-88. *Economic Geography,* 68(1): 272-290.

Kumar, S. N. (2001). Container port dilemma on the U.S. east coast: an analysis of causes and consequences. *Proceedings of the 9th World Conference on Transport Research,* Seoul, Korea, 22-27 July 2001.

Lee, T.Z. and Tseng, Y.F. (2006) Explore the Optimal Allocation Problem with AHP/DEA. *Asia Pacific Management Review*,11 (6):389-92.

Levine, J., Park, S., Underwood, S.E., and Wallace, R.R. (1999). Stakeholder preferences in advanced public transportation system planning. *Journal of Public Transportation* , 2(2): 5-45.

Liberatore, M.J. (1989). A decision approach for R&D project selection. In Golden, B.L., Wasil, E.A. and Harker, P.T. (eds.) *The Analytic Hierarchy Process: Applications and Studies*, Springer Verlag, New York, U.S.A.

Limayem, M. and and DeSanctis, G. (2000). Providing decisional guidance for multicriteria decision making in groups. *Information Systems Research*, 11 (4): 386-503.

Lirn, T.C., Thanopoulou, H.A, Beynon, M, and Beresford, A.K.C. (2004). An Application of AHP on Transhipment Port Selection: A Global Perspective. *Maritime Economics and Logistics*, 6(1): 70-91.

Lockett, G., Hetherington,B., Yallup, P., Stratford, M. and Cox, B. (1986). Modelling a research portfolio using AHP: *A Group Decision Process. R&D Management* 16(2): 151-60.

Loetscher, T. and Keller, J. (2002). A decision support system for selecting sanitation systems in developing countries. *Socio-Economic Planning Sciences*, 36(4):267-290.

Loo, B.P.Y. (1999). Development of a regional transport infrastructure: some lessons from the Zhujiang Delta, Guangdong, China. *Journal of Transport Geography*, 7(1): 43-63.

MacCarthy K.J. (1992). Comment on the "Analytic Delphi Method". *International Journal of Production Economics*. 27(2): 135-136.

Malchow, M. and Kanafani, A. (2001). A disaggregate analysis of factors influencing port selection, *Maritime Policy and Management*, 28(3): 265-277.

Marchant, T. (2000). Group decision support systems: a brief review, *INFOR*, 38 (1): 1-13.

Malchow, M. and Kanafani, A. (2001). A disaggregate analysis of factors influencing port selection, *Maritime Policy and Management*, 28(3): 265-277.

Malchow, M. and Kanafani, A. (2004) A disaggregate analysis of port selection, *Transportation Research: Part E*, 40: 317–337.

Marshall, C. and Rossman, G.B. (1999). *Designing Qualitative Research*, 3rd edition, Thousand Oaks, Sage, CA, USA.

Marti, B.E. (1988). The evolution of Pacific basin load centres, *Maritime Policy and Management*, 15(1): 57-66.

McCalla, R.J. (1999). Global change, local pain: intermodal seaport terminals and their service areas. *Journal of Transport Geography*, 7(1): 247-254.

Mentzer, J.T., Stank, T., and Esper, T.L. (2008). Defining SCM and its Relationship to Logistics, Marketing, Manufacturing and Operations Management, *Journal of Business Logistics*. 29 (1): 31-46.

Millet, I. and Harker, P.T. (1990). Globally effective questioning in the Analytic Hierarchy Process. *European Journal of Operational Research*, 48: 88-97.

Muller, G. (1999). Intermodal freight transportation 4th Edition, Eno Transportation Foundation, Inc., Washington D.C, U.S.A.

Nazareth D.L. (1993). Integrating MCDM and DSS: barriers and counter strategies. *INFOR*, 31 (1): 1-15.

Nijkamp, P. and Van Delft, A. (1977). Multi-criteria analysis and regional decision-making, Interprint, Leiden, Netherlands.

Nijkamp, P. and Reichman, S. (1986). *Transportation Planning in a Changing World,* Ashgate Publishing , Aldershot, U.K.

Nijstad, B.A., Stroebe, W. and Lodewijkx, H.F.M. (1999). Persistence of brainstorming groups: how do people know when to stop? *Journal of Experimental Social Psychology*, 35(2): 165–185.

Notteboom, T.E. (1997). Concentration and load centre development in the European container port system. *Journal of Transport Geography*, 5(1): 99-115.

Notteboom, T.E. and Rodrigue, J.P. (2005). Port regionalization: towards a new phase in port, *Maritime Policy and Management*, 32(3): 297-313.

Notteboom, T.E. and Rodrigue, J.P. (2008). Containerization, box logistics and global supply chains: the integration of ports and liner shipping networks, *Maritime Economics and Logistics*, 10(1-2): 152-174.

Ocean Shipping Consultants. (1999). *World container port markets to 2012,* London, U.K.

Ogden, K.-W. (1992). *Urban Goods Movement: A Guide to Policy and Planning,* Ashgate Publishing, Aldershot, U.K.

Oliver, D. (2005). Private entry and emerging partnerships in container terminal operations: evidence from Asia". *Maritime Economics and Logistics*, 7(1): 87-115.

Osman, M.S.S.. (2002). The dynamics of supply chain management in a transhipment hub. *Proceedings of the 2003 Annual Terminal Operations Conference*, Kuala Lumpur, Malaysia, February 19–21.

Ozernoy, V.M. (1992). Choosing the "best" multiple criteria decision-making method. *INFOR*, 30 (2): 159-171.

Perry, C. (1995) *How to Get a PhD*, Retrieved 15/11/2005, From: http://www.mcb.co.uk/imc/news/occpaper/cpindex.html.

Partovi, F.Y. and Hopton, W.E. (1994). The analytic hierarchy process as applied to two types of inventory problems. *Production and Inventory Management Journal*, 35 (1): 13-19.

Perez J. (1995). Some comments on Saaty's AHP. *Management Science*, 41(6): 1091-1095.

Pallis, A.A., De Langen, P.W. and Vistsounis, T.K. (2007). A port research review: themes, approaches, findings and new research questions. *Proceedings of 11th World Conference on Transport Research*, Berkley, CA, USA.

Peters, H.J.F. (2001). Developments in global sea-trade and container shipping markets: their effects on the port industry and private sector involvement, *International Journal of Maritime Economics*, 3(1): 3–26.

Puckett, S.M.; Hensher, D.A., Rose, J. and Collins, A. (2007). Design and development of a stated choice experiment in a two-agent setting: interactions between buyers and sellers of urban freight services, *Transportation*, 34(4): 429-51.

Raju, K.S. and Pillai, C.R.S. (1999). Multicriterion decision making in performance evaluation of an irrigation system. *European Journal of Operational Research*. 112 (3): 479-488

Ra, J.W. (1999). Chainwise paired comparisons. *Decision Sciences*, 30(2): 581-589.

Ramanujam, V. and Saaty, T.L. (1981). Technological choice in the less developed countries: An Analytic Hierarchy Process, *Technological Forecasting and Cultural Change*, 19: 81-98.

Rao, K. and Yong, R.R. (1994). Global supply chains: factors influencing outsourcing of logistics functions, *International Journal of Physical Distribution & Logistics Management*, 24: 11-19

235

Ridolfi, G. (1999). Containerisation in the mediterranean: between global routeways and feeder services. *GeoJournal*, 48(1): 29-34.

Rimmer, P.J. (1998). Ocean liner shipping services: corporate restructuring and port selection/competition. *Asia Pacific Viewpoint*, 39(1): 193-208.

Robinson, R. (1998). Asian hub/feeder nets: the dynamics of restructuring. *Maritime Policy and Management*, 25(1): 21-40.

Robinson, R. (2002). Ports as elements in value-driven chain systems: the new paradigm, *Maritime Policy and Management*, 29(3): 241-255.

Rodnikov, A.N. 1994, Logistics in command and mixed economies, *International Journal of Physical Distribution & Logistics Management*, 24: 4-14.

Roy, B. (1990). Decision Aid and Decision Making. *Readings in Multiple Criteria Decision Aid*, Bana, E. and C. A. Costa (eds), Springer-Verlag, Berlin, Germany.

Runhaar, H. (2002). *Freight transport: at any price? Effects of transport costs on book and newspaper supply chains in the Netherlands.* PhD Thesis, TRAIL Research School/Delft University Press, Delft, The Netherlands.

Saaty, T.L. (1977). A scaling method for priorities in hierarchical sructures. *Journal of Mathematical Psychology* 15(3): 234-8 1.

Saaty, T.L. (1980). *The Analytic Hierarchy Process: Planning, Priority Setting, Resource Allocation*, McGraw-Hill, New York, U.S.A.

Saaty T.L. (1986). Axiomatic foundation of the Analytic Hierarchy Process, *Management Science*, 32(7): 841-855.

Saaty, T.L., (1988). *Decision Making for Leaders*, RWS Publications, Pittsburgh, U.S.A.

Saaty, T.L. (1994). *Fundamental of Decision Making and Priority Theory with the Analytic Hierarchy Process*, RWS Publications, Pittsburgh, U.S.A.

Saaty T.L. (1994). Homogeneity and clustering in AHP ensures the validity of the scale, *European Journal of Operational Research*, 72(3): 598-561.

Saaty, T.L. (1995). *Decision making for leaders. The analytic hierarchy process for decisions in a complex world.* (3rd Edition) RWS Publications, Pittsburgh, U.S.A.

Saaty T.L. (2000). *The Brain- Unravelling the Mystery of How It Works – the Neural Network Process.* RWS Publications, Pittsburgh, U.S.A.

Saaty T.L. (2001). *The Analytic Network Process.* RWS Publications, Pittsburgh, U.S.A.

Saaty T.L. (2003). Decision-making with the AHP: why is the principal eigenvector necessary? *European Journal of Operational Research,* 145(1): 85-91.

Saaty, T.L. and Vargas, L.G. (1991). Prediction, Projection and Forecasting: Applications of the Analytic Hierarchy Process in Economics, Finance, Politics, Games and Sports, Kluwer Academic Publisher, Boston, MA, U.S.A.

Schmidt, R.L. and Freeland, J.R. (1992). Recent progress in modeling R&D project-selection processes, *IEEE Transactions on Engineering Management* 39(2): 189-201.

Saaty T.L. and Ozdemir M.S. (2004). Why the magic number seven plus or minus two? *Mathematical and Computer Modelling,* 38(3-4): 233-244.

Sen, A. and Smith, T. (1995), *Gravity Models of Spatial Interaction Behaviour.* Springer-Verlag, Berlin, Germany.

Sharp, J.A., (1987). Hauler selection: an application of the Analytic Hierarchy Process, *Journal of Operational Research Society,* 38(4): 319-328.

Skibniewski, M.J. (1992). Evaluation of advanced construction technology with AHP method, *Journal of Construction Engineering and Management,* 118(3): 577-593.

Slack, B. (1985). Containerization, inter-port competition, and port selection, *Maritime Policy and Management,* 12(4): 293-303.

Slack, B. (1990). Intermodal transportation in North America and the development of inland load centres, *Professional Geographer,* 42: 72-83.

Slack, B., Comtois, C. and Sletmo, G. (1996). Shipping lines as agents of change in the port industry, *Maritime Policy and Management,* 23(1): 289-300.

Slack, B. and Fremont, A. (2005). Transformation of port terminal operations: from the local to the global, *Transport Reviews,* 25(1):117-130.

Sletmo, G.K. (1999). Port life cycles: policy and strategy in the global economy. *International Journal of Maritime Economics* 1 (1): 11–37.

Song, D.-W. (2003). Port co-opetition in concept and practice. *Maritime Policy and Management*, 30(1): 29-44.

Song, D.-W., Yeo, K.-T. (2004). A competitive analysis of Chinese container ports using the Analytic Hierarchy Process, *Maritime Economics and Logistics*, 6: 34-52.

Stewart, T.J. (1991). A multi-criteria decision support system for R&D project selection. *Journal of Operation Research Society*, 42 (1): 17-26.

Stewart, T.J. (1992). A critical survey on the status of multiple criteria decision making: *Theory and Practice*. Omega 20(5/6): 569-586.

Stewart, T.J. (1995). Models of priority-setting for public sector research. *Research Policy*, 24:115-126.

Stewart, T.J. (1996). Relationships between data envelopment analysis and multicriteria decision analysis. *The Journal of the Operational Research Society*, 47(5): 654-665.

Stewart, T.J. (1997), Future trends in MCDM, Climaco, J. (eds), *Multicriteria Analysis*, Springer, Berlin, Germany.

Sun, S., Hoffman, D. and Newton, C. (1996). *A Bibliography of Analytic Hierarchy Process (1990-1996)*, A Technical Report of School of Computer Science, University College, University of New South Wales, Australian Defence Force Academy.

Tabucanon, T. and Lee. G. (1995). Multiple criteria evaluation of transportation system improvement projects: The case of Korea, *Journal of Transportation Engineering* 29(1): 39-44.

Taiwan High Speed Rail Consortium (2008). *Taiwan High Speed Rail Plan Overview*, http://www.thsrc.com.tw/en/about/plan.asp. Retrieved on 2009/02/13. (In Chinese).

Tan, T.Y. (2007). Port cities and hinterlands: a comparative study of Singapore and Calcutta', *Political Geography* , 26: 851-865

The Institute of Transportation (1999). *The Total Scale and Future Development Design of Kaohsiung Port*, The Institute of Transportation Press, The Ministry of Transportation and Communication of Republic of China, Taipei, Taiwan, R.O.C. (In Chinese).

The Institute of Transportation (2000). *The Analysis of Future Development of Ports in Taiwan*, The Institute of Transportation Press, The Ministry of Transportation and Communication of Republic of China, Taipei, Taiwan, R.O.C. (In Chinese).

The Institute of Transportation (2007). *The Analysis of Transport Information*, The Institute of Transportation Press, The Ministry of Transportation and Communication of Republic of China, Taipei, Taiwan, R.O.C. (In Chinese).

The Ministry of Transportation and Communication (2005), *The Shipping Directory in Taiwan*, 2005 edition. The Ministry of Transportation and Communication of Republic of China, Taipei, Taiwan, R.O.C. (In Chinese).

The Ministry of Transportation and Communication (2007). *The Ministry of Transportation and Communication Annual Report (1991-2007)*, The Institute of Transportation Press, The Ministry of Transportation and Communication of Republic of China, Taipei, Taiwan, R.O.C. (In Chinese).

The Taiwan Railway Administration (2007). *Strategy for Improving the Operations of the Freight Service,* The Taiwan Railway Administration Press, The Ministry of Transportation and Communication, Taipei, Taiwan, R.O.C. (In Chinese).

Tiwary, P., Itoh, H. and Doi, M. (2003), Shippers' port and carrier selection behaviour in China, *A Discrete Choice Analysis, Maritime Economics and Logistics*, 5: 23–39.

Todd, D. (1990). New port developments and balanced regional growth: a Taiwan example. *Geoforum*, 21(1): 421-433.

Triantaphyllou, E. (2000). *Multi-Criteria decision making method: A Comparative Study*, Kluwer Academic Publishers, Netherlands.

Triantaphyllou E. and Lin C.-T. (1996). Development and evaluation of five fuzzy multiattribute decision-making methods. *International Journal of Approximate Reasoning* . 14(4): 281-310.

Trochim B. (2002). *Research Methods Tutorials - Research Design & Internal Validity*. Retrieved 15/11/2007, From: http://trochim.human.cornell.edu/kb/design.htm.

United Nation Economic Commission for Europe (2009). *Glossary of Transport Statistics, 4th Edition, UNECE* Publications Service, Geneva, Switzerland.

van Klink, H.A. and van der Berg, G.C. (1998). Gateways and intermodalism. *Journal of Transport Geography*, 6(1): 1-9.

Vargas, L.G. (1990). An overview of the analytic hierarchy process and its applications. *European Journal of Operational Research* 48(1): 2-8.

239

Wang, J.J. (1998). A container load centre with a developing hinterland: a case study of Hong Kong. *Journal of Transport Geography*, 6(1): 187-201.

Watanabe, Y. and Hirohito, K. (1988). A study on the inland flow of containerized cargoes, *Infrastructure Planning*, 11:11-20.

Wedley W.C., 1990. Combining qualitative and quantitative factors-an Analytic Hierarchy Approach, *Socio-Economic Planning Sciences*, 24(1): 57-64.

Weigend, G.G. (1958). Some elements in the study of port geography. *Geographical Review*, 48: 185-200.

Wernerfelt, B. (1984). A resource-based view of the firm, *Strategic Management Journal*, 5(2): 171-180.

Wijnolst, N., Waals, F., Bello, F., Gendronneau,Y. and Van Kempen, D. (2000). *Malacca-Max II: Container Shipping Network Economy*, Delft University Press, Delft, Netherlands.

Woodburn, A.G. (2001). The changing nature of rail freight in Great Britain: the start of a renaissance? *Transport Reviews*, 21(1): 1-13.

Woolley, J. and Tripp, R. (1994). Priority Setting Tools for Research Groups, Meindertsma, J. D. (eds.) *Setting Research Priorities: Towards Effective Farmer-Oriented Research*, *Royal Tropical Institute*, Amsterdam, Netherlands.

World Bank. (2002). *The Evolution of Ports in a Competitive World*. Washington, D.C. U.S.A.

World Cargo News (2004). *Taiwan to upgrade five ports.* Retrieved 24/01/2006,
From: http://www.worldcargonews.com/htm/n20041126.198422.htm

Yeo, G-T, Roe, M.S. and Dinwoodie, J. (2008). Evaluating the Competitiveness of Container Ports in Korea and China, *Transportation Research Part A: Policy and Practice*, 42 (1):910-921.

Yin, R.K. (1994), *Case Study Research: Design and Methods*, 2nd ed., Sage Publications, Thousand Oaks, CA. U.S.A.

Zahedi, F. (1986). The Analytic Hierarchy Process - a survey of the method and its applications. *Interfaces*, 16(4): 96-108.

Zanakis, S., Mandakovic, T., Gupta, S., Sahay, S. and Hong, S. (1995). A review of program evaluation and fund allocation methods within the service and government sectors, *Socio-Economic Planning Sciences*, 29(1): 59-79.

Zeleny, M. (1982). *Multiple Criteria Decision Making.* McGraw-Hill, London, U.K. .

Zietsman, J., Rilett, L.R. and Kim, S.-J. (2006), Transportation corridor decision-making with multi-attribute utility theory. *International Journal of Management and Decision Making,* 7(2): 254–266.

Zophil, J. and Prijon, M., (1999). The MED Rule: The interdependence of container throughput and transhipment volumes in the mediterranean ports. *Maritime Policy and Management,* 26(2): 175-193.