2007

Port competitiveness in North East Asia : an integrated fuzzy approach to expert evaluations

Yeo, Gi-Tae

PORT COMPETITIVENESS IN NORTH EAST ASIA: AN INTEGRATED FUZZY APPROACH TO EXPERT EVALUATIONS

by

GI-TAE YEO

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

DOCTOR OF PHILOSOPHY

International Shipping and Logistics Group
Plymouth Business School

2007

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.....

Gi-Tae Yeo

The author

Abstract

GI-TAE YEO

PORT COMPETITIVENESS IN NORTH EAST ASIA:
AN INTEGRATED FUZZY APPROACH TO EXPERT EVALUATIONS

Despite the fact that the Northeast Asia (NEA) region, which had four of the top five and 20 of the top 30 container ports in the world in 2003, can be regarded as holding a central position in liner shipping and the handling of container cargo volumes, very little research has been done into the evaluation of its port competitiveness (EPC). For this reason, the EPC in NEA can be regarded as a problematic and urgent issue to be solved, and worthy of academic attention.

From this aspect, this research set out to attempt to address the above issue by means of utilizing expert knowledge. However, the EPC contains problems of complex multiple-attributes and multiple-hierarchies (CMAMH). In addition, difficulties concerning certain characteristics of evaluation such as complexity, uncertainty and ambiguity are also involved. To deal with such problems, in this research, the employment of integrated fuzzy evaluation (IFE) as a methodology was decided upon.

As a result of the adaptation of the methodology, certain indications from this research to the theory and practice for container ports have emerged and are clearly identifiable. With regard to theory, this study has contributed to theoretical development significantly in four ways. First, the factors and taxonomy of port competitiveness for the container ports in NEA have been provided for the first time. Second, this is the first integrated approach for the EPC in NEA, the most competitive area in the world. Third, this research was also the first to attempt extracting critical weak points and/or influential factors affecting current port competitiveness. Finally, the adoption of IFE made it possible for the first time to uncover the interactive relationships between the competing container ports.

In terms of practice, this research has also provided certain contributions of utmost importance. First of all, the study has provided a suggestion for the most recent port ranking in respect of port competitiveness. Moreover, changes in competitiveness power, which are dynamically and interactively affected by the relationship between the ports, have been successfully estimated and suggested. Thus, such changes in the competitiveness in NEA can now be easily forecasted by port actors.

List of Contents

Contents

List of Tables

List of Figures

Acknowledgements

I would like to thank all the various people involved in the preparation of this thesis for their assistance, dedication and help. First, and foremost, I wish to express my sincerest gratitude and appreciation to Professor Michael Roe, Chair, International Shipping and Logistics Policy and Director of Studies, for his continuous encouragement, careful guidance and invaluable suggestions. My heartfelt thanks and gratefulness also go to Dr. John Dinwoodie, Principal Lecturer, and Dr Irma Pasukeviciute, acting as my second and third supervisors, for their helpful criticism and active support, without which this thesis would not have succeeded. I also express my thankfulness to all of the academic staff in the International Shipping and Logistics Group at University of Plymouth for their kind advice and friendly support. Especially Dr. Tengfei Wang and Dr. Dongping Song, with their valuable opinions, were extremely helpful in the process of making the initial pilot survey.

My deepest appreciation goes to Dr. Dong-Wook Song and Dr. Ki-Soon Hwang for their support and giving me the motivation to start my second PhD. In this respect, Professor Cheol-Yeong Lee, who acted as the supervisor for my first PhD in South Korea, Korea Maritime University, also deserves my thanks for his endless encouragement. In addition, I extend my appreciation to Professor Seong-Hyeok Moon, Dr. Dong-Keun Yoo and Dr. Sang-youl Kim for their helpful comments on studying in the United Kingdom.

I am also grateful to the following friends in Plymouth, with whom I shared enjoyable times, did exercise together and sometimes discussed the studies: Kimmo Kosunen, Ravi Shankar Saxena, Kelvin Pang, Daba Chowdhury and the Korean students at Plymouth University, Soon-Jeong Lee, Jai-Sung Choi, Seuk Kwon and Dong-Ho Jang. Furthermore, I received valuable information regarding settling down in the U.K. from Dr Hong-Seung Rho and Dr Yong-Jun Jang, who deserve my thanks.

I wish to extend the expression of my appreciation and gratitude to cover my parents and parents-in-law as well as my brothers and brothers-in-law for their continuous support and encouragement.

Last but not the least, my deepest thanks straight from the heart go to my beloved wife Hyun-Sook and my sons In-Ho and In-Hyeok for their love, understanding, inspiration and patience.

Author's Declaration

At no time during the registration for the degree of Doctor of Philosophy has the author been registered for any other University award.

Relevant seminars and conferences were regularly attended at which some work was presented; papers were published and submitted for possible publications. Moreover, acting as ad hoc reviewer of international journals was performed.

Published refereed conference paper

Yeo, G., Roe, M. and Dinwoodie, J. (2006) Quantification of experts' knowledge for port competitiveness using trapezoid fuzzy number, *Proceeding of the 4th International Gwangyang Port Forum and International Conference of Journal of Shipping and Logistics*, Kwangyang, South Korea, pp. 665-682,

Submitted refereed paper

- A paper submitted at *Transportation Research Part A: Policy and Practice,* titled 'Evaluating the Competitiveness of Container Ports in Korea and China'.

- A paper submitted at *European Journal of Operational Research*, titled 'The determination of compromise weights in an MDMG problem studying the competitiveness of container ports'.

Acting as ad hoc reviewer of international journals

- *Transportation Research Part E: Logistics and Transportation Review*
- *International Journal of Logistics: Research and Application*

Word count of main body of thesis: 60,628

Signed.....

Date.....14th February 2007.....

Glossary of Symbols and Abbreviations

AHP	Analytic Hierarchy Process
CMAMH	Complex Multiple-Attributes and Multiple-Hierarchies
DEA	Data Envelope Analysis
DS theory	Dempster-Shafer theory
EDI	Electronic Data Interchange
FA	Factor Analysis
FDI	Foreign Direct Investment
FF	Freight Forwarder
FFT	Foreign Flag as a % of Total
FI	Fuzzy Integral
FMCDM	Fuzzy Multiple Criteria Decision Making
FSM	Fuzzy Structural Modelling
FTZ	Free Trade Zone
$g(\cdot)$	Fuzzy measure
GIS	Geographic Information System
GO	Government
GTOs	Global Terminal Operators
HFI	Hierarchical Fuzzy Integrals
HFP	Hierarchical Fuzzy Process
$h(\cdot)$	Fuzzy evaluation value
h^l	Sub-solutions
h^m	Super-solutions
$I(\cdot)$	Fuzzy integral values
IFE	Integrated Fuzzy Evaluation

IRFE	Inverse Relation of Fuzzy Evaluation
ISM	Interpretive Structural Modelling
IT/IS	Information Technology and Information System
JIT	Just-In-Time
LM	Logit Model
MADM	Multiple Attribute Decision Making
MCDM	Multiple Criteria Decision Making
MDMG	Multiple Decision Making Group problems
MOC	China's Ministry of Communications
NEA	North East Asia
NF	National Flag
NIEs	Newly Industrialized Economies
ODCY	Off-Dock Container Yards
PA	Port Authority
PCA	Principal Components Analysis
Port-MIS	Port Management Information System
RI	Regional Institute
SC	Shipping Company
SEA	South East Asia
SFM	Stochastic Frontier Model
STEP	The State Economy and Trade Department
TEUs	Twenty Equivalent Units
TO	Terminal Operator
TQM	Total Quality Management
TWT	Total as a % of World Total
ULCS	Ultra Large Container Ship
UN	University

VTS	Vessel Traffic System
$w(\cdot)$	Importance weights of port competitiveness factors
x_1	Port service
x_2	Hinterland condition
x_3	Availability
x_4	Convenience
x_5	Logistics cost
x_6	Regional centre
x_7	Connectivity
YRD	Yangtze River Delta
λ_{ij}	Degree of overlap between port competitiveness factors

CHAPTER 1

Introduction

The main objective of this chapter is to outline the research objectives and introduce the background to the research. Furthermore, besides addressing the problems connected with researching container port competitiveness in Northeast Asia (NEA), which is the main objective of this research, this chapter also briefly justifies the choice of research methodology. Finally, to guide the reader through the whole thesis, a simplified explanation for each chapter will be provided.

1.1 Research Background

The NEA consists of China, Japan, Mongolia, North Korea, the Russian Federation, and South Korea, amongst which the most rapidly growing markets are found in China and South Korea. These two nations together with Japan have a notable 33.51% share of total world ship deadweight tonnage and 20.6% of total world trade. Thus the NEA region can be regarded as having a central position in liner shipping and the handling of container cargo volumes. Recently, moreover, as a consequence of China's booming economy and the increased import and export container cargo volumes in the area, four of the top five, and 20 of the top 30 container ports, were located in NEA in 2003 (Hoffmann, 2004; UNCTAD, 2004). Due to this, competition amongst ports and competitiveness in NEA have become hot issues to every stakeholder e.g. shipping companies, freight forwarders, logistics companies, terminal operators, port authorities, researchers and academics.

Regarding the definition of port competitiveness, Haezendonck and Notteboom (2002, p. 68) insisted that the competitiveness of a port is not only partly determined by its internal

strengths and weaknesses but also depends on external co-ordination and control. In addition, Fleming and Baird (1999), Kent and Ashar (2001) and Tongzon and Heng (2005) also revealed various factors related to port competitiveness, which can be summarized into six categories i.e. port competition, port efficiency, port performance, port selection, port service and other related issues.

However, only limited studies have been conducted on this theme in this region while abundant studies have been made in the regions of Europe and the USA. Moreover, with regard to port competition and competitiveness, no exact definition can be found. In particular, very little research has been done into the evaluation of port competitiveness. For all these reasons, the evaluation of port competitiveness in NEA can be regarded as problematic, an urgent issue to be solved, and worthy of academic attention.

Even though the results of evaluation of port competitiveness can give meaningful information to every stakeholder in ports, such evaluation has been identified as a complicated problem, where a number of alternatives and actions or stakeholders need to be chosen based on a given set of criteria and hierarchies (Aouam T. *et al.*, 2003). Moreover, when evaluation is dependant on confidentiality and corporate business secrets, obtaining secondary data is impossible. In addition to these obstacles, further difficulties exist in measuring uncertainty and ambiguity in evaluation and quantifying experts' opinions, which include subjective and qualitative dimensions (Chen *et al.*, 2006). To deal with such dynamic and complicated problems as the evaluation of port competitiveness, an evaluation method which can overcome the shortcomings experienced when using the existing quantitative methodologies will be needed so that the exact rankings of port competitiveness can be calculated.

Furthermore, any evaluation which only calculates rankings of container ports cannot be used to suggest critical weak points and/or influential factors affecting current port competitiveness. Therefore, an introduction to the calculation procedures for these factors will be required, as, when these factors are employed, interactive relationships between competing container ports can be drawn out.

With this background in mind, in this research, the integrated fuzzy approach is to be adopted as a methodology, which will be discussed in more detail in Chapter 5, and also a comparative study for targeted ports in NEA will be carried out.

1.2 Research Objectives

The main objective of the research is to evaluate the container port competitiveness in the NEA using experts' knowledge within the boundaries of the integrated fuzzy approach. Under the main research objectives, the specific objectives are divided into five aims as follows:

- First, to discover key factors and structures influencing container port competitiveness.
- Second, to analyze the values of each factor in each port using linguistic expressions and experts' judgement within a mathematical framework, the so-called fuzzy number method.
- Third, to investigate the competitive power of each targeted port in terms of their rankings from the perspective of port stakeholders.
- Fourth, to find out influential factors and simulate their effect on competitive power.
- Finally, to find out any interactive relationships and also to suggest optimal port strategies for the targeted ports.

1.3 Research Methodology

The evaluation of port competitiveness can be regarded as a problem incorporating problems of complex multiple-attributes and multiple-hierarchies (CMAMH). In addition, it also has difficulties concerning certain characteristics of evaluation such as complexity, uncertainty and ambiguity. To deal with such problems, the employment of the integrated fuzzy evaluation (IFE) as a methodology was decided upon. It can be divided into two stages, the first of which, the direct fuzzy evaluation, so-called multi decision making group-hierarchical fuzzy process (MDMG-HFP), has been adapted to obtain rankings of port competitiveness. For this application, importance weights of port competitiveness factors, $w(\cdot)$, the degree of overlap among port competitiveness factors, λ ,and scoring rating of factors for each targeted port, $h(\cdot)$, will be calculated in Chapter 6.

The second, an inverse relation of fuzzy evaluation (IRFE) will be used for analysing dynamic interaction among the targeted ports, and can also be divided into two parts: selecting influential factors using the $\underline{\beta}$ operation, and a scenario analysis using influential factors and the fuzzy integral. The first and the second one are dealt with in Chapters 7 and 8 respectively.

1.4 Structure of the thesis

The research consists of nine chapters. A brief illustration of each chapter is provided in Figure 1.1 below. After the introduction, the changes in shipping and container ports are explained in Chapter 2, and, in particular, the growing container ports in Northeast Asia will be dealt with, including the topics of rapid changes in sea ports and forecasting for container ports. Furthermore, port competition in NEA will be investigated. Finally, on the basis of the reviews, any problematic issues that may arise will be dealt with, and the direction for future research is also discussed in this chapter.

In Chapter 3, key factors influencing container port competitiveness will be drawn out through thorough reviews of port competitiveness. This chapter comprises six categories i.e. port competition, port efficiency, port performance, port selection, port service and other related issues. Fuller reviews are provided through the entire chapter detailing the characteristics of each category.

Chapter 4 mainly focuses on and investigates the main difficulties in dealing with the key factors drawn from Chapter 3. When investigating port competitiveness, many factors of evaluation have qualitative characteristics. Furthermore, when they are associated with confidentiality and corporate business secrets, obtaining secondary data is impossible. To overcome these obstacles, this chapter suggests a new conceptual model for the evaluation of port competitiveness using the following steps: to review previous studies, which used proxies instead of evaluation factors; to analyse the obstacles occurring when measuring fuzziness data; to deal with the methodological limitations in previous studies for solving the problems in evaluating port competitiveness.

In Chapter 5, an exploratory methodology is designed and suggested to solve the complicated problems associated with port competitiveness. It contains the justification and development process of using fuzzy evaluation, the operational definitions, a detailed data collection method, and an overall explanation of the calculation part.

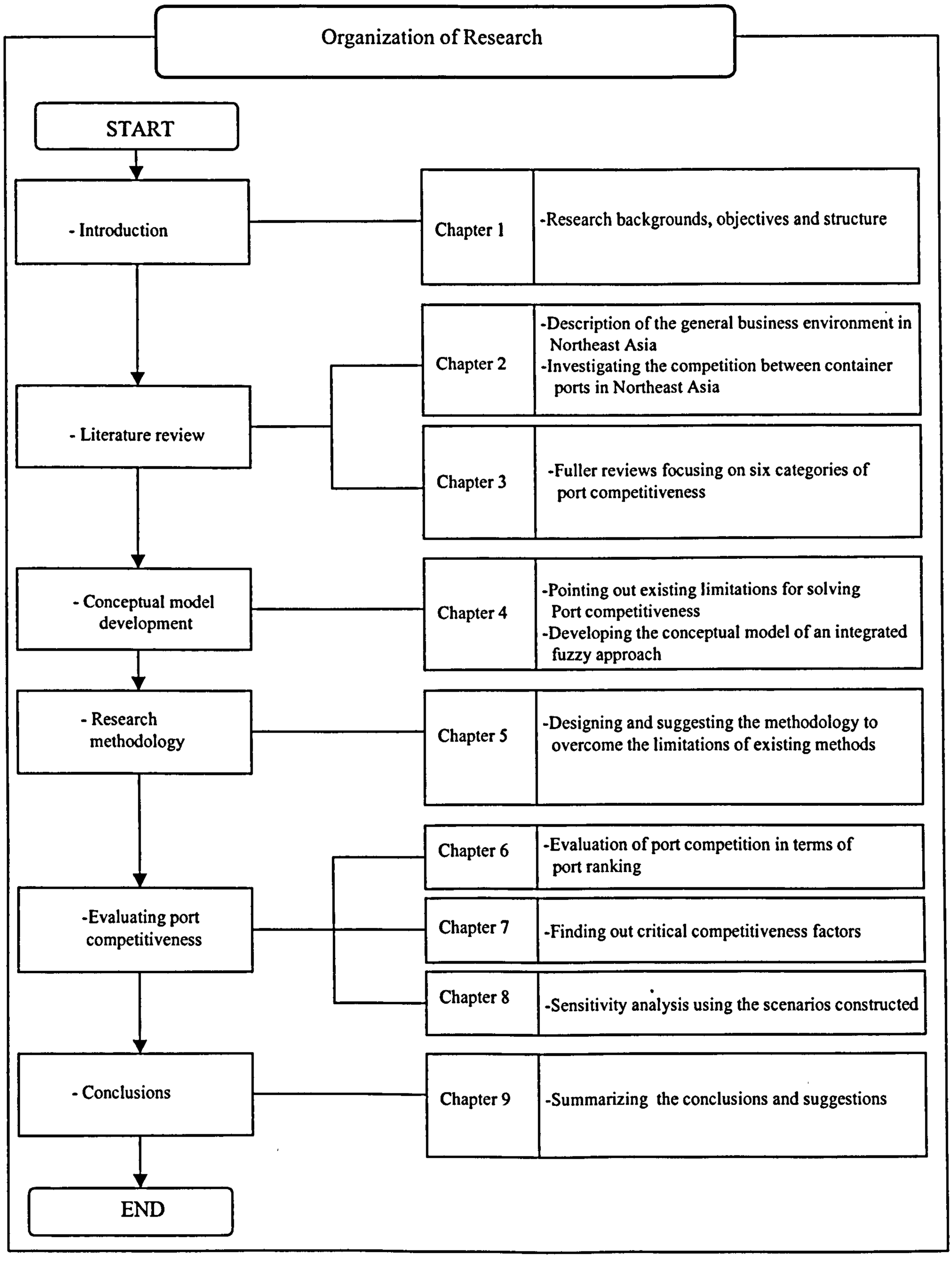
Chapter 6 critically investigates the evaluation of rankings in terms of competitiveness for the targeted ports, and can be divided into three stages. First, detailed explanations for the port selection method for the analysis, questionnaire development, the pilot survey,

comments from respondents, the sample selection and the respondent profiles are identified. Second, the specific calculation processes for analysing port competitiveness i.e. fuzzy evaluation value, overlap degree, fuzzy measure value and fuzzy integral are to be described. Third, insights and implications of the results arising from the use of the model will be provided.

Chapter 7 aims to present critical points (influential factors) that affect port competitiveness using the inverse relation of fuzzy evaluation (IRFE). For the selection of non-influential factors and the influential factors, $\underline{\alpha}$ operation and $\underline{\beta}$ operation of IRFE have been adapted. After the selection, overall implications for each targeted port will be given.

Chapter 8 deals mainly with sensitivity analysis using the influential factors suggested in Chapter 7 for finding the changes in port competitiveness. Using constructed scenarios based on the relations and interactions among the targeted ports, a sensitivity analysis will be made. Finally, overall implications and insights will be offered.

Figure 1.1 Framework of research



CHAPTER 2

Business Environment of Container Ports in Northeast Asia

Recently, there have been rapid changes in the business environment of container ports in NEA which have resulted in severe port competition for securing calls made by shipping lines, increased transhipment throughput, and the extension of hinterland domination. In particular, as a consequence of China's booming economy and increased import and export container cargo volumes in the area, six ports have been ranked in the world top ten list and new emerging ports are rapidly expanding (UNCTAD, 2004).

This chapter aims to describe the general business environment in the area, investigate the competition between container ports and identify the problems and issues for solving the problems arising from this competition.

The chapter consists of four sections. In the first section, the changes in shipping and container ports are explained. The second section deals with the growing container ports in NEA, and includes the topics of rapid changes at sea ports and forecasting for container ports. The third section investigates port competition in NEA, including South Korea, China, Taiwan and Japan and discusses the strategic positions of container ports in each nation concerned, the level of competition among the ports, and the strategies each nation has adopted. On the basis of the above, the fourth section will attempt to extract the any problematic issues that may arise and the direction for future research. The whole chapter is summarised in the final section.

2.1 Changes in Shipping and Container Ports

2.1.1 Increasing container cargo volume

World trade and the global economy have been transformed due to the globalization of business, trade relationships and the revolution in communication (Ha, 2003). Consequently, international trade has closely affected port throughput, operations, concentration and increased container cargo volumes. Regarding NEA, Hong Kong, South Korea and Taiwan have adopted export-oriented strategies and have achieved economic expansion. Furthermore, due to China's effect on these regions, they are exhibiting strong container-handling performance. During the past two decades, container throughput of the top ten ports in East Asia has grown by an annual average of 20%, compared with world container volume increases of 9% (Yap and Lam, 2006).

2.1.1.1 Estimated container handling volumes

Between 1970-2000, the container handling volumes in container terminals all over the world increased over 37 times. In 2002, the throughput of containers reached 266 million TEUs, including transhipment and empty container handling. Within this throughput, East Asia's share of global market has grown dramatically i.e. from 37.6% in 1990 to 43.5% in 1995 and 46.4% in 2002 (Ocean Shipping Consultants, 2003). On the other hand, the shares of ports in the Americas and Europe had fallen to 19.6% and 23.3% in 2002 respectively.

Table 2.1 World container port throughput by each region

	1990	1995	1996	1997	1998	1999	2000	2001	2002
Million TEUs									
East Asia	32.27	62.66	68.38	75.46	80.65	92.02	105.85	110.99	123.31
Americas	21.57	32.06	33.63	38.10	42.03	44.34	48.57	49.61	52.22
Europe/ Mediterranean	23.14	34.12	37.71	42.70	47.20	50.49	55.47	57.39	62.11
Total	**85.93**	**144.04**	**156.43**	**174.60**	**189.62**	**208.59**	**233.66**	**243.59**	**266.00**
Percent share									
East Asia	37.6	43.5	43.7	43.2	42.5	44.1	45.3	45.6	46.4
Americas	25.1	22.3	21.5	21.8	22.2	21.3	20.8	20.4	19.6
Europe/ Mediterranean	26.9	23.7	24.1	24.5	24.9	24.2	23.7	23.6	23.3
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Source: Ocean Shipping Consultants (2003), *World Containerport Outlook to 2015*.

Four of the top five and 20 of the top 30 container ports were located in Asia in 2003. That year, Shanghai and Shenzhen overtook Busan and, three ports from China, including Hong Kong, entered the group of top five ports (Hoffmann, 2004). This means that the NEA region has a central position in liner shipping and container handling container cargo volumes.

Table 2.2 Container port throughput in major ports

(Units: 10 thousand TEUs)

Ranking	Ports	1999	2000	2001	2002	2003	Rate of increase (%)	Nationality
1	Hongkong	1,621	1,780	1,782	1,914	2,010	4.40	China
2	Singapore	1,594	1,704	1,557	1,694	1,810	2.57	Singapore
3	Shanghai	421	561	633	862	1,128	21.79	China
4	Shenzhen	361	399	504	761	1,061	24.06	China
5	Busan	643	754	807	945	1,036	10.01	Korea
6	Kaohsiung	634	742	754	849	884	6.87	Taiwan
7	Los Angeles	382	487	518	610	718	13.45	USA
8	Rotterdam	634	630	609	651	710	2.29	Netherlands

Source: Containerisation International Yearbook (various years)

According to an analysis by Ocean Shipping Consultants (2003), 'depending on the economic scenarios', the total world container throughput will increase by 74~92% and

reach 423~468 million TEUs by 2010. Furthemore, in 2015, the estimated throughput will be 527~620 million TEUs. Of these throughputs, East Asia's share is expected to be 48%, the thoughputs amounting to 205~226 million TEUs in 2010.

Table 2.3 Forecasting of container throughput through economic scenarios

(Units: million TEUs)

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2015
Case 1											
World total	243.6	266.0	287.0	310.1	334.3	358.5	384.1	410.9	438.8	467.9	620.0
East Asia	111.0	123.3	134.2	146.2	158.5	171.0	183.9	197.5	211.3	225.5	294.8
ENE	74.5	83.8	91.2	98.9	106.7	114.7	122.8	131.1	139.2	147.1	184.7
ESE	36.6	39.6	43.0	47.2	51.8	56.3	61.1	66.4	72.2	78.4	110.2
Case 2											
World total	243.6	266.0	286.9	305.4	324.5	345.8	362.1	382.0	402.3	423.1	527.1
East Asia	111.0	123.3	134.2	143.9	153.8	166.2	173.6	184.1	194.5	205.0	254.8
ENE	74.5	83.8	91.2	97.6	104.1	113.1	117.0	123.6	129.9	136.0	164.6
ESE	36.6	39.6	43.0	46.3	49.7	53.1	56.7	60.5	64.6	69.0	90.2

Source: Ocean Shipping Consultants (2003), *World Containerport Outlook to 2015*.
Note: ENE; Entire North East Asia, ESE; Entire South East Asia

2.1.1.2 Transhipment cargo volume

ESCAP (1999) has estimated that the world transhipment container throughput will be 64 million TEUs in 2010 and after that, the total transhipment volume will be increased through the use of large container vessels and the 'hub and spoke' strategies utilised in liner shipping. However, Ocean Shipping Consultants (2003) noted that world container transhipment throughput more than doubled between 1995 and 2001 and reached 54.61 million TEUs, which was 22 % of the total world container throughput that year. Of this, 57.8 % was handled in East Asia.

Table 2.4 Transhipment container port throughput by each region

(Units: million TEUs)

	1995	1996	1997	1998	1999	2000	2001
World total	26.50	29.67	33.83	37.84	44.56	51.26	54.61
East Asia	16.74	18.04	19.62	21.05	25.68	29.75	31.59
ENE	7.12	7.41	7.91	8.90	11.79	14.23	15.10
ESE	9.63	10.64	11.71	12.16	13.89	15.52	16.50

Source: Ocean Shipping Consultants (2003), *World Containerport Outlook to 2015*.
Note: ENEA; Entire North East Asia, ESEA; Entire South East Asia

Regarding the total world container transhipment throughput, Ocean Shipping Consultants (2003) suggested that such throughput will increase by 89~111% and reach 103~115 million TEUs in 2010. Furthermore, in 2015, the estimated throughput will be 130~155 million TEUs. East Asia's share of these throughputs will be 60% and they are expected to be in the region of 78~92 million TEUs in 2015.

Table 2.5 Forecasting of transhipment container throughput

(Units: million TEUs)

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2015
Case 1											
World total	54.6	61.3	66.9	73.1	79.7	86.1	92.8	100.0	107.6	115.5	154.6
East Asia	31.6	35.7	39.2	43.0	47.0	50.9	55.1	59.5	64.1	68.9	91.8
ENE	15.1	17.6	19.3	21.1	22.9	24.6	26.7	28.6	30.6	32.5	41.4
ESE	16.5	18.1	19.9	21.9	24.1	26.2	28.4	30.9	33.6	36.5	50.3
Case 2											
World total	54.6	61.3	66.9	71.8	76.9	81.8	86.8	92.1	97.5	103.2	129.7
East Asia	31.6	35.7	39.2	42.2	45.4	48.4	51.6	55.0	58.4	61.9	77.8
ENE	15.1	17.6	19.3	20.8	22.3	23.8	25.3	26.9	28.4	29.8	36.6
ESE	16.5	18.1	19.9	21.5	23.1	24.7	26.3	28.1	20.0	32.1	41.3

Source: Ocean Shipping Consultants (2003), *World Containerport Outlook to 2015.*

2.1.2 Changes in shipping companies

2.1.2.1 Emergence of large container ships

The major liner shipping companies operate large container ships due to the benefit that can be reaped from the economies of scale achieved and the possible reduction in the cost per TEU (Ocean Shipping Consultants, 2005b). The number of world container vessels stood at 3,148 and the total capacity was 6,345 thousand TEUs in 2003. Among these, 272 vessels were of over 4,000 TEUs, i.e. 24.8% of the total capacity.

Imai (2006) has noted that a number of ships with capacity over 7,000 TEUs have been operating in the major shpping routes and, furthermore, many port stakeholders forecast the emergence of ships with over 10,000TEU capacity, called Mega-ships. Lloyd's Register has also investigated the possibility of a 12,500TEU ship, known as an Ultra

Large Container Ship (ULCS). Liner shipping companies are already operating 9,000 TEU-plus ships, and, recently, Cosco has ordered 16 vessels with capacities from 8,400 to 10,000 TEUs (Journal of Commerce, 2005).

The development and enlargement of containerships started from that of the 1st generation of container ships, carried out with modified tankers or dry cargo vessels in the mid 1960s (Willmington, 2002). Then, 2nd generation ships with cellular structures for containers were developed (Wang and Foinikis, 2001). In the late 1970s, the 3rd generation ships (so called Panamax) arrived at 3000 TEU capacity. After that, their size has increased offering more flexibility. They are termed Super Post Panamax.

Table 2.6 Container ship generations

Generation		1st	2nd	3rd	4th	5th	6th	7th	8th
Starting point		Late 1960s	1970	Late 1970s – early 1980s	Late 1980s	Early 1990s	Late 1990s	Late 1990s	Early 2000s
Capacity (TEU)		700 ~ 1,500	1,800 ~ 2,300	2,000 ~ 2,500	2,500 ~ 4,400	4,300 ~ 5,400	6,000 ~ 6,670	7,000 ~ 8,700	10,000 ~ 13,000
*	Liner shipping	NYK	MOL	Safmarine	APL	Hapag-Lloyd	Maersk	Maersk	-
	Year of built	1968	1973	1979	1988	1991	1996	1997	(2007)
	Name of ship	Hakone maru	New jersey	S.A. Waterpark	Levenkusen E.	P. Truman	Regina M.	Souverin M.	-
**	Maximum Capacity (TEU)	752	1,887	2,464	4,340	4,626	6,418	6,600	(13,000)
	Length; LBP(m)	187.0	263.3	247.4	260.8	281.6	302.3	331.5	(365.0)
	Length; LOS (m)	200.0	280.0	258.5	275.2	294.0	318.2	247.0	(380.0)
	Breadth (m)	26.0	32.2	32.2	39.4	32.25	42.8	42.8	(55.0)
	Depth (m)	15.5	19.6	24.1	23.6	21.4	24.1	24.1	(30.0)
	Draft(m)	10.5	11.5	13.2	12.5	13.5	14.0	14.5	(15.0)
	GT	16,240	37,799	52,615	50,206	53,800	81,488	91,560	(150,000)
***	Horse power	27,800	69,600	34,840	59,960	49,640	74,640	74,555	(140,000)
	Speed (Knots)	22.6	26.0	19.5	24.2	24.5	25.0	26.4	-
	Screw shaft	1	1	1	1	1	1	1	(2)

Source: Park, T-W. and Jeong, B-M. (2002), *Analysis of economic effects of large container vessel*, Korea Maritime Institute, Seoul.

Note: *; Representative ships, **; Specifications of ships; ***; Details of engine

Regarding new container ship building, it should also be noted that there was a continuous increase in ship size between 1970 and 1980. However, due to the demand for small and medium size ships for feeder routes internally within Asia in 1990, the trend towards enlargement eased. After 2000, in the context of economies of scale, the size of new building container ships has been increasing.

Table 2.7 Trend of increasing containership size

Year	Number of vessels	Average ship size (TEU)	Maximum ship size (TEU)	World container ship capacity (Thousand TEUs)
1968	76	450	1,404	56
1970	120	655	1,852	79
1975	325	1,093	3,201	355
1980	634	1,159	3,201	735
1985	809	1,374	4,354	1,111
1990	952	1,604	4,354	1,527
1991	970	1,695	4,639	1,645
1992	1,028	1,763	4,651	1,812
1993	1,384	1,615	4,651	2,235
1994	1,534	1,630	4,800	2,500
1995	1,710	1,651	4,950	2,823
1996	1,886	1,693	6,000	3,224
1997	2,118	1,728	6,600	3,721
1998	2,328	1,761	6,690	4,181
1999	2,441	1,773	6,690	4,409
2000	2,588	1,834	6,690	4,829
2001	2,743	1,947	7,500	5,109
2002	2,788	1,988	7,500	5,504

Source: Containerisation International Yearbook (2003)

2.1.2.2 Speed of containership

It is noted that the increased speed of ships and delivery creates a better quality service which can attract more cargos and shippers. In the mid 1980s, the speed of the majority of container ships was within 20 knots. However, this increased to over 25 knots and 5,000-6,000 TEU capacity by 1990 and to 26 knots and 7,000-8,000 TEUs by 2000.

Increasing containership speed means that shipping companies are placing more emphasis on fast service. For the development of high speed containerships, several countries e.g. Japan, Korea, EU and USA, have launched research and testing projects (Baird, 2000; Wang and Mcowan, 2000).

However, opinions clash regarding fast ship projects. Thus, some have argued that fast ship projects have failed due to their excessive fuel costs and port congestion (Laine and Vepsäläinen, 1994) while others hold that it is a viable project which could assist the modal shift even further.

2.1.2.3 Alliances of shipping companies

On liner alliances and cooperation, UNCTAD (2004, p.12) stated the following:

"Liner shipping is a very structured market, with each company owning a fleet of vessels. Both commercial considerations; market coverage, service frequency, cost control, etc., and operational arrangements; vessel space utilization, container deployment, etc., have forced shipping lines to organize themselves in close cooperative and partnership arrangements, e.g. liner conferences, alliances, consortia, join-ventures and mergers"

The definition by UNCTAD (2004) is in line with previous research which has suggested the motives for cooperation of liner shipping (Alix *et al*, 1999; Thanopoulou and Yoo, 1999; Midoro and Pitto, 2000; Slack *et al*, 2002) and can be summarized as shown in Table 2.8.

Table 2.8 Motives for cooperation in liner shipping

Motives for liner cooperation		Corresponding logistics concepts
Economies of scale	→	Total cost reduciton, multi-user distribution
Market access	→	Market penetration, global services
Less investment in physical assets	→	Assets sharing
Market coverage	→	One-stop shipping/shopping, global services
Service frequency	→	Scheduling, JIT, order processing, lead time
Marketing capability	→	Customer service management, value added
Cost control	→	Cost reduction and control
Vessel space utilization	→	Inventory planning and management
Container deployment	→	Warehouse operations, inventory control
Operational know-how	→	Communication systems and information sharing

Source: UNCTAD (2004)

In 2004, the top 25 container carriers shared 79% of the world's TEU capacity, which had increased by 12% compared to 2003. Ten of the fifteen top shipping companies-Evergreen, Hanjin, APL, NYK, Cosco, China Shipping, K-Line, OOCL, MOL and ZIM- are located in Asia (Hoffmann, 2004). Liner shipping companies are clustered into five large global alliances as shown below in Table 2.9.

Table 2.9 Global alliances in shipping market

Name of alliance	Participants	Number of vessels	Maximum capacity (TEUs)
Grand Alliance	NYK, P&O-Nedlloyd, HapagLloyd, OOCL, MISC	323	954,767
Maersk-Sealand	Maersk-Sealand	257	875,086
New World Alliance	MOL, APL, HMM	170	578,447
CKYHS	Cosco, K-Line, YML, HANJIN, SENATOR	341	913,812
Evergreen/LT	Evergreen, LT	147	438,124
	Total	1,238	3,760,236

Source: Hanjin Shipping (2005), *Company Profile*

With a desired reduction in the number of partners, differentiation of their roles and co-ordination of marketing and sales, merger and acquisition activity has been a major trend, which has resulted in the emergence of a new generation of strategic alliances. On this, Midoro and Pitto (2000) noted the following:

"It will be composed of a limited (two to three) number of partners of very large and similar dimensions (as Maersk and SeaLand) or, while retaining a wide member base, will be led by a dominant partner"

The mergers and acquisitions (M&A) activity within liner shipping companies since 1995 is illustrated in table 2.10.

2.1.3 Changes in container ports

In NEA, increased competition in container ports has resulted in the modernization, reduction of bureaucracy and introduction of private sector investment in ports (UNCTAD, 2003). Furthermore, due to the trend towards introducing mega container ships, sea ports have expressed several handling operational needs such as very large quay cranes, faster handling capabilities and deeper draft at ports (Imai, 2006). To satisfy such needs and to become a hub, sea ports are currently attempting to make the changes required.

Table 2.10 Merger and acquisition activity within liner shipping companies

Year	Companies in leading mergers	Merged companies
1995	CP Ships	Cast 1993 Ltd.
1996	TMM	Flota Mercante Grancolombiana
	CMA	CGM
1997	P&O Containers	Nedlloyd Lines
	Hanjin Shipping	DSR Senator
	CP Ships	Lykes Lines
	CP Ships	Contship Containerlines
	NOL	APL
1998	P&O Nedlloyd	Blue Star Lines
	CP Ships	Ivaran Lines
	SCL	Safmarine
	Safmarine	Barbican (ECSA/Africa/Australia)
	Hamburg Sud	Barbican (Australia/S Pacific Island)
	Hamburg Sud	South Seas Steamship Co
	Hamburg Sud	Empresa de Navegacao Alianca
	Evergreen Marine Corp	Lloyd Triestino di Navigazione SpA
	CP Ships	Australia-new zealand Direct line
	CMA GCM	ANL Container Line Pty Ltd
1999	AP Moller	Safmarine Container Lines
	CP Ships	Transportacion Maritima Mexicana
	P&O Nedlloyd	Tasman Express Line
	CSAV	Companhia Libra de Navegacao
	CSAV	Montemar SA
	Hamburg Sud-The shipping Group	Transroll International
	Hamburg Sud-The shipping Group	South Pacific Container Line
	Delmas	OT Africa Line
	AP Moller	Sea-Land Services
	Sea Consortium	Sea Med Link
2000	CP Ships	Americana Ships
	Hamburg Sud - The shipping Group	Crowley American Transport
	Naviera Odiel	Compania Trasatlantica Espanola
	CP Ships	Christensen Canadian African Line
	CSAV	Norasia Line
	P&O Nedlloyd	Farrell Line
	P&O Nedlloyd	Harrison Line
	Grimaldi	Atlantic Container line(40% Stake)
	Mars(Related to CMA CGM)	Atlantic Container line(10% Stake)
2001	Grimaldi	Atlantic Container line(10% Stake)
2003	Hamburg Sud	Kien Hung

Source: Drewry Shipping Consultants (2004)

2.1.3.1 Improving port facilities

Draught

The introduction of today's ultra post Panamax container ships, which usually have greater length, width and especially draught, affects sea ports with respect to water draught. In fact, in many ports, the water depth in front of the terminals and the access channels is insufficient for these vessels to approach. For this reason, liner operators have limited options when ordering such large vessels.

Table 2.11 The specification of large container vessels

Type of ship	TEU	DWT(ton)	Length(m)	Width(m)	Draught(m)
P&O Nedlloyd Southampton	6,674	87,900	300	42.8	14.0
Sovereign Maersk	6,600	98,000	347	42.8	14.5
Suez-Max ship	11,989	157,935	400	50.0	15.0
15,000TEU container ship	15,000	220,000	400	66.0	17.0

Sources: Extracted from Monie (1985) and Yu *et al.*(2002)

In response to liner shipping companies' requirements of larger ships and scale economics, which has also lead to the increase in ship size, major sea ports have plans to increase their water depth by means of dredging and through developing new terminals. The following plans shown in Table 2.12 have been promoted by the world's leading sea ports.

Table 2.12 Plans to increase water depth

Region	Nation	Port	Targeted water depth level
Asia	Korea	Busan	15m
		Gwangyang	15m
	China	Shanghai	15m
		Fozhou	14m
	Japan	Kobe	15 ~ 16m
		Naha	15 ~ 16m
		Yokohama	15m
	Philippines	Subic	12.8m
	Yemen	Aden	16m
	Oman	Shalalaha	16m
	Singapore	Singapore	15 ~ 16m
	Hong kong	HIT	15m
		Lantau	15m
	Taiwan	Kaohsiung	15m
		Keelung	30-50m
	Malaysia	Tanjung Pelepas	18m
	Sri Lanka	Colombo	15 ~ 16m
Europe	Nederland	Rotterdam	16.65m/19m
	United Kingdom	Thamesport	15.5m
	France	Dunkirk	14.5m/16.5m
	Spain	Algeciras	16m
		Valencia	16m
	Belgium	Antwerp	16m
	Germany	Wilhemshaven	18.5m
	Italy	Genoa	16m
	Portugal	Sines	17m
America	USA	Los Angeles	16.5m
		NY/NJ	15m
		Oakland	15m
		Long Beach	16.8m
		Seattle	15.2m
	Canada	Halifax	16m

Source: Park, T-W and Jeong, B-M. (2002), *Analysis of economic effects of large container vessel*, Korea Maritime Institute, Seoul.

Cargo handling facilities

Certain ways to reduce the time spent in port have been considered to set up faster cargo loading and unloading systems. From this viewpoint, a variety of products and ideas on cargo handling facilities have emerged. With regard to quay cranes, they have become increasingly bigger to enable the handling of ultra post-Panamax vessels, which have a

greater outreach requirement. A quay crane capacity for 3,000 and 4,000 TEU containerships is needed to serve up to 13 or 14 rows of boxes across the deck respectively.

Table 2.13 Quay crane specifications

Types of machine	Outreach (m)	Needed rows (Number of TEU)
Standard Panamax	36 ~ 44	14 ~ 16
Post Panamax	44 ~ 48	16 ~ 18
Super Panamax	50 ~ 52	18 ~ 20
Ultra Post Panamax	54 ~ 56	20 ~ 22

Source: Samsung heavy industries(2005), *Company Profile*

The largest quay cranes will be estimated to offer an outreach of over 57 m, and a capability to serve up to 22~23 rows of boxes across the deck.

Table 2.14 Number of rows possible on over 6,000 TEUs container ships

Ship size(TEUs)	Width(m)	Rows	
6,000 - 7,600	42.8	17	In operation
8,000 - 9,100	45.3~45.6	18	In operation
12,000	57.0	22~3	Estimated

Source: Samsung heavy industries (2005), *Company Profile*

In order to catch up with the trend of increasing ship size, several sea ports have already set up very large quay cranes. ECT Rotterdam has the largest quay cranes with 66m outreach and can deal with 25~26 rows.

Table 2.15 Status of setting up quay cranes

Port terminal(Nationality)	Outreach(m)	Crows	Manufacturer
Oakland (USA)	60	23-24	ZPMC (China)
Xiamen (China)	62	24-25	ZPMC (China)
North Sea Terminal (Canada)	62	24-25	ZPMC (China)
Salalah port (Oman)	63.5	25-26	ZPMC (China)
Yokohama (Japan)	65	25-26	IHI (Japan)
ECT Rotterdam (Netherlands)	66	25-26	Noell (German)

Source: Cargo System, 2001. 3.
Note: ZPMC; Zenhua Port Machinery Corpation, IHI; Ishikawajima Harima Heavy Insdustries, ECT; Europe Combined Terminal.

2.1.3.2 Globalisation of operations

Many sea ports have had to improve their operating systems according to the strategies for 'global operation' held by terminal operators who are pushed to do so by the shipping companies. This has caused many changes in port management and port facilities, with respect to terminal operators, who, during the 1980s, expanded their business area from a national basis to an international orientation. Since this period, they have been called 'global stevedores'. Peters (2001) classifies terminal operators into the following three categories:

"The first operators are to expand their operations on a geographical basis; the second wave of operators are seeking expansion internationally; and final category consists of major ocean carriers"

According to his definition, the first operators are trying to expand their operations geographically based on number of port locations. The second operators mainly focus on international terminal operation while the third group consists of global shipping companies.

56.7 % of container throughput was handled by the world's top 20 terminal operators in 2002. Of these, eleven companies are related to shipping lines (Hoffmann, 2004).

Table 2.16 The market share of major terminal operators

Ranking	Companies	Thoughput (Million TEUs)	Rate of share (%)	Ranking	Companies	Thoughput (Million TEUs)	Rate of share (%)
1	HPH* (Hong Kong)	36.7	13.3	11	APL (Singapore)	4.3	1.6
2	PSA* (Singapore)	26.2	9.5	12	HHLA* (Germany)	4	1.4
3	APM (Denmark)	17.2	6.2	13	NYK (Japan)	3.5	1.3
4	P&O Ports (United Kingdom)	12.8	4.6	14	OOCL (Hong Kong)	3	1.1
Sub-total	**Top 4 operators**	**92.9**	**33.6**	15	CSX WT* (USA)	2.7	1
5	Eurogate* (Germany)	9.5	3.5	16	MOL (Japan)	2.7	1
6	Evergreen (Taiwan)	5.7	2.1	17	Dragados* (Spain)	2.3	0.8
7	Dubai PA* (UAE)	5.3	1.9	18	K Line (Japan)	2.2	0.8
8	COSCO (China)	4.7	1.7	19	Barcelona Terminal* (Spain)	2.2	0.8
9	Hanjin (South Korea)	4.7	1.7	20	MSC (Swiss)	2.2	0.8
10	SSA Marine* (USA)	4.4	1.6	**Grand total**	**Top 20 operators**	**156.3**	**56.7**

Source: Drewry Shipping Consultants, 2002.

Note: *means global terminal operator and not relating the shipping company.

Global terminal operators have expanded their business scope into NEA and have built up their service networks there. Sea ports which are outside this network will suffer when attempting to attract container cargos. The status of global terminal operators in NEA is as illustrated in Table 2.17.

Table 2.17 The status of global terminal operators in NEA

Companies	Nations	Ports	Terminals	Length of berth (m)	Annual throughput (million TEUs)
APM TML	Taiwan	Kaohsiung	Piers 76/77	675	1.00
			Piers 118/119	640	0.80
	Japan	Kobe	RC 4/5	700	0.46
		Yokohama	MC1	750	1.10
	China	Dalian	DCT	1,461	1.50
HPH	Hong Kong	Hong Kong	Terminal 4, 6, 7	3,292	14.50
			Terminal 8 east	1,088	1.50
	China	Shanghai	Shanghai CT	2,081	1.70
			Shanghai Pudong CT	900	1.80
		Yantian	YICT	2,350	3.00
		Xiamen	XICT	640	0.60
			Hutchison Delta Ports	2,611	1.20
		Ningbo	Ningbi Beilun CT	900	1.20
	Korea	Busan	Hutchison Busan CT	1,447	1.20
			Hutchison Gamman	350	0.30
		Gwangyang	HKCT	2,550	2.01
P&O Ports	Russia	Vostochny	VICS	672	0.40
	China	Qingdao	Qianwan CT	766	1.00
		Shekou	Shwkou CT	650	0.80
PSA Corp.	Singapore	Tanjung Pagar, Keppel, Brani, Pasir Panjang		8,228	16.50
				2,145	5.00
	China	Dalian	Dalian CT	1,461	1.50
			Dalian Dagang	555	0.30
		Fuzhou	Fuzhou Qingzhou	519	0.40
		Guangzhou	Guangzhou CT	1,299	1.40
	Korea	Incheon	CT	900	1.13
CSX World TML	China	Tianjin	CSX Orient T.	640	1.00
		Xiamen	Xianyu CT		
	Russia	Vostochny	VICS	672	3.38
	Korea	Busan	Newport (Under construction)	3,200	2.70

Source: Containerisation International Yearbook (2003)

2.2 Growing Container Ports in Northeast Asia

In 1980, in terms of container traffic volume, Hong Kong handled 1.46 million TEUs and was the busiest port by far in NEA, followed by Kobe and Kaohsiung. Their port rankings worldwide were second, fourth and fifth respectively.

Ten years later, Hong Kong had become the world's second largest port while Kaohsiung and Kobe ranked fourth and fifth. The trend was the same, in the case of

Busan, whose traffic volume increased 3.7 fold between 1980 and 1990, and caused it to jump to the position of the sixth largest container port in the world.

In 2003, five of the world's top six ports were located in NEA, except for Singapore in Southeast Asia. During this period, Shanghai became the world's third busiest port, having been 43rd in 1990. Also Shenzhen improved its performance and jumped to fourth position. Chinese container ports are expected to grow and the ports in NEA will be discussed in more detail in the following sections.

2.2.1 Rapid changes at sea ports in Northeast Asia

2.2.1.1 Importance of Northeast Asia

Northeast Asia (NEA) consists of China, Japan, Mongolia, North Korea, the Russian Federation, and South Korea (Yun and Zhang, 2006). It is also part of the Asia–Pacific community and has grown to become the largest of Asian markets (Ohashia, 2005). Among these NEA nations, the representatives of major growth markets are China, Korea and Japan. Recently, using their geographical advantage of being close to the main sea trunk routes, they have shown aspirations of becoming global or regional transport and logistics hubs.

UNCTAD (2005) has suggested the most important 35 maritime countries by means of ranking them according to deadweight tonnage. They noted that these 35 countries and territories controlled 95 per cent of the world merchant fleet in 2004. Among them, the NEA countries had markedly high rankings i.e. second for Japan, fourth for China, seventh for Hong Kong, eighth for South Korea, tenth for Taiwan and thirteenth for Russia. These nations' total share of world ship deadweight total is presently 33.51%.

Table 2.18 Most important maritime countries in terms of deadweight

(as of the end of 2004)

	Number of vessels			Deadweight tonnage				
	NF	FF	Total	NF	FF	Total	FFT	TWT
Greece	739	2,245	2,984	50,997	104,147	155,144	67.13	18.48
Japan	717	2,228	2,945	12,611	105,050	117,662	89.28	14.01
Germany	349	2,266	2,615	9,033	48,877	57,911	84.40	6.90
China	1,695	917	2,612	27,110	29,703	56,812	52.28	6.77
United States	624	1,009	1,633	10,301	36,038	46,338	77.77	5.52
Norway	768	821	1,589	14,344	29,645	43,989	67.39	5.24
Hong Kong(China)	274	331	605	17,246	23,747	40,993	57.93	4.88
South Korea	567	372	939	10,371	16,887	27,258	61.95	3.25
United Kingdom	426	459	885	10,865	14,978	25,843	57.96	3.08
Taiwan	112	419	531	5,297	18,034	23,331	77.30	2.78
Singapore	443	297	740	12,424	9,909	22,333	44.37	2.66
Denmark	300	346	646	8,376	8,491	16,867	50.34	2.01
Russian Federation	1,721	362	2,083	6,845	8,405	15,250	55.11	1.82

Source: UNCTAD (2005b)

Note: NF; National Flag, FF; Foreign Flag, FFT; Foreign Flag as a % of Total, TWT; Total as a % of world total

Regarding major trading nations, the NEA countries have shown leading positions in the world in terms of their percentage share of world trade i.e. third for China, fourth for Japan, eleventh for Hong Kong, twelfth for South Korea, fifteenth for Taiwan, and seventeenth for Russia. These nations' total share of world trade is 20.6%. In reference to the other aspects concerned, ten of the twenty leading container terminal operators in the world are located in NEA, e.g., the Evergreen group (3rd, Taiwan), Hanjin (7th, South Korea), NYK (8th, Japan), COSCO (9th, China), China Shipping (10th, China), OOCL (11th, Hong Kong), MOL (12th, Japan), K Line (15th, Japan), Yang Ming (18th, Taiwan) and Hyundai (19th, South Korea) (UNCTAD, 2005).

Table 2.19 Maritime engagement of 20 major trading nations

(as of the end of 2004)

Country	Percentage share of world trade generated, in terms of value
United States	12.6
Germany	8.8
China	6.2
Japan	5.5
France	4.9
United Kingdom	4.3
Italy	3.7
Netherlands	3.7
Canada	3.2
Belgium	3.2
Hong Kong(China)	2.9
South Korea	2.6
Spain	2.3
Mexico	2.1
Taiwan	1.9
Singapore	1.8
Russian Federation	1.5
Switzerland	1.2
Malaysia	1.2
Sweden	1.2

Source: UNCTAD (2005b)

By means of rankings according to deadweight, major trading nations and the world leading container terminal operators, NEA can be seen as possessing a leading position in world production and shipping. Especially noteworthy here is that, due to the fact that the world's top six busiest and largest container ports are located in NEA, port competition and competitiveness have become hot issues in the last ten years.

2.2.1.2 Definition and estimated changes in liner shipping in Northeast Asia

Due to the reallocation of the shipping network with more focus on the Chinese sea ports, the patterns in the service provided by shipping companies have changed fundamentally and are summarized as the following four trends (KMI, 2004).

The first of these is increased direct calling to Chinese ports, including newly emerging container ports i.e. Dailian, Qingdao and Tianjin etc. The reason why liner shipping companies call at these ports is the need for the transport of container cargo volumes originating from mainland China. On the Trans-Pacific route, the share of Chinese container cargos increased dramatically from 13.6% in 1993 to 50.3% in 2003. Consequently, many shipping companies have moved their base to China.

- The second is service diversification which brought about the introduction of multipolarized container ports in NEA. The factors affected by it are the rapid growth of Chinese ports, the emergence of new large container ports and the slowing down of Korean and Japanese ports. Following these circumstances, more direct calling services are to be expected.

The third is the increase in 'express service' between two given ports e.g. the route from Southern China to Western USA by Evergreen Company and that from China to Longbeach by Hanjin Shipping Company, and the route from China to Oakland by Hyundai Merchant Marine (HMM, 2005). These special shipping routes have arisen from shippers' requirements for fast service and time reductions in the maritime transport leg. This service will be increased because many shipping companies consider utilizing new special routes.

The final trend is the appearance of market segmentation. This means that shipping companies' service is changed from the traditional shipping route- Hong Kong, Taiwan, Korea and Japan- to a new, divided route- one between Korea and China or that between Japan and China. By means of this new service, shipping companies will reduce their port calling and operation costs.

From the above discussion, it can be concluded that liner shipping companies' service patterns have exhibited 'service diversification' and 'market segmentation', which indicates that 'the hub and spoke theory' in the shipping industry is not suitable in NEA at present.

On the other hand, by using the ultra large container ship in the near future in this region, shipping companies will reduce the number of calling ports to 2 or 3 which can accommodate large container vessels and thus develop a sizeable market share. In order to be designated as a hub port accommodating large vessels, the ports in NEA will face severe competition.

2.2.2 Forecasts for container ports in Northeast Asia

Among the nations in NEA, the most rapidly growing ones are South Korea and China. These nations were to experience GDP growths of 6% for South Korea and 9.9% for China in 1991~2000. Interestingly, in terms of container increasing rate, the figure for Northern China was estimated to increase by 24.1% and by 33.4% for Southern China while for South Korea, the rate of increase was expected to be 10.1%.

Table 2.20 Increasing trends in GDP and container cargos in Northeast Asia

		1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	Average rate 1991-2001	Average rate 1995-2001
South Korea														
GDP rate(%)		9.2	5.4	5.5	8.3	8.9	6.8	5.0	-6.7	10.9	9.3	3.0	6.0	5.3
container rate(%)		8.8	7.8	8.5	15.5	14.7	9.2	10.9	11.2	10.3	10.5	3.3	10.1	10.0
Japan														
GDP rate(%)		3.8	1.0	0.5	0.9	1.7	3.6	1.8	-1.2	0.8	2.4	-0.3	1.4	1.3
container rate(%)		7.9	3.6	5.0	10.3	5.4	4.0	2.5	-0.8	8.3	12.8	-1.1	5.3	4.4
China														
Northern China	GDP rate(%)	9.2	14.2	13.5	12.6	10.5	9.6	8.8	7.8	7.1	8.0	7.3	9.9	8.4
	container rate(%)	26.0	18.9	26.1	32.8	25.2	22.4	18.3	15.9	23.7	34.5	20.8	24.1	23.0
Southern China	GDP rate(%)	9.2	14.2	13.5	12.6	10.5	9.6	8.8	7.8	7.1	8.0	7.3	9.9	8.4
	container rate(%)	42.3	28.4	28.6	40.4	26.6	41.3	34.7	38.1	36.4	31.0	19.2	33.4	32.5
Hong Kong														
GDP rate(%)		5.1	6.3	6.1	5.4	3.9	4.5	5.0	-5.3	3.0	10.4	0.2	4.1	3.1
container rate(%)		21.4	30.2	17.1	13.1	7.4	7.6	8.6	-2.3	-1.5	7.2	-3.4	9.6	3.4
Taiwan														
GDP rate(%)		7.6	6.8	6.5	7.1	6.4	6.1	6.7	4.6	5.4	5.9	-1.9	5.6	4.7
container rate(%)		11.5	3.5	6.2	3.7	3.7	3.4	5.1	-3.8	5.5	5.7	-4.1	3.7	2.2

Source: Ocean Shipping Consultants (2003), UNCTAD (2005)

OSC (2003) has estimated the growth rate of GDP for each nation in NEA until 2015, and predicts that China will show the fastest growth, followed by Korea and Taiwan.

Table 2.21 Estimated rate of increase in GDP

	2006-2010		2011-2015	
	Case 1 (%)	Case 2 (%)	Case 1 (%)	Case 2 (%)
Korea	5.3	4.3	4.8	3.8
Japan	2.2	1.1	2.2	1.4
China	7.1	6.5	6.7	6.0
Hong Kong	3.5	2.0	3.0	2.0
Taiwan	4.5	3.5	4.0	3.0

Source: Ocean Shipping Consultants (2003), UNCTAD (2005)

Depending on the economic scenarios based on the GDP, OSC (2003) also estimated that total import and export container throughput in NEA will reach 109.8~117.3 million TEUs by 2010 and 133.3-146.7 million TEUs by 2015.

Among these throughputs, Korea's throughputs will be 14.9 million TEUs in 2010 (KMI, 2003). China's share is estimated to reach 58.6-61.8 million TEUs in 2010 and 74.2~80.4 million TEUs in 2015 while Japan's will be 15.2~17.8 million TEUs in 2010 and 16.7~20.7 million TEUs in 2015 (OSC, 2003).

Table 2.22 Total import and export container throughput forecast for Northeast Asia

(Units: million TEUs)

	2002	2005	2010	2015
Korea	7.4	10.6	14.9	19.0
Japan	12.3	13.5 ~ 14.2	15.2 ~ 17.8	16.7 ~ 20.7
China	29.2	40.5 ~ 41.3	58.6 ~ 61.8	74.2 ~ 80.4
Northern China	7.1	10.3 ~ 10.6	16.0 ~ 17.0	21.9 ~ 24.1
Southern China	22.1	30.2 ~ 30.7	42.6 ~ 44.8	52.3 ~ 56.3
Hong Kong	11.2	12.2 ~ 12.4	13.4 ~ 14.7	14.8 ~ 17.1
Taiwan	6.1	6.7 ~ 6.8	7.7 ~ 8.1	8.6 ~ 9.5
Total	66.1	83.5 ~ 85.3	109.8 ~ 117.3	133.3 ~ 146.7

Source: Korea Maritime Institute (2003), Ocean Shipping Consultants (2003)

Transhipment container throughputs will rapidly increase compared to import and export container cargo volumes. The total transhipment container throughputs in NEA are expected to reach 34.9~37.5 million TEUs in 2010 and 42.3~46.1 million TEUs in 2015.

Among these throughputs, Korea's throughputs will be 13.2 million TEUs in 2010 (KMI, 2003) while China's is estimated at 1.3~1.7 million TEUs in 2010 and 3.2-3.8 million TEUs in 2015. Finally, Japan's share will be 0.9-1.4 million TEUs in 2010 and 0.9~1.5 million TEUs in 2015 (OSC, 2003).

Table 2.23 Forecast for transhipment container throughputs in Northeast Asia

(Units: million TEUs)

	2002	2005	2010	2015
Korea	4.2	8.0	13.2	16.2
Japan	0.9	1.0 ~ 1.2	0.9 ~ 1.4	0.9 ~ 1.5
China	0.2	0.3 ~ 0.5	1.3 ~ 1.7	3.2 ~ 3.8
Northern China	0.2	0.3 ~ 0.4	0.6 ~ 0.7	1.1 ~ 1.3
Southern China	0.0	0.0 ~ 0.1	0.7 ~ 1.0	2.1 ~ 2.5
Hong Kong	7.5	9.4 ~ 9.6	11.3 ~ 12.5	12.4 ~ 14.1
Taiwan	5.2	6.4 ~ 6.5	8.2 ~ 8.7	9.6 ~ 10.5
Total	17.6	25.1 ~ 25.8	34.9 ~ 37.5	42.3 ~ 46.1

Source: Korea Maritime Institute (2003), Ocean Shipping Consultants (2003)

The total container throughput in NEA is expected to reach 146.7-156.0 million TEUs in 2010 and 178.4~194.8 million TEUs in 2015.

Among these throughputs, Korea's will be 29.7 million TEUs in 2010 (KMI, 2003). China is estimated at 60.2~63.1 million TEUs in 2010 and 77.8~83.8 million TEUs in 2015 while Japan's figure are 16.1~19.2 million TEUs and 17.5~22.2 million TEUs for the same time periods (OSC, 2003).

Table 2.24 Forecast for total container throughputs in Northeast Asia

(Units: million TEUs)

	2002	2005	2010	2015
Korea	11.9	19.3	29.7	37.6
Japan	13.1	14.5 ~ 15.3	16.1 ~ 19.2	17.5 ~ 22.2
China	29.3	40.9 ~ 41.6	60.2 ~ 63.1	77.8 ~ 83.8
Northern China	7.2	10.6 ~ 10.9	16.6 ~ 17.7	23.0 ~ 25.4
Southern China	22.1	30.3 ~ 30.7	43.6 ~ 45.4	54.8 ~ 58.4
Hong Kong	18.7	21.5 ~ 22.0	24.8 ~ 27.2	27.2 ~ 31.2
Taiwan	11.2	13.1 ~ 13.3	15.9 ~ 16.8	18.3 ~ 20.0
Total	83.7	109.3 ~ 111.5	146.7 ~ 156.0	178.4 ~ 194.8

Source: Korea Maritime Institute (2003), Ocean Shipping Consultants (2003)

Regarding forecasting container ports' capacity to demand ratio, in the case of Korea, the container ports' capacity will suffer badly if no development is undertaken. In the case of the ports in Southern and Northern China, it is also estimated that there will be a lack of

capacity, which is also true for the ports in Hong Kong and Taiwan. However, the rate of increase for container cargo volumes in Japan is very slow, and, as the facilities available are already plentiful, no difficulty concerning container facilities there is expected.

Table 2.25 Forecast for container port capacity vs demand ratio

(Units: million TEUs)

	2002	2003	2004	2005	2010
Korea					
Capacity (A)	8.8	11.5	12.8	18.9	30.0
Demand (B)	11.9	12.2	13.8	19.2	29.7
B/A (%)	135.2	106.1	107..8	101.6	99.0
Japan					
Capacity (A)	17.9	19.1	19.8	23.0	26.0
Demand (B)	13.1	13.8	14.2 ~ 14.6	14.5 ~ 15.3	16.1 ~ 19.2
B/A (%)	73.2	72.3	71.7 ~ 73.7	63.0 ~ 66.5	61.9 ~ 73.8
China					
Capacity (A)	31.0	34.4	38.4	42.9	55.5
Demand (B)	29.3	33.4	37.1 ~ 37.5	40.9 ~ 41.6	60.2 ~ 63.1
B/A (%)	94.5	97.1	96.6 ~ 97.7	95.3 ~ 97.0	108.5 ~ 113.7
Northern China					
Capacity (A)	8.2	9.5	11.3	13.2	18.5
Demand (B)	7.2	8.3	9.5 ~ 9.6	10.6 ~ 10.9	16.6 ~ 17.7
B/A (%)	87.8	87.4	84.0 ~ 85.0	80.3 ~ 82.6	89.8 ~ 95.7
Southern China					
Capacity (A)	22.8	24.9	27.1	29.7	37.0
Demand (B)	22.1	25.1	27.6 ~ 27.9	30.3 ~ 30.7	43.6 ~ 45.4
B/A (%)	96.8	100.5	101.8 ~ 102.8	101.7 ~ 103.3	117.8 ~ 122.6
Hong Kong					
Capacity (A)	18.6	19.1	21.2	21.2	21.2
Demand (B)	18.7	19.8	20.7 ~ 20.9	21.5 ~ 22.0	24.8 ~ 27.2
B/A (%)	100.5	103.7	97.6 ~ 98.6	101.4 ~ 103.8	116.9 ~ 128.3
Taiwan					
Capacity (A)	13.8	13.8	13.8	13.8	16.8
Demand (B)	11.2	11.9	12.5 ~ 12.6	13.1 ~ 13.3	15.9 ~ 16.8
B/A (%)	81.2	86.2	90.6 ~ 91.3	94.9 ~ 96.4	94.6 ~ 100.0

Source: Korea Maritime Institute (2003), Ocean Shipping Consultants (2003)
Note: Throughput for 2002 is based on real data while those between 2003 and 2010 are based on estimated data.

Due to the rapid increase in their container cargo throughputs, the deficiency of container port capacity in Chinese ports needs to be estimated. Especially noteworthy in this context is the case of Shanghai port, which is expected to suffer from a shortage of facilities from year 2005 onwards. In addition, the major container ports in Northern China i.e. Dalian, Qingdao and Tianjin will experience similar difficulties in the near future.

Table 2.26 Forecast for container throughputs in Northern China

(Units: million TEUs)

	Ports	2002	2005	2010	2015
Estimated container throughputs (A)	Sub Total	15.77	23.89 ~ 24.48	37.83 ~ 40.40	50.24 ~ 56.46
	Dalian	1.35	1.98~2.02	2.97~3.17	3.97~4.46
	Tianjin	2.41	3.58~3.67	5.51~5.88	7.06~7.92
	Qingdao	3.40	5.12~5.25	8.13~8.70	11.04~12.47
	Shanghai	8.61	13.21~13.54	21.22~22.65	28.17~31.61
Estimated capacity of container ports (B)	Sub Total	15.80	24.33	35.56	40.96
	Dalian	1.80	3.30	3.30	3.30
	Tianjin	2.40	3.53	5.26	5.26
	Qingdao	3.60	5.60	9.00	9.00
	Shanghai	8.00	11.90	18.00	23.40
Excess or deficiency (B-A)	Sub Total	0.03	0.44~(−0.15)	(−2.27) ~ (−4.84)	(−9.28) ~ (−15.50)
	Dalian	0.45	1.28~1.32	0.13~0.33	(−0.67) ~ (−1.16)
	Tianjin	(−0.01)	(−0.06) ~ (−0.15)	(−0.25) ~ (−0.62)	(−1.80) ~ (−2.66)
	Qingdao	0.20	0.35~0.48	0.30~0.87	(−2.04) ~ (−3.47)
	Shanghai	(−0.61)	(−1.31) ~ (−1.64)	(−3.22) ~ (−4.65)	(−4.77) ~ (−8.21)

Source: Ocean Shipping Consultants (2003)

2.3 Port Competition in Northeast Asia

The economic boom is turning mainland China into the world's power station, the centre of the world economy and consumption. As a result, Chinese ports have become new transhipment and gateway hubs and many Chinese ports are enjoying record throughput growth (Yap et al., 2003).

After the 1990s, port competition in NEA has become more severe mainly for three reasons. The first major change is connected with the Great Hanshin earthquake, which damaged Kobe in 1995, the full repairs for which required over two years to complete. Prior to 1995, Kobe had been ranked sixth among container ports worldwide, but in 1997 it plunged down to the 17th position (Chang, 2000). During the repair period, Busan and Kaohsiung expanded their facilities and absorbed the transhipment container traffic Kobe could not deal with. Secondly, Korean ports have shown a low increase in container traffic and have been losing transhipment cargo volume to competition from the Chinese ports. Yap and Lam (2006) claimed that *'The 1990s had seen Japanese ports lose the bulk of their transhipment traffic to Hong Kong, Kaohsiung and Busan. The first decade of the 21st century might witness Kaohsiung and Busan losing the bulk of their transhipment traffic to mainland Chinese ports'*. Thirdly, Chinese ports have undergone dramatic development. In the near the future, several new emerging Chinese ports such as Dalian, Qingdao, Tianjin, Shanghai and Shenzhen will threaten the neighbouring container ports in the competition for hub port position.

2.3.1 Strategic positions of container ports in each nation in Northeast Asia

According to KMI (2004), who analysed NEA's sea ports, including their strategic positions, in the first half of the 1980s, the average market share of Hong Kong, Kobe, Kaohsiung, Yokohama, Keelung, Busan and Tokyo was 4.8% and indicated 'a cash cow'

situation. However, in spite of the high rate of increase, the Chinese container ports' market share was lower than 1%. In the latter half, Singapore appeared in the 'star' position, with 18.5% average container traffic growth and Busan had overtaken Yokohama and Keelung. Moreover, the Japanese ports' market share had decreased from 14.8% to 9.9% while the Chinese had increased by 20% annually.

In the first half of the 1990s, Hong Kong shared pole position with Singapore. Busan also overtook Kobe and Tokyo which plummeted. In the latter half, Busan grew rapidly while Keelung and other Japanese ports waned. Meanwhile, Shanghai had shown high growth rates of container traffic and had a 3.8% market share.

To synthesize the above, Singapore (in the 1980s), Hong Kong (in the early 1990s) and Busan (in the latter half of 1990s) predominated. On this aspect, Yap and Lam (2006) argue that Hong Kong and Busan have been the beneficiaries from the inter-port competition in the region for the past three decades.

2.3.2 Competition among ports in Korea and China

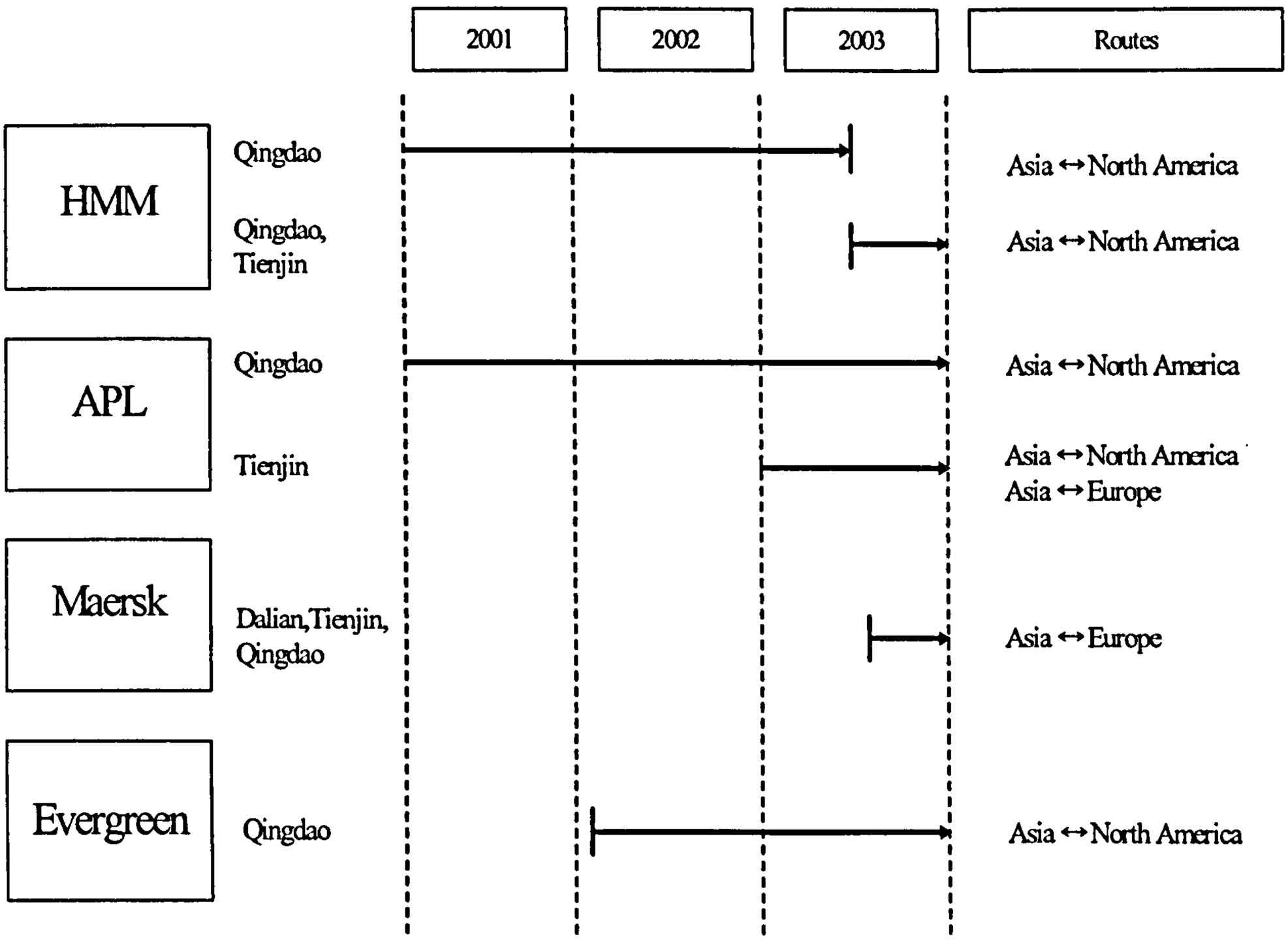
In NEA, severe port competition is expected to occur between Korea and China. This section deals with the recent competition phenomena between these two countries.

Direct callings by Maersk, P&O Nedlloyd in ports including Qingdao, Tianjin and Dalian have indirect implications for the importance of ports in Central and Northern China. This trend has motivated China to carry out large scale port development.

In addition good conditions for investment provided by China's open door policy have induced many foreign shipping companies and terminal operators to locate their operations

there. This situation is sufficiently striking to have captivated the attention of Korea's ports and government, in direct competition with China.

Figure 2.1 Major shipping companies calling directly at ports in northern China



Source: Redrawn by author from figures published by KMI (2003)

The overall status of direct calling by major shipping companies in Northern China and Korea is illustrated in Tables 2.27 and 2.28.

Table 2.27 Shipping companies making direct calls (US bound)

Shipping Companies	Vessel(TEU)	Ningbo	Shanghai	Qingdao	Dalian	Tianjin	HongKong	Busan	Kwangyang
APL/Hyundai/MOL	2885	o	o						
	3298			o				o	
	4469		o				o	o	
	6479						o	o	o
China Shipping	3090	o					o		
CMA-CGM/P&O Nedlloyd	3438		o				o	o	
CAN-CGM Norasia(Wallem)	3966		o				o	o	
COSCO	2868			o	o	o		o	
	3560	o	o						
COSCO/Hanjin/KL/Yang	4000		o				o	o	
Ming	3400			o			o		
CSAV(Wallem)	3800-4000		o				o	o	
Evergreen/L. Triestino	1672		o	o				o	
	2728	o	o						
Hanjin	3000	o	o					o	o
Hapag/NYK/OOCL	2888		o						
P&O Nedlloyd	3832	o	o	o				o	
	2958		o	o			o	o	
KL/Yang Ming	5598	o	o				o		
	3332		o	o					
Maersk Sealand	2816	o	o				o	o	o
MSC	4329		o				o	o	
Sinotrans	2523		o				o	o	
Zim(GMK)	2912		o				o		

Source: Ocean Shipping Consultants (2003).

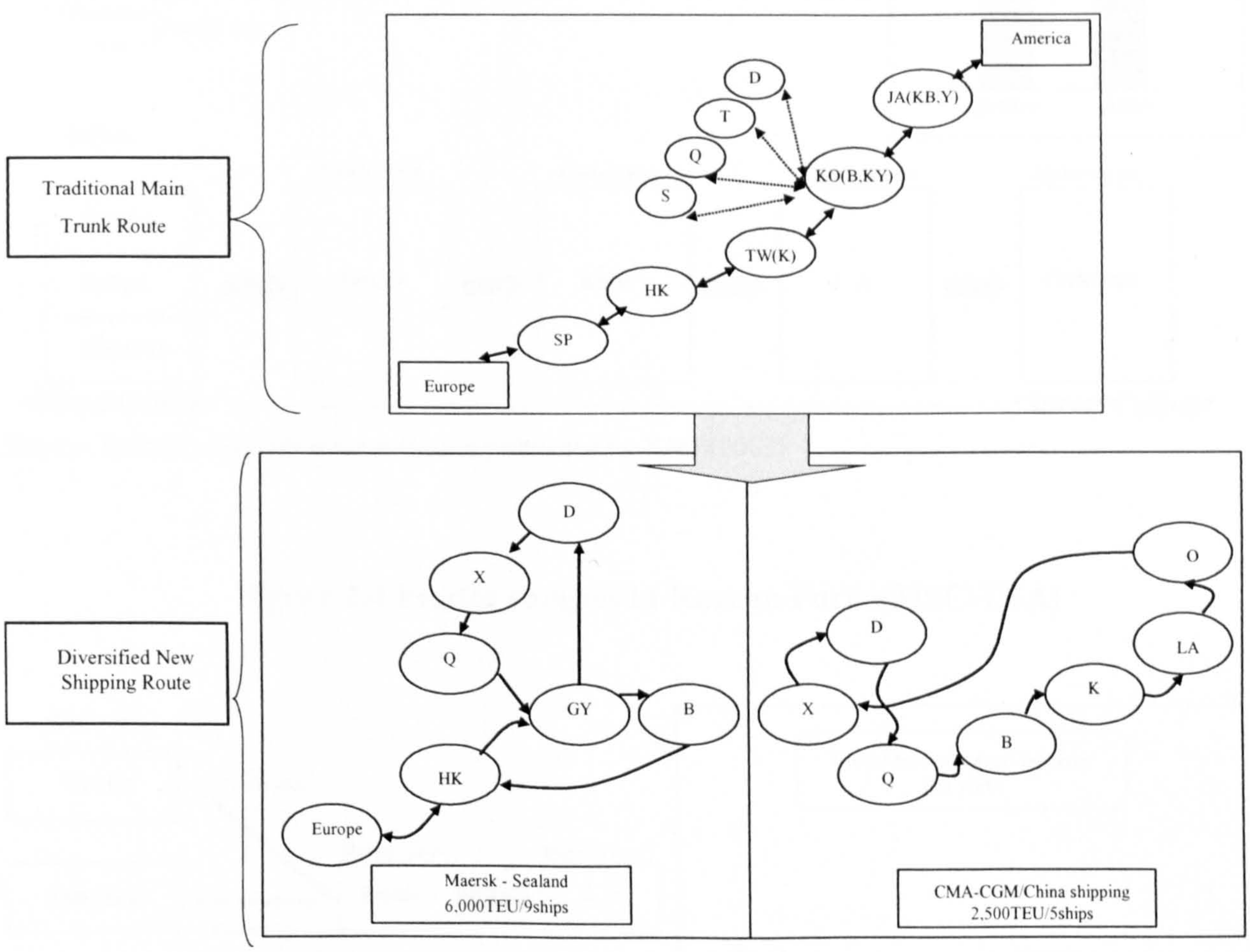
Table 2.28 Shipping companies making direct calls (Europe bound)

Shipping Companies	Vessel (TEU)	Ningbo	Shanghai	Qingdao	Dalian	Tianjin	Kaohsiung	Busan	Kwangyang
APL/Hyundai/MOL	5094		o						
China Shipping	3771	o	o						
CAN-CGM(Ben)	6510	o	o						
/Norasia(Wallem)	4152			o		o		o	o
COSCO	5299		o	o	o				
Evergreen/ L. Triestino	5616	o	o		o		o		
Hanjin/Senator	5000		o						
	5000			o		o	o	o	
Hapag/MISC/NYK/OOCL	5670			o			o	o	
/P&O Nedlloyd	7051		o						
KL/Yang Ming	5598	o	o						
Maersk Sealand	6128	o	o					o	o
MSC	6737	o		o		o		o	
CAN-CGM(Ben)	4226		o					o	
/Norasia(Wallem)									
COSCO/KL/Yang Ming	3359		o						
Evergreen/L. Triestino	2899	o					o		
	2899	o	o				o		
Hanjin/Senator	2700		o					o	
Hapag/MISC/NYK/OOCL	4511		o					o	
/P&O Nedlloyd									
MSC	3169		o						
	3169	o		o				o	
ZIM(GMK)	2679		o					o	
PIL	2601	o	o					o	o

Source: Ocean Shipping Consultants (2003).

Due to the changing environment, the traditional main trunk route; Europe- Singapore- Hong Kong- Taiwan(Kaohsiung, Keelung)- Korea(Busan, Kwangyang)- Japan(Kobe, Yokohama)- America, has diversified to incorporate several special routes including Chinese ports.

Figure 2.2 Changes in traditional main trunk routes

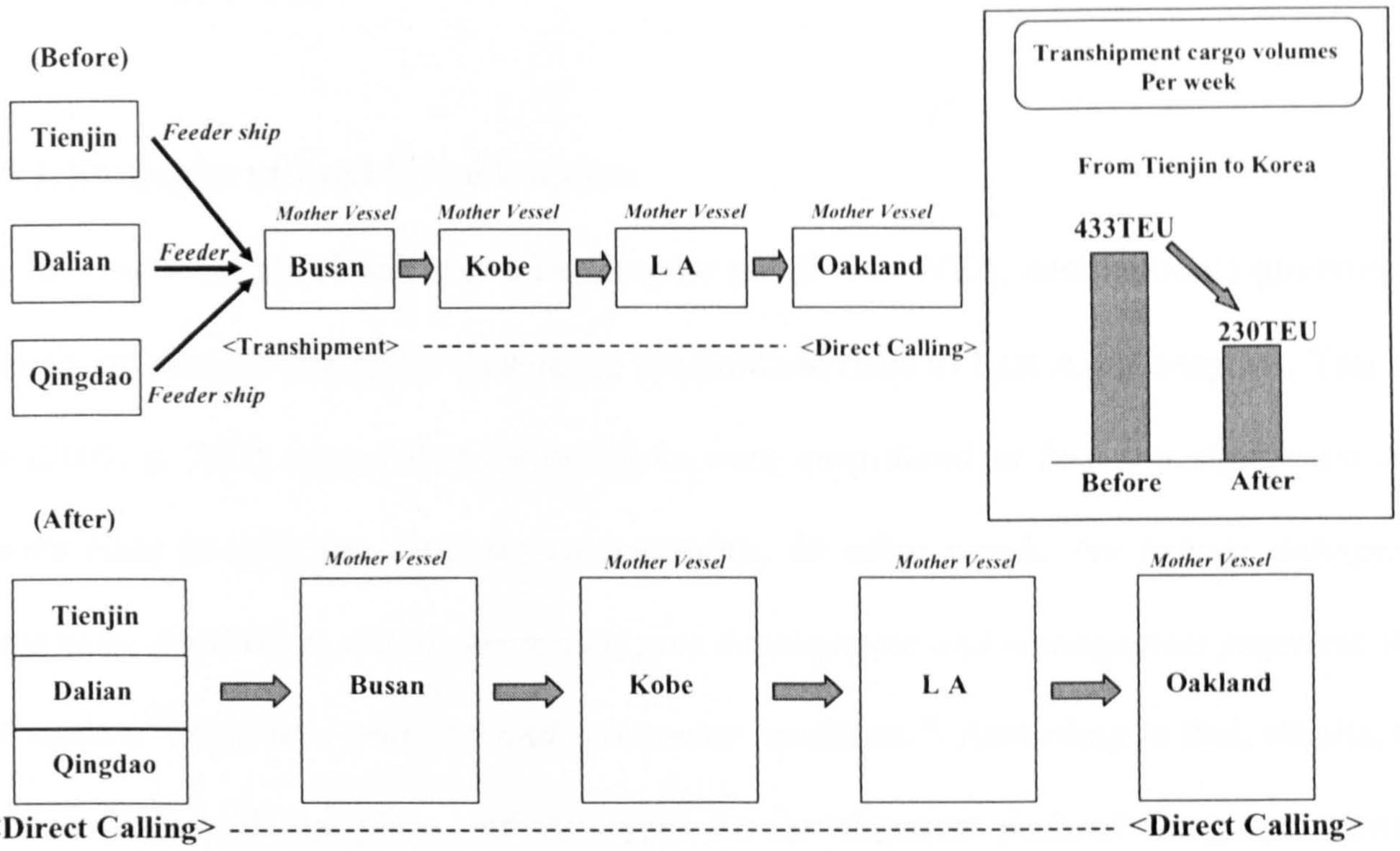


Source: Redrawn by author from figures published by KMI (2003)

Note: B(Busan), D(Dalian), GY(Gwangyang), HK(Hong Kong), JA(Japan), K(Kaohsiung), KB(Kobe), KO(Korea), KY(Kwangyang), LA(Los Angeles), O(Oakland), Q(Qingdao), S(Shanghai), SP(Singapore), T(Tianjin), TW(Taiwan), X(Xingang), Y(Yokohama)

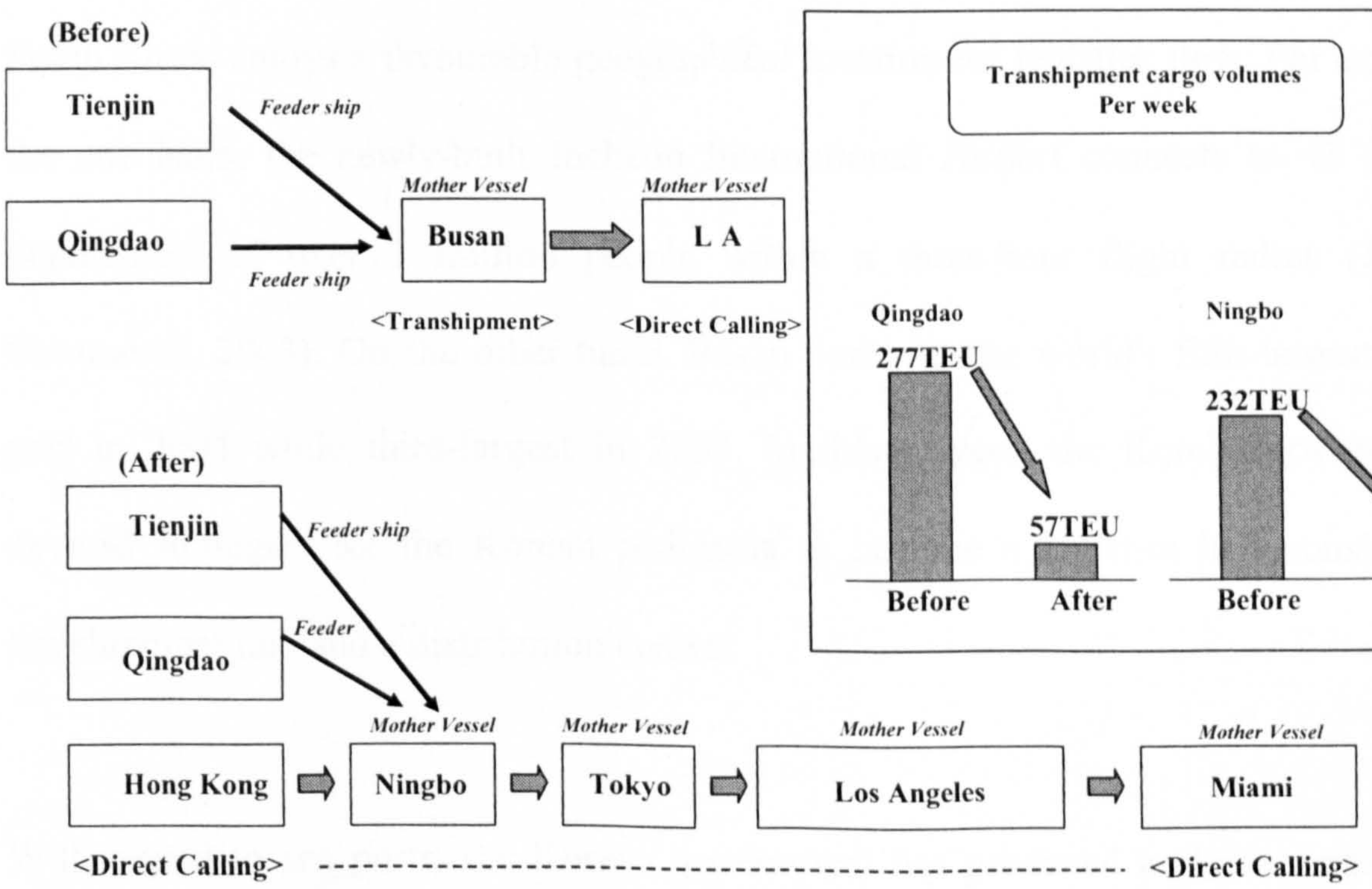
From Korea's perspective, this means losing many feeder cargoes, because up to now the ports in Northern China have usually used Korean ports for feeder services.

Figure 2.3 Feeder cargoes in Korean Ports (China Shipping-USA)



Source: Redrawn by author from figures published by KMI (2003)

Figure 2.4 Feeder cargoes in Korean Ports (MSC-USA)



Source: Redrawn by author from figures published by KMI (2003)

Therefore, Korea's container ports are confronted with severe competition from both world top-class container ports such as Hong Kong and newly emerging container ports including those in Northern China.

2.3.3. Strategies utilized by each nation

To become a logistical hub and take the pole position in NEA, each nation's government focuses on various strategies. Regarding the political risks to East Asian seaports, Tsai and Su (2005, p. 297) argued that "*micro-risks were considered to be more significant than macro risks in affecting business environments. In other words, the carrier enterprises were more sensitive to the governments' port development and management practices than the nations' integrated political and economics conditions*". According to their results, this section deals with the plans and strategies for development each of the government in question has.

2.3.3.1 Port strategies in Korea

South Korea enjoys a favourable geographical location for logistics flow. For example, on the one hand, the newly-built Incheon International Airport connects to 43 cities with populations of over 1 million people within a three-hour flight radius (Journal of Commerce, 2003). On the other hand, Busan port was the world's fifth-largest container port in 2004 while third-largest in 2003. In this respect, the Korean government has devised strategies for the Korean peninsula to become a logistics hub consisting of a transhipment hub and a distribution centre.

With regard to sea ports, the Korean government has produced a plan to make the two ports, Busan and Kwangyang, world hub logistics centres by means of constructing berths, their infra and super structure, and hinterlands etc (Han, 2004).

Table 2.29 Development Plans for Container Ports

	New Busan Port (1995 ~ 2011)	Kwangyang Port (1987 ~ 2011)
Berth	30	33
Capacity	8.04 million TEU	9.13 million TEU
Cost(US $)	8.5 Billion	7.3 Billion
Investors	Private sector, Korea Container Terminal Authority, Government sector	Korea Container Terminal Authority, Government sector

Source: Ministry of Marine Affairs and Fisheries, 2003

Busan Port, seeking to become a Pacific Hub of the 21st Century by 2011, is investing US $ 8.5 billion to construct 30 berths in the container port in Kadukdo, south-west of Busan (Ministry of Maritime Affairs and Fisheries, 2003).

Table 2.30 Development Schedule for New Busan Port

Items (Total 30 berths)	Schedules (1995~2011)
- Phase 1-1 container berth(6 berths)	- Planning: 2001, Completion: 2006, Opening: 2007
- Phase 1-2 container berth(3 berths)	- Planning: 2000, Beginning: 2004, Completion: 2008, Opening: 2008
- Multi-Purpose berth(1 berth)	- Beginning: 2002, Completion: 2007, Opening: 2008
- Phase 2-1 container berth(3 berths)	- Planning: 2003, Beginning: 2004, Completion: 2008, Opening: 2009
- Phase 2-2 container berth(3 berths)	- Planning: 2003, Beginning: 2004, Completion: 2008, Opening: 2009
- Phase 2-3 container berth(4 berths)	- Planning: 2004, Beginning: 2005, Completion: 2009, Opening: 2010
- Phase 2-4 container berth(5 berths)	- Planning: 2005, Beginning: 2006, Completion: 2010, Opening: 2011
- Phase 2-5 container berth(5 berths)	- Planning: 2005, Beginning: 2006, Completion: 2011 Opening: 2012

Source: Ministry of Marine Affairs and Fisheries, 2003, 12.

By 2011, Kwangwang Port is to invest US$ 7.3 billion in the construction of 33 berths and related structures.

Table 2.31 Development Schedule for Kwangyang Port

Items (Total 33 berths)	Schedules (1987~2011)
- Phase 1 container berth(4 berths)	- Planning: 1985, Completion: 1987, Opening: 1998
- Phase 2-1 container berth(4 berths)	- Planning: 1996, Completion: 2001, Opening: 2002
- Phase 2-2 container berth(4 berths)	- Planning: 1999, Completion: 2003, Opening: 2004
- Phase 3-1 container berth(4 berths)	- Planning: 2001, Beginning: 2002, Completion: 2006, Opening: 2007
- Phase 3-2 container berth(3 berths)	- Planning: 2002, Beginning: 2003, Completion: 2008, Opening: 2009
- Phase 3-3 container berth(5 berths)	- Planning: 2003, Beginning: 2004, Completion: 2009, Opening: 20010
- Phase 3-4 container berth(5 berths)	- Planning: 2004, Beginning: 2005, Completion: 2010, Opening: 2011
- Phase 3-5 container berth(4 berths)	- Planning: 2005, Beginning: 2006, Completion: 2011, Opening: 2012

Source: Ministry of Marine Affairs and Fisheries, 2003, 12.

Besides the development plans for the two mega-hub-ports, US$ 38.1 billion will be invested in medium sized container port development in Korea, signalling stronger

container port competition between Korea and China. To enhance an efficient port network, the Korean government has plans in place to connect Busan and Kwangyang to small and medium container ports, e.g., Incheon and Pyeongtaek. The overall forecast for container port traffic in Korea is illustrated in Table 2.32.

Table 2.32 Forecast for container traffic in Korea

(Unit: Thousand TEUs)

		1997	1998	1999	2000	2001	2002	2006	2011	2015	2020
Total	Import	2,306	2,507	2,852	4,428	3,306	3,645	5,119	7,214	9,218	12,396
	Export	2,405	2,651	2,895	3,225	3,285	3,710	5,455	7,650	9,749	13,035
	*	586	634	932	1,264	3,111	4,205	8,005	13,176	16,181	20,928
	Coastal	178	310	295	274	289	329	687	1,628	2,418	3,966
	Sub total	5,475	6,102	6,974	9,191	9,991	11,889	19,266	29,668	37,566	50,325
Busan	Import	1,993	2,154	2,272	2,484	2,497	2,729	2,731	3,075	4,067	5,458
	Export	2,136	2,385	2,406	2,551	2,514	2,792	2,924	3,269	4,208	5,672
	*	586	634	848	1,232	2,943	3,888	5,203	7,246	8,415	10,464
	Coastal	97	138	129	116	119	44	236	448	666	1,094
	Sub total	4,812	5,311	5,655	6,383	8,073	9,453	11,094	14,038	17,356	22,688
Kwang -yang	Import	10	35	235	302	333	367	1,230	2,154	2,489	3,354
	Export	9	24	198	317	344	396	1,270	2,185	2,735	3,697
	*	0	0	14	32	166	314	2,242	4,612	6,391	8,999
	Coastal	0	9	8	27	44	48	108	366	543	889
	Sub total	19	68	455	678	887	1,125	4,850	9,317	12,158	16,939
Incheon	Import	238	241	252	274	308	359	358	665	935	1,194
	Export	195	161	195	210	229	292	290	575	825	1,043
	Coastal	0	0	0	0	1	2	560	1,318	1,375	1,465
	Sub total	433	402	447	484	538	653	1,208	2,558	3,135	3,702
Pyeong -taek	Import	19	68	455	678	887	1,125	4,850	9,317	12,158	16,939
	Export	0	0	0	1	11	34	102	122	153	205
	*	0	0	0	0	10	32	149	208	249	332
	Coastal	0	0	0	0	0	0	54	84	164	225
	Sub total	19	68	455	679	908	1,191	5,155	9,731	12,724	17,701
Others	Import	65	77	93	1,367	157	156	698	1198	1574	2185
	Export	65	81	96	147	188	198	822	1413	1732	2291
	*	0	0	70	0	1	0	0	0	0	0
	Coastal	6	50	31	3	1	120	53	88	175	246
	Sub total	136	208	290	1,517	347	474	1,573	2,699	3,481	4,722

Source: Ministry of Marine Affairs and Fisheries, 2003, 12.
Note: Estimated values from 2006, where * stands for transhipment

2.3.3.2 Port strategies in China

Regarding the first milestone in the Chinese logistics industry, Zhang (2002, p22) summarized that '*China's ministry of communications (MOC) released a memorandum on several viewpoints on accelerating the development of the logistics sector in March 2001 e.g. urge cargo carriers to expand their services to the logistics area, encourage liberalization across the entire field, call for joint ventures between domestic and foreign players and call for provincial governments to reduce regional trade barriers within WTO commitments'.*

Zhu (2004, p117) noted that *'the state economy and trade department (STEP) initiated the logistics standard project and the state technology department decided to make 'e-commerce and modern logistics' in 2002 as the important points'.*

Along with the above efforts, the Chinese government has created more logistics infrastructure and built 73,000 kilometers of national railways, 179,600 kilometers of roads, 12,200 kilometers of internal canal routes and 600 deepwater berths at seaports on the coast. The recent emergence of three major areas i.e. Bohai Sea, Yangtze River Delta (YRD), and Pearl River Delta have brought about more importance to logistics, finally causing logistics to be listed as a key sector in China's 10th Five-Year Plan.

However, Wang et al. (2004, p240) listed the following as the problems affecting Chinese container ports.

1) Inadequate physical infrastructure, including a weak multimodal inland network.

2) Inadequate deep-water ports by international standards.

3) Heavy bureaucratic redundancy.

4) Weak and ambiguous legal framework, including customs bureaucracy.

5) Lack of a healthy competitive and innovative environment in port and shipping industries.

6) Strong political culture of localism as resisting change.

According to Wang and Slack (2004, p364), to solve the problematic issues concerning sea ports, the Ministry of Communication (MOC) has considered a 'rational' re-allocation of port activities as discussed in the following.

Shanghai should be the container hub port which has

1) The role of the international gateway and regional gateway of YRD,

2) The distribution and logistics centre for all cargoes generated or designated in and around Shanghai,

3) The ocean-going transhipment hub for the large container vessels.

This means that all feeder service near the YRD should use Shanghai instead of Hong Kong, Busan or Kobe, and all the other ports, including Ningbo and Nanjing, should be regarded as secondary centres. Recently, Shanghai has invested in the second phase of its multi-billion dollar Yangshan container port project to a consortium including Hutchison, Cosco and APM terminals (Journal of Commerce, 2005).

According to Goh and Ling (2003), the MOC has suggested long-term plans for water transport development from 2001 to 2040, in which the building of another 135 deep-water berth and container handling capacity with 16.5 million TEUs is scheduled by 2010. When the project is finished, the final number of deep-water berths will total 1,100, of which 40 per cent will be able to handle vessel loads of in excess of 30,000 tons.

Ocean Shipping Consultants (2003) estimated that the world trade cargo volumes will be 620 million TEUs in the year 2015. Of these cargoes, Northeast Asia and Southeast Asia will handle 184.7 million and 110.2 million TEUs respectively. The ports in Southern and Northern China, although hampered by limited water depth and lack of port facilities, are expected to grow rapidly. This situation is illustrated in more detail Table 2.33.

Table 2.33 Estimated container throughputs in China's major ports

(Unit: Thousand TEUs per annum)

	2001	2004	2007	2010
Northern China	6 800	11 325	15 340	18 460
Tianjin	2 000	3 150	4 240	5 260
Qingdao	2 600	4 800	7 400	9 500
Dalian	1 800	2 975	3 300	3 300
Others	400	400	400	400
Sourthern China	21 210	27 088	33 894	37 044
Shanghai	6 300	7 500	8 300	9 100
Yangshan	0	0	1 000	2 500
Ningbo	1 200	1 950	2 600	3 250
Fuzhou	450	800	800	800
Xiamen	1 500	2 400	2 400	2 400
Yantian	3 000	3 500	5 000	5 000
Shekou	1 300	2 100	2 900	2 900
Chiwan	2 100	2 800	2 800	2 800
Guangzhou	1 800	1 800	2 500	2 500
H.Delta Ports	1 350	1 350	1 350	1 350
Others	2 210	2 888	4 244	4 444

Source: Ocean Shipping Consultants(2003).

2.3.3.3 Port strategies in Japan

Doi *et al.* (2001, p187) summarized port development plans in Japan as follows:

The Ministry of Transport established the programs of the Ninth Seven-year Port Development Plan in line with the long-term policy in 1995. As part of the programs, high-standard container terminals will be also developed at eight subsidiary gateway ports selected out of the twenty regional main ports. Improvement of port service quality and the introduction of advanced information systems will also be carried out.

Terada (2002) provided an analysis according to which investment had been focused on several container ports such as Tokyo Bay and Osaka Bay so as to keep pace with the rapid developments in containerization. According to her research, Japanese port planning had proceeded from 'draft master plans for each port authority' to 'local port committees', and a 'central port committee in Ministry of Transport (MOT) in that order.

However, in preparation for ever-increasing containership size and re-location of hub ports, the Japanese government has a new strategy, called 'concentration on a few major ports' replacing of the above mentioned procedures from 2002. Furthermore, in 2003, they started a project consisting of the establishment of an integration system of port logistics information. Table 2.34 illustrates the major development plans for Japanese sea ports.

Table 2.34 Major development plans for Japanese sea ports

Ports	Projects	Length of berth (m)	Capacity (millionTEUs)	Estimated completion
Yokohama	Minami Honmoku: Terminal no. 3	700	0.85	2010
	Terminal no. 4	700	0.85	2015
Tokyo	No. 4 Container complex: Phase 1	600	0.40	2005
Kobe	Rokko Island:			
	2 berths of feeder ship	700	0.60	2006
Nagoya	Nabeta berth	350	0.30	2005
Kitakyushu	Hibikinada			
	2 berths for mother vessel	650	0.35	2007
	2 berths for mother vessel	650	0.35	2010
	1 berths for feeder vessel	170	0.05	2010
	2 berths for mother vessel	650	0.35	2015
	2 berths for mother vessel	650	0.35	2020
	1 berths for feeder vessel	170	0.05	2020
Hakata	Island City:			
	3 berths for mother vessel	930	0.80	2005

Source: Ocean Shipping Consultants (2003)

The total container throughputs at the major ports in Japan will be TEU 25.9 million in 2010, of which Yokohama with TEU 6 million and Tokyo and Kobe with 3.6 and 4 million TEU respectively (OCS, 2003).

Table 2.35 Estimated container throughputs in Japan's major ports

(Unit: Thousand TEUs per annum)

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Total	**17,110**	**17,888**	**19,088**	**19,788**	**22,994**	**23,894**	**24,544**	**24,544**	**24,544**	**25,994**
Yokohama	3,650	3,900	4,300	4,300	5,150	5,150	5,150	5,150	5,150	6,000
Tokyo	3,000	3,000	3,250	3,250	3,650	3,650	3,650	3,650	3,650	3,650
Kobe	2,700	3,100	2,600	3,300	3,300	4,000	4,000	4,000	4,000	4,000
Nagoya	2,050	2,050	2,050	2,050	2,350	2,350	2,350	2,350	2,350	2,350
Osaka	2,400	2,400	2,400	2,400	2,400	2,400	2,400	2,400	2,400	2,400
Hakata	600	600	600	600	1,400	1,400	1,400	1,400	1,400	1,400
Kitakyushu	500	500	1,000	1,000	1,000	1,000	1,350	1,350	1,350	1,750
Others	2,210	2,338	2,888	2,888	3,744	3,944	4,244	4,244	4,244	4,444

Source: Ocean Shipping Consultants (2003)

2.3.3.4 Strategies for Taiwanese ports

The Taiwanese government has designed a plan aimed at 'an Asia-Pacific regional operation centre', especially focusing on the industries of logistics, financing and manufacturing. Furthermore, using the country's geographical advantages, they hope to become a global logistics centre. To achieve this goal, they devised a 'global logistics development plan'. The plan involves the construction of a new sea port terminal in Kaohsiung and Teipei which could accommodate 15,000 TEU containerships as shown in Table 2.36.

Table 2.36 Major development plans for Taiwanese sea ports

	Kaohsiung	Taipei
Length of berth (m)	1,500	2,355
Number of berth	4	7
Capacity (million TEUs)	1.6	2.8
Draft (m)	16	15.5
Area (ha)	74.8	94.4
Estimated completion	2009	2014
Construction method (years)	BOT (50)	BOT (50)
Total cost (million US$)	377	629

Due to the development in the neighbouring countries such as Thailand and the Philippines and the recent improved relations with mainland China, the container throughputs in Kaohsiung increased from 3.9 million TEUs in 1991 to 7.4 TEUs in 2000. According to the OSC (2003), the total container throughputs in the major ports in Taiwan are estimated to reach 16.8 million TEU in 2010, of which Kaohsiung's will be 12 million TEU, and Keelung and Taichung will obtain 2.5 and 1.3 million TEUs respectively.

Table 2.37 Estimated container throughputs in Taiwan's major ports

(Unit: Thousand TEUs per annum)

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Total	**13,800**	**13,800**	**13,800**	**13,800**	**13,800**	**14,550**	**15,550**	**16,300**	**16,800**	**16,800**
Kaohsiung	10,000	10,000	10,000	10,000	10,000	10,500	11,000	11,500	12,000	12,000
Keelung	2,500	2,500	2,500	2,500	2,500	2,500	2,500	2,500	2,500	2,500
Taichung	1,300	1,300	1,300	1,300	1,300	1,300	1,300	1,300	1,300	1,300
Tamsui(Taipei)	0	0	0	0	0	250	750	1,000	1,000	1,000

Source: Ocean Shipping Consultants (2003)

2.4 Problematic Issues and Research Direction

To summarize the above sections, the following results and issues emerged.

Firstly, although severe port competition has occurred in NEA, only a few limited studies have been carried out on this theme in this region. More specifically, in most of the previous research, which has dealt with the regions of Europe and USA, the analyses have been rather general in terms of very few factors having been utilised.

Moreover, their targeted area was rather broad and sometimes out of the range of port competition. On the other hand, some studies only focused on a very limited number of ports even though there were other ports in competition near the ports selected.

Secondly, no exact definition of port competition and competitiveness for ports located in NEA exists.

Thirdly, to improve container port competitiveness, each nation concerned has adopted complex port strategies. Among these, an extremely small number of factors can be expressed in quantitative data, while many of them have qualitative characteristics. Furthermore, these qualitative factors are extracted from expert knowledge and decision makers' perceptions. With regard to this issue, a suitable methodology is needed and this will be further investigated in the following Chapters.

CHAPTER 3

Container Port Competitiveness: Literature Review and Definition

The role of sea ports has changed from the traditional sea and land interface to that of value added logistics (UNCTAD, 2004). Various strategies have been introduced to improve profits and attract port throughputs. Shipping companies, which usually interact with ports as customers, have always chosen the most efficient ports and services, and also concentrated on a limited number of ports due to scale economics. For these reasons, port competitiveness has concerned stakeholders with port-related interests. In this Chapter, key factors influencing container port competitiveness will be drawn out through a literature review and they will provide the foundation for further analysis. After the introduction, in the first section, thorough reviews of port competitiveness are provided. This section covers six aspects. The first and the second deal with port competition and selection, examining the stakeholders' various views. In the third and fourth, port efficiency and port performance are investigated. In the fifth, determinants for port service are discussed before the sixth discusses other relevant port-related issues. In the second section, the conceptualisation of port competitiveness will be obtained by means of using the reviews from the first section.

Regarding port competitiveness, Haezendonck and Notteboom (2002) argued that it is not determined only by port related components but also decided by a combination of elements including logistics chain concepts. In this respect, the definition and the selection of the determinants of port competitiveness are becoming problematic.

When investigating key influential factors for port competitiveness, Fleming and Baird (1999) focused on the UK, the USA and northwestern Europe. They found that port

competitiveness has been impacted on by six sets of key influences, of which the following are the suggested major ones (Fleming and Baird, 1999, p.389)

Port tradition and organization

- *In cities where there has been a long tradition of high-level political support for port expansion projects this, therefore, gives rise to a culture supporting constant port improvement.*

Port accessibility by land and sea

- *Accessibility may be further enhanced through natural advantages such as deep water channels and sheltered location. On the landside, direct connections to highways, rail and inland navigation systems will further benefit a port.*

State aid and its influence on port costs

- *The greater the state aid, then the lower will be port costs.*

Port productivity

- *Productivity can be affected by a number of factors i.e. the level of technology used in cargo handling and information management, labour practices and extent of training, labour costs and, the amount of land available for stacking and quay length for berthing vessels.*

Port selection preferences of carriers

- *Carriers and shippers are showing less loyalty to specific ports and easily move their traffic over routes which offer the best outcomes in terms of their preferences.*

Comparative locational advantage

- *The relative geographic location of the port i.e. centres of production and consumption, and major trade lanes and their intersections, is an important consideration.*

Kent and Ashar (2001) suggested a conceptual framework for monitoring port competitiveness. They were attempting to introduce different aspects of the competitive setting of a sea port, and concluded that it can be seen as consisting of the following four options (Kent and Ashar, 2001, p.34).

Transportation Options

- *the competitiveness of the country's entire port inland transport system in terms of total system costs*

Operational Performance

- *the competitiveness of each port in terms of availability and level of cargo handling services*

Tariff Comparison

- *the competitiveness of each port in terms of its level of charges (costs)*

Financial Performance

- *the competitiveness of each port, in terms of its overall profitability*

More recently, Tongzon and Heng (2005, p.409) analysed how competitive advantage can be maintained and retained. They argued that private sector participation in a sea port can optimize its operational efficiency, and through increased efficiency, the port can obtain competitive advantage. The important factors and definitions determining port competitiveness suggested by them were the following.

Port operation efficiency level

- *The level of efficiency can represent how quickly containers are handled and how quickly vessels are turned around at ports. The higher the efficiency level of a port or terminal operation, the more port users are likely to choose it as their port of call, which, in turn, will make the port gain more market shares.*

Port cargo handling charges

- *A port with a lower charge is more competitive than its rivals, holding other factors constant. Since cargo handling services are the most important for port users in terms of total charges, these charges significantly affect a port's competitive position.*

Reliability

- *Reliability means a steady and predictable performance adapted to shipping lines' schedules. If a port authority or port operator always causes delays during operations due to strikes, equipment breakdown, weather, etc, shipping companies and shippers will suffer huge losses due to these kinds of unreliability.*

Port selection preferences of carriers and shippers

- *Carriers and shippers are showing less loyalty to specific ports. Ports face the constant risk of losing important clients because the client has rearranged its service networks or has engaged in new partnerships with other carriers in terms of port selection preferences.*

The depth of the navigation channel

- *Insufficient water depths in access channels and port basins prevent some ports from being a Transhipment centre.*

Adaptability to the changing market environment

- *A successful port must constantly be prepared to adopt new roles in order to cope with the changing market environment*

Landside accessibility

- *New remote coastal terminals with good landside connections, and ports strategically located close to the main global trade lanes, increasingly offer carriers and shippers a more appropriate option.*

Product (service) differentiation

- *A differentiation strategy aims at providing specific port services in market niches distinct from those provided by other ports, offering greater value to the port users. This is so-called economies of scope.*

To summarize, studies of port competitiveness comprise six categories i.e. port competition, port efficiency, port performance, port selection, port service and other related issues. Fuller reviews are provided in the following sections detailing the characteristics of each category.

3.1 Port Competition

Because it involves various stakeholders with conflicting interests, an unequivocal definition of port competition is very difficult (Voorde and Winkelmans, 2002). However, competition between seaports is becoming fierce owing to the process of shipping companies forming strategic alliances, the reduction of their port calls, the enlargement of their vessels and the increased requirements to port service providers. As a consequence of this pressure, many ports have been forced to establish new strategies for competing with their rivals (Perez-Labajos and Blanco, 2004).

Voorde and Winkelmans (2002, p.11) argued that when defining port competition, every aspect relevant to ports and competition needs to be included, and provided the following definition:

"Sea port competition refers to competition between port undertakings, or as the case may be, terminal operators in relation to specific transactions. Each operator is driven by the objective to achieve maximum growth in relation to goods handling, in terms of value added or otherwise. Port competition is influenced by (1) specific demand from consumers, (2) specific factors of production, (3) supporting industries connected with each operator, and (4) the specific competencies of each operator and their rivals. Finally, port competition is also affected by port authorities and other public bodies".

Meanwhile, Veldman and Buckmann (2003) used two major factors for analysing port competition and choice i.e. cost and quality of service. They concluded that a large amount of competition existed in the Antwerp–Hamburg range because there were many alternative routings which could be chosen by the customer, and great overlap between the hinterlands of sea ports. These factors were (Veldman and Buckmann, 2003, p.10):

Cost factor

- *The costs of transporting a container between the stack in a seaport and the centre of a hinterland region*

Service factor

- *Frequency of service*
- *Quality of service*
- *Probability of choosing a route*

Perez-Labajos and Blanco (2004) stated that nowadays commercial sea ports have been losing the 'loyalty' of their traffic and have to establish new strategies for securing customer loyalty. In this respect, they suggested two important factor groups i.e. one concerned with commercial factors and the other dealing with technological factors. They argued that the former consisted of the level of infrastructure, transport networks, logistics services, level of port operation, regularity of services and differentiation of prices and/or quality. On the other hand, the technological factor e.g. electronic data interchange (EDI), vessel traffic system (VTS) and geographic information system (GIS) was needed to help information flows between the relevant activities.

Very interestingly, Ohashia *et al.* (2005) claimed that suggesting meaningful results for airport competition had been problematic because there had been a limited number of studies available and very few empirical. They referenced sea port competition factors and suggested two major factors i.e. cost and service quality, already discussed above in connection with Veldman and Buckmann (2003). Their detailed definitions are as follows (Ohashia *et al.*, 2005, p.151).

Cost factor

- *Port charge*
- *Cargo transport cost*

Service quality factor(time cost)

- *Cruising/flight time*
- *Loading and unloading time*
- *Customs clearance and other processing time*
- *Waiting time for the next available flight*

In the above three studies, multi-dimensional factors were used for evaluating port competition. However, the following researchers have introduced a single or simple measure for calculating the competition phenomenon.

Rimmer (1998) argued that port competition and/or selection were closely related to the ports' location and throughput. These factors, in turn, affected direct port calls of shipping companies.

Regarding port calls by shipping companies, Robinson (1998) suggested that a more complex hierarchical port network needed to be produced. He used port calls as an evaluation factor of port competition i.e. mega-terminals have over twenty daily calls, second order ports between ten and twenty, and finally third order ports less than ten.

McCalla (1999) claimed that concentration of port service was the most effective way to keep and attract port traffic. He emphasised the fact that the right responses such as an increasing number of terminals and cranes, could meet the demands of shipping companies.

Chang (2000) noted that Transhipment and intermodal cargo were the crucial factors to improve port competition. He concluded that transhipment cargoes made container ports increasingly larger, even to such an extent as Hong Kong and Singapore, and also insisted that "*Tacoma's success in attracting SeaLand shipping line from neighbouring Seattle is due to better access to intermodal facilities*"(Chang , 2000, p54).

Fung (2001, p.4) also emphasised the importance of transhipment cargos for port competition. He stated that the biggest beneficiaries from transhipment cargoes were Hong Kong and Singapore.

"Since the late 1980s, the rising domestic production cost in Japan and in other newly industrialized economies (NIEs) in Asia, namely Taiwan, South Korea, Hong Kong and Singapore, has forced manufacturers in these economies to move their operations into neighbouring low-cost regions, such as China, Thailand, Indonesia, Malaysia and the Philippines. However, the port facilities in those low-cost regions are not sufficient to cope with the large volume of exports and imports. Consequently, the manufacturers have to tranship their products and materials through major ports in East and Southeast Asia".

Heaver *et al.* (2001) proposed two critical factors i.e. port location and network strategies which are regarded as very influential for port competition. They argued that when ports were located in a prime location, they could have an advantage in the negotiating stage with their customers. They also stressed the importance of network strategies as follows (Heaver *et al.*, 2001, p.300):

> *"Initially, such new competitors may not pose much of a threat, but some gain a critical mass of traffic and establish effective hinterland connections. Monitoring the effectiveness of new ports requires careful attention to the success of their network strategies, even at the level of agencies and forwarding firms".*

From a different point of view, Song (2002) analyzed the administrative and ownership structures of ports. He found that the Hutchison Port Holdings Group had largely invested in Hong Kong, although they were also active in the private sector in Shenzhen port, which actually was a rival of the former. He summarized that competition and co-operation occurred at the same time in special regions and, therefore, the terminal operators there needed to adopt two-sided strategies to deal with both situations, so-called co-opetition (Song, 2003).

Along the same lines as Rimmer (1998), Yap and Lam (2006), in an attempt to unveil the competition dynamics in East Asia container ports, used container throughput as a factor of competition.

3.2 Port Selection

In this section, studies published after 2000 were thoroughly analysed, and more detailed reviews will be provided in Section 3.8.

With regard to port selection, Lirn *et al.* (2003) investigated the transhipment port selection criteria and sub-criteria. They identified 47 relevant criteria through a literature review, and

grouped these into four and 16 sub-criteria using the Delphi technique, in which opinions were asked for from 10 experts on the shipping industry. Suggested major factors were as follows (Lirn *et al.*, 2003, p.240):

1) Port's basic physical characteristics
- *Infrastructure improvement*
- *Port facilities and equipment*
- *Convenience of inter-modal link*
- *Size of marshalling yard and container yard*

2) Port's geographical location
- *Closeness to import/export consumption areas*
- *Closeness to main navigation route*
- *Proximity of feeder ports*
- *Proximity of competing ports and modes*

3) Port's management
- *Port administration and customs regulation*
- *Berthing delay and loading/discharging rate*
- *Port safety and terminal security*

4) Carriers' cost perspective
- *Carrier's loading/discharging cost*
- *Ownership of the port and terminal*
- *Privileged terms to the carriers*
- *Government levy and duty*

After another round of Delphi technique in 2004, they reduced the criteria from 16 to 12 so as to improve the clarity and consistency of the questionnaire (Lirn *et al.*, 2004). The final highest importance weights using the AHP method suggested were 'handling cost of containers', 'proximity to main navigation routes', 'proximity to import/export areas', 'basic infrastructure condition' and 'existing feeder network'.

Nir *et al.* (2003) analysed port choice behaviour from the shipper's perspective in Taiwan. They used four variables i.e. travel time, travel cost, route and frequency in a linear multiple port choice model to select competitive ports, and suggested that travel time and cost are the most significant variables.

In addition to the study by Nir *et al.* (2003), Tiwari *et al.* (2003) examined the shippers' port and carrier selection problem using a discrete choice model. From the literature reviews, they proposed in broad terms that the influential determinants for the selection of sea port, shipping line and shipper were the following (Tiwari *et al.*, 2003, p.32):

1) Port characteristics
- *Ship calls*
- *Total TEU handled at the port*
- *Number of berths*
- *Number of cranes*
- *Water depth*
- *Routes offered*
- *Usage factor*
- *Port and loading charges*

2) Shipping line characteristics
- *Total TEU handled during the year*
- *Fleet size*

3) Shippers' characteristics
- *Distance of shipper from port*
- *Type of trade*
- *Distance of foreign port in nautical miles*

Among the above determinants, they finally came to the conclusion that the most important factors were the distance of the shipper from port, distance to destination (in case of exports), distance from origin (in case of imports), port congestion, and shipping line's fleet size.

Malchow and Kanafani (2004) attempted to find significant criteria for port choice in the USA using the discrete choice model. They argued that more efficient ports had higher level of competitiveness. The following are the variables proposed by them relating to port efficiency in terms of transit time and cost (Malchow and Kanafani, 2004, p.321):

1) Transit time
- *Distance from origin to port,*
- *Time needed to transfer shipment from ground to vessel,*
- *Time incurred as vessel calls at other ports in transit*
- *Oceanic distance from port to shipmen's destination.*

2) Operating cost

- *Inland distance from origin to port,*
- *Charges assessed by port,*
- *Oceanic distance from port to destination of shipmen*
- *Average vessel size, representing economies of scale and density.*

However, due to limitations on collecting data, only four variables i.e. oceanic distance, inland distance, sailing headway, and vessel capacity were used.

From a slightly different point of view, with regard to the ship managers' selection problem, Panayides and Cullinane (2002) considered 14 variables i.e. price, size, advertising, reputation, recommendation, technical ability, experience, qualifications, time, service range, location, specialization, large managed fleet and own vessels to be of importance. After the questionnaire survey, they found that the three most important factors were 'reputation of the company', 'technical ability of personnel' and 'price'.

Regarding shippers' perception of the truckload industry, Kent *et al.* (2001) noted that the important selection attributes were reputation for quality and integrity, knowledge and problem solving skills, competitive pricing, action and following up on service complaints, consistency and transit times.

On the other hand, from the aspect of supplier selection, Bevilacqua and Petroni (2002) suggest nine critical factors i.e. total cost, implementation of total quality management (TQM), cycle times and just-in-time (JIT) delivery capability, technological capabilities, flexibility of response to customers, financial stability, after-sales technical, organisational, cultural and geographical position.

From the results of the above three studies, it can be concluded that similarity exists in choice problems. That is, costs are very important variables in every choice study. The

geographical location and service attributes can also be regarded as valuable in these kinds of studies.

3.3 Port Efficiency

Cullinane *et al.* (2002, 2006) attempted to measure port efficiency by using data envelopment analysis and the stochastic frontier model. Regarding variables, they reviewed the previous studies and suggest three inputs i.e. terminal quay length, terminal area and the amount of cargo handling equipment, and one output variable i.e. annual container throughput in TEUs.

Along lines similar to Cullinane et al. (2002), Itoh (2002) also used four input variables i.e the number of container berths, the number of cranes, the area of container terminal and the labour condition, and one output variable i.e. handling volumes for export and import.

With reference to factors influencing port efficiency, Sanchez *et al.* (2003, p.210) investigated more specifically the determinants using principal component analysis and suggested the following three factor groups:

1) Port's time efficiency
Bureaucratic turnaround of a container
Terminal turnaround for loading and unloading of a container
Average waiting time for ships during congestion time
Average waiting time for ships without congestion in the port
Time of port congestion during the year.

2) Productivity of terminal
Loading and unloading rate per hour
Handling capacity
Average number of containers per ship handled in terminals

3) Average port stay of ships

Inversely, Everett (2003) argued that political interference caused major inefficiencies within sea ports.

Barros and Athanassiou (2004) examined thoroughly the input and output criteria, and used four factors for output i.e. ships, movement of freight, total cargo handled and containers loaded and unloaded, and two for input i.e. labour and capital.

3.4 Port Performance

With regard to port performance, Turner (2000) investigated the link between terminal leasing policy and throughput productivity in North America. He argued that pooling of demand in port terminals could reduce the vessel time in port and, in turn, increase port performance. To model this system, he used the following variables (Turner, 2000, p.286).

- *Number of container terminals.*
- *Type of terminal operation (dedicated or common-user).*
- *Number of container gantry cranes by terminal.*
- *Handling rate (moves/hour) of container gantry cranes.*

From another point of view, De and Ghosy (2003) examined the relationship between port performance and port traffic in Indian ports. They claimed that higher performance rates lead to more port traffic, which could improve port throughputs. They used the following port performance index (De and Ghosy, 2003, p.7):

1) Operational performance
- *Ship turnaround time (TRT),*
- *Pre-berthing waiting time(PBWT),*
- *Percentage of idle time at berth to time at working berth (PITTWB),*

2) Asset performance
- *Output per ship berth day (OSBD),*
- *Berth throughput rate (BTR),*
- *Berth occupancy rate (BOR))*

3) Financial performance
- *Surplus per tonne of cargo handled (PTOS)*
- *Rate of return on turnover (RRT)*

Bichou and Gray (2004) argued that conventional methods for measuring port performance were biased towards sea access. They suggested an integrated concept which included the concept of port performance and supply chain management.

In the same field, Lai *et al.* (2002) also analysed the supply chain performance of transport logistics. They suggested three categories: 'service effectiveness for shippers', 'operations efficiency for transport logistics service providers' and 'service effectiveness for consignees', including 26 determinants of performance evaluation. They concluded that the most important factors to improve performance were the service factor and the efficiency of operation.

Furthermore, regarding the service factor, Stank *et al.* (2003, p.27) provided the following definition: *"Logistics service performance, therefore, assesses a provider's ability to deliver consistently requested products within the requested delivery time frame at an acceptable cost"*. Their suggested measurement items of evaluation are as follows (Stank *et al.*, 2003, p.53):

1) Assessment of service performance
- *Operational performance*
- *Relational performance*
- *Cost performance*

2) Assessment of satisfaction and loyalty
- *Customer satisfaction*
- *Customer loyalty*

3) Assessment of financial performance
- *Market share*

From a slightly different point of view, Chou and Liang (2001) analysed the performance of the shipping company. They also drew out three criteria i.e. customer service quality, logistics service quality, and financial performance, and ten sub criteria. They concluded that financial performance was the most important criterion. In another analysis of the performance of the shipping industry, Panayides (2003, p123) found a *"positive*

relationship between pursuing competitive strategies and company performance in ship management". From the results of the above two studies on ports related industries, service quality, financial performance and competitive strategies can be regarded as the most important factors. These results are in line with those in the previous section regarding the sea port industry.

3.5 Port Service

McCalla (1999, p.253) stated that many ports are faced with "the global issues and the local responses" regarding port service. He also mentioned that global issues included global shipping alliances and the enlargement of vessels. He also explained that the local responses were efficient reactions (services) from the port's side towards the customers' needs e.g. improvement for draught, terminal capacity, labour productivity and port cost.

Haralambides (2002, p.323) argued that port price, which consisted of port dues and cargo handling charges, was one of most important port service factors, and went on to state that port price could *make or break a port.*

For evaluation of port service quality, Ha (2003) investigated the criteria and sub criteria in broad terms, and suggested the following seven major criteria and 30 sub criteria (Ha, 2003, p.134):

1) Ready information availability of port-related activities
- *Efficient operation and quality of customs clearance*
- *Efficient establishment of EDI system*
- *Provision of port-related information through the Internet*
- *Provision of a cargo tracing system*

2) Port location
- *Suitable location in main trunk routes*
- *Effective location as the Transhipment centre*
- *Convenient entry/exit for ultra-large container ships*

3) Port turnaround time
- *Ship congestion in port*

- *Free dwell time for containers*
- *On-dock handling of containers*

4) Facilities available

- *Provision of vessel traffic system*
- *Provision of effective approaching channel*
- *Establishment of intermodal transport systems*
- *Availability of adequate container yards and backup facilities*
- *Availability of container handling equipment*
- *Procurement of extra container berths for unexpected circumstances*
- *Automation of cargo-handling systems*

5) Port management

- *Port labourers' performance*
- *Port workers' safety rules*
- *Port authority's sales activities and marketing advertisement*
- *Port workers' foreign language skills*

6) Port costs

- *Port charges*
- *Terminal handling charges*
- *Pilotage*
- *Towage*

7) Customer convenience

- *Ready procedure for port use*
- *Reflection of container port users' opinions and requirements*
- *Immediate handling of container port users' dissatisfaction*
- *Settlement of accident claims in port*
- *Favours and benefits to the regular shipping operators*

Very interestingly, the determinants suggested above have similarity to the factors affecting port competition and port choice.

Pallis and Vaggelas (2005) stated that for better port service, every port should have at least two providers, and they categorized port service into two parts as follows (Pallis and Vaggelas, 2005, p.118):

Technical–navigational services
Pilotage, towage, and mooring

Cargo-handling services
Stevedoring, stowage, Transhipment, and other intra-terminal transport
Storage, depot, and warehousing
Cargo consolidation

Regarding the logistics service industry, Lu (1999, 2000) investigated important strategic dimensions and revealed that the most important principal components were value-added service, promotion, equipment and facilities, speed and reliability.

3.6 Other Issues

Among the six categories, five are concerned with the major issue of port competitiveness, however, the final one can be expressed as dealing with other, minor issues related to port competitiveness e.g. port policy, privatization, construction of container terminals and port functions.

Regarding port policy, Wang *et al.* (2004) analysed China's port governance and suggested two sub models i.e. Shenzhen and Shanghai. The former pursued the '*hands-off*' policy, which indicated that the port authority performed overall port management according to the concept of commercial operations, while the latter is run by central government. The latter model could also be easily found in the older major ports in China, which mainly relied on institutional resources. The above authors argued that the former could be regarded as the better model of the two.

Tsai and Su (2005) also assessed container ports in terms of political risk. They constructed political risk factors and structures using the Delphi technique and suggested the following nineteen significant factors (Tsai and Su, 2005, p. 294):

1) Port development policy

- *Port organization pattern*
- *Liberalization and internationalization degree*
- *Industrial potential in neighbouring areas*
- *Relative to other international ports within a nation*

2) Port management policy

- *Private financing policy of port infrastructure*
- *Port due and charge policy*
- *Efficient operation policy*

- *Customs practices*

3) Foreign enterprise policy

- *Capital and remittance controls*
- *Tax incentives*
- *Trade restriction*

4) Political and social systems

- *Political stability*
- *Government efficiency and incorruptibility*
- *Internationalization*
- *Social stability*

5) Macro economic factors

- *Economic invigoration*
- *Stability in interest and foreign exchange rates*
- *GDP growth*
- *Balancing of national saving and debt*

They argued that lower political risk would provide for better business environments, and also attract more carriers and greater cargo volumes. In addition, they concluded that port stakeholders were more sensitive to micro political risk e.g. port development and management practices rather than macro political risk e.g. economic invigoration, stability in interest and foreign exchange rates, GDP growth and balancing of national savings and debt. Chan (2005) also found similar results regarding state policy and regulation in the USA. He claimed that regulation had a significant influence on logistics activities. Regarding government regulations on the ports industry, Baird (1995) provided four models of port administration using the degree of regulatory control: pure public sector, public/private, private/public and pure private sector. Recently, many mega hub ports have introduced the concept of privatisation in their operation to improve port competitiveness.

Wang and Slack (2000) examined container ports in the Pearl River Delta in China and stated that the most important factors which influenced port competitiveness were port policy, the impact of globalization and container standardization, the impact of multi modal accessibility and connectivity and port cost. Along similar lines, Seabrooke *et al.* (2003) stressed similar important factors for port competitiveness in Hong Kong i.e. macro

economic conditions, regional competition, China's entry to the WTO, and the direct trade between China and Taiwan.

Haralambides (2002, p.328) divided port function into two i.e. hub and feeder, which derived from economies of scale in liner shipping and the capital-intensity of modern containerships, and argued that they severely impacted on port competitiveness.

3.7 Summary of Reviews

In the above Sections, six categories regarding port competitiveness were fully reviewed. In the case of the category of port competition, numerous factors were identified and suggested. Among these, the most significant were cost, quality of service, technology used, location, throughput, port network, and attraction of Transhipment cargos.

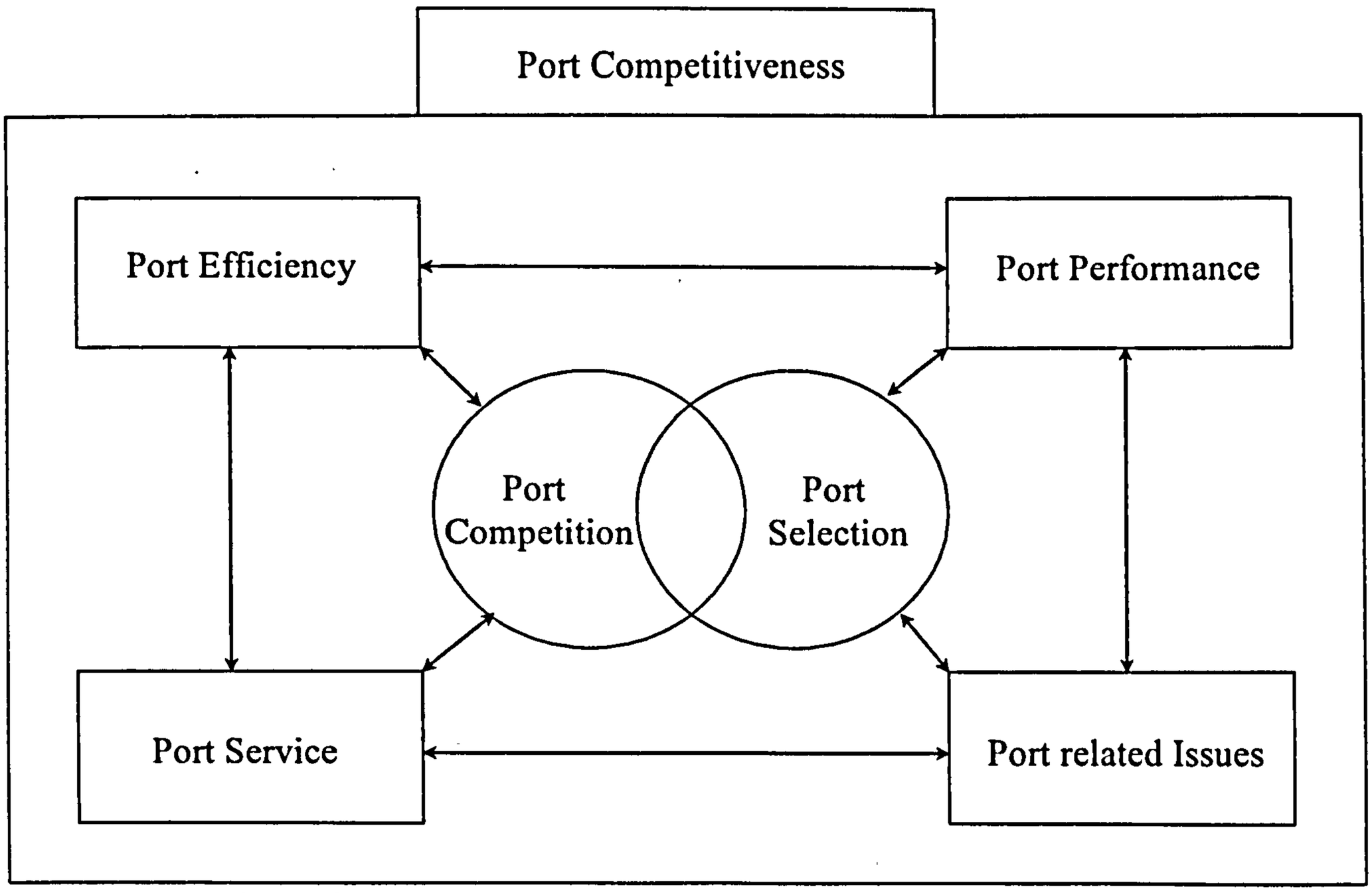
The category for port selection has very similar, important factors with the category of port competition. The factors obtained are the physical characteristics of the port, its location, management, cost, frequency of calling, time spent in port and congestion. The results of these two categories can provide a direction for port competitiveness.

In the category for port efficiency, the previous studies stressed the port's time efficiency and the productivity of terminals, while in the category for port performance, the emphasis lay on the performance of operation, assets and finance.

The important factors for the port service category were in line with those of port competition. Finally, regarding the category for other port related issues, port policy, globalization and the bargaining power of shipping companies were regarded as the most important factors.

To summarize the above results, six categories seem to overlap to a great extent. However, the main categories were identified as 'port competition' and 'port selection' as shown in Figure 3.1.

Figure 3.1 Conceptual diagram for port competitiveness



Source: Drawn by author

3.8 Conceptualisation of Port Competitiveness

As mentioned in the previous section, the evaluation of port competitiveness has mainly focused on research into port competition and selection. In order to provide a clearer definition and to formulate a conceptual framework of port competitiveness, this section mainly concentrates on reviews for port competition and/or port selection from 1980 to the early 2000s.

In the 1980s, Pearson (1980), Willingale (1981), Collison (1984) and Slack (1985) suggested various components of port selection which covered Europe, America and Southeast Asia. Moreover in the 1990s, Peters (1990), Murphy et al. (1988, 1989, 1991 and 1992), UNCTAD (1992), Brooks (1984 and 1985) and McCalla (1994) revealed varying

analytical dimensions and major factors influencing them. Studies in the 1990s included American studies of the geographic location of ports, inland railway transportation, investment in port facilities and the stability of port labour (Starr, 1994).

In 1995, Tengku's PhD thesis at Cardiff University, entitled 'Marketing of freight liner shipping services with reference to the Far East-Europe trade: a Malaysian perspective', highlighted port tariffs, safe handling of cargoes, confidence in port schedules and port service. A year later, at the same institution, in Chiu's PhD thesis 'Logistics performance of liner shipping in Taiwan' it was noted that customs service, rapidity of processing, simplicity of documentation in port, cargo damage and skills of port labour influenced port competitiveness (Table 3.1).

Table 3.1 Literature review of components of port competitiveness

Author (date)	Components identified
Pearson (1980)	Confidence in port schedules, Frequency of calling vessels, Variety of shipping routes, Accessibility of port
Willingale (1981)	Navigation Distance, Hinterland nearness, Connectivity to ports, Port facilities, Availability of port, Port tariffs
Collison (1984)	Average waiting time in port, Confidence in port schedules, Port service capacity
Slack (1985)	Calling frequency, Tariffs, Accessibility to the port, Port congestion, Inter-linked transportation networks
Brooks (1984, 1985)	Port costs, Frequency of calling vessels, Port reputation and/or loyalty, Ship direct calling, Experience of cargo damage.
Murphy et al. (1988, 1989, 1991, 1992)	Availability of loading and unloading facilities for large and/or odd-sized freight, Allows for large volume shipments, Has low freight handling shipments, Provides a low frequency of loss and damage, Has equipment available, Offers convenient pickup and delivery times, Provides information concerning handling, Offers assistance in claims handling, Offers flexibility in meeting special handling requirements
Peters (1990)	Internal factors; Service level, Available facility capacity, Status of the facility, Port operation policy External factors; International politics, Change of social environment, Trade market, Economic factors, Features of competitive ports, Functional changes of transportation and materials handling.
UNCTAD (1992)	Geographical location, Hinterland networks, Availability and efficiency of transportation, Port tariffs, Stability of port, Port information system
McCalla (1994)	Port facilities, Inland transportation networks, Container transport routes
Starr (1994)	Geographic location of ports, Inland railway transportation, Investment of port facilities, Stability of port labour
Tengku (1995)	Port tariffs, Safety handling of cargoes, Confidence in port schedules
Chiu (1996)	Customs service, Rapidness, Simple documents in port, Cargo damage and skills of port

Later, Malchow and Kanafani (2001) analysed the flow of four commodities in eight major U.S. ports. Moreover, they extended their studies in ten major U.S. ports by incorporating additional attributes finding that the most significant characteristic of a port was its location (Malchow and Kanafani, 2004). Recently, Tongzon and Heng (2005) suggested eight determinants of port competitiveness and Bichou and Gray (2005) argued that port competition would shift from the institutional, functional and/or spatial levels to channel management.

Some regional research into port competition between Korea and China has also been undertaken. Kim (1993) analyzed the port selection decisions by Korean shippers, consignees and shipping liners. According to him, in reducing order of significance, export port selection depended on distance between origin and destination, annual cargo handling volume, loading hours, average detention hours at port, goods value per tonne and inland trucking cost per kilometre affected. Sea transportation distance, number of liner calls, annual volume imported and inland transportation charges per unit distance were also regarded as the major factors affecting import port selection. In Jeon's study in 1993, port selection was found to depend on navigation facilities and equipment holding status, port productivity, price competition, and port service quality. Song and Yeo (2004) identified five most important criteria for the competitiveness of port businesses in Asia: cargo volume, port facilities, port location, service level and port expenses.

From the literature review in this section, many influential factors dealing with port competitiveness could be drawn, of which the following final 38 were selected after eliminating overlaps.

Table 3.2 Selected components of port competitiveness

1. Availability of vessel berth on arrival in port	21. Port accessibility
2. Cargo proportion of Transhipment cargo	22. Port congestion
3. Cost for cargo handling, transfer and storage	23. Port sales: port promotion
4. Cost related vessel and cargo entering	24. Port's safety
5. Deviation from main trunk routes	25. Real working time
6. Efficient inland transport network	26. Recognition and reputation of port
7. Free dwell time on the terminal	27. Reliability of schedules in port
8. Frequency of cargo loss and damage	28. Service capacity for ship's size
9. Frequency of large container ships' calling	29. Size and activity of FTZ in port hinterland
10. Frequency of ship's calling and diversify of ship's route	30. Size of contiguous city's economy
11. Government, local autonomous entity, private sectors	31. Sophistication level of port information & its application scope
12. Inland transportation cost	32. Stability of port's labour
13. Inter-modal link	33. Terminal productivity
14. Land distance and connectivity to major shippers	34. Volume of inducing cargoes by your company
15. Level of service for fresh water, bunkering and ship's products	35. Volume of total container cargoes
16. Level of ship's entrance and departure navigation aids systems	36. Water depth in approach channel and at berth
17. Number of direct calling of ocean going vessel	37. Zero waiting time service
18. Professionals and skilled labour in port operations	38. 24hour/seven days a week service
19. Prompt response	
20. Promptness of issue document handling	

Regarding port competitiveness, Haezendonck and Notteboom (2002, p.68) mentioned that *"seaports' competitiveness is becoming increasingly dependent on external co- ordination and control"*. Perez-Labajos and Blanco (2004) stressed the fact that the level of vertical integration and horizontal integration could be used as a measure of port competitiveness. Yap and Lam (2006) also suggested critical factors to improve port competitiveness i.e. hinterland accessibility, productivity, quality, cargo generating effect, reputation and reliability. In this context, the selected port competitiveness components in this section can be regarded as reasonable because competitiveness is not only related to the port on its own but also to the nodal points in the logistics chain.

3.9 Problematic issues and research direction

For the use of the selected port competitiveness factors in Section 3.8 above, there still remain critical issues i.e. the difference of geographical focus and the choice of key factors.

Regarding the former, Fleming and Baird (1999) argued that "*different ports in different parts of the world do it differently*". That is, every different region has its own laws, policies, traditions and historical background.

In the above sections, the results from the review drawn from the six categories regarding port competitiveness, clearly indicate the differences between each region. Therefore, according to the research objective, involving the analysis of NEA, suitable factors should be chosen from the 38 suggested.

With regard to the choice of key factors, the factors still have a slight overlap, and unimportant factors for the research region remain, of which a more detailed discussion will be provided in Chapter 4. Furthermore, using all these factors in the methodology will cause problems with time and cost limitation. For these reasons, undertaking the selection of key factors using scientific methods is a crucial process and will be explained in Section 5.2.1.

CHAPTER 4

Proposed Conceptual Model for evaluating Port Competitiveness

Among the factors suggested in Chapter 3 for the improvement of port competitiveness, very few have quantitative characteristics. Furthermore, when they are related to confidentiality and corporate business secrets, obtaining secondary data is impossible. Thus, the main difficulties in dealing with such factors are investigated in this chapter. To overcome these problems and to solve those associated with port competitiveness, a conceptual model will be provided. This Chapter consists of four sections. In the first section, reviews of previous studies using proxies for factors are investigated. The second section mainly analyses the obstacles occurring when measuring the fuzziness data obtained. The third section deals with the methodological limitations in the previous studies for solving the problems in evaluating port competitiveness. In the final, fourth, section, the conceptual model for the evaluation of port competitiveness will be suggested.

4.1 Approaches Used in Previous Research

In Chapter 3, studies regarding port competitiveness were thoroughly reviewed and every aspect of significant factors identified. However, some but not all of these factors have been used in the majority of the studies reviewed due to reasons such as the limitation of time and cost, the confidentiality of data and the difficulties in obtaining data. Therefore, the input factors have been abstracted and only a limited number have been selected. Furthermore, for use of the mathematical model, a few quantitative variables have been used as proxies.

Kent and Ashar (2001) suggested a conceptual framework for monitoring port competitiveness, which consisted of four options: those for transportation, operational

performance, tariff comparison and financial performance. However, to obtain their data, they used proxies for these options: accessibility and cost differentials for transportation, ship's waiting and berth utilisation for operational performance; port cost and tariff for tariff comparison, and profitability for financial performance.

Cullinane *et al.* (2002) attempted to use the economic inputs of capital and labour in order to analyse port efficiency. Due to the obstacles to obtaining the data, they used the physical characteristics of terminals i.e. terminal quay length, terminal area in hectares and the number of pieces of cargo handled.

Tiwari *et al.* (2003) analysed the shipper's set of choices based on combinations of carriers and ports. They examined the characteristics of port, shipping line and shipper. For the use of a discrete choice model, they used proxies for these three characteristics: ship calls, total TEU handled at the port, number of berths, number of cranes, water depth, routes offered, usage factors, port and loading charges for port characteristics; total TEU handled during the year, fleet size for shipping line characteristics; distance of shipper from port, type of trade, and distance of foreign port in nautical miles for shippers' characteristics.

Veldman and Buckmann (2003) originally intended to use two major factors to analyse port competition and choice i.e. that of cost and of quality of service. However, due to limitations in obtaining sufficient data on the former, they only used the service factors, shown in Table 4.1.

Table 4.1 Proxies for cost and service factors

Items	Contents
Category	Port selection
Perspective / Object	- Perspective focused on: Major shipping companies - Object evaluated: Western European hub ports
Factors selected	1) Frequency of service 2) Quality of service 3) Probability of choosing route
Proxies	1) Average inter-arrival time of two consecutive calls: Number of calls 2) Market share of port: Hinterland throughput 3) The ratio of containers on that route to total amount of maritime containers

Malchow and Kanafani (2004) analysed the port selection problem from the shipper's and the carrier's perspectives. They attempted to use transit time and cost criteria consisting of eight sub-criteria. However, in the end, they only used six criteria due to difficulties with measurement: the distance from the origin to the port, the time incurred as the vessel calls at other ports in transit, and the oceanic distance from the port to the shipment's destination for the transit time, the inland distance from the origin to the port, the oceanic distance from the port to the destination of the shipment, and the average vessel size and density for the operating cost.

Ohashia *et al.* (2005) found out two important factors: cost and service quality. However, they did not include the cost factor, and only used a few proxies of service quality as shown in Table 4.2.

Table 4.2 Proxies for cost and service factors in airport competition

Items	Contents
Category	(Air) Port selection
Perspective / Object	- Perspective focused on: Shipper - Object evaluated: Major airports in Northeast Asia
Factors selected	1) Monetary cost 2) Time cost(service quality)
Proxies	1) Air charges: Cargo line-haul cost 2) Cruising time: Loading and unloading time, customs clearance, processing time, waiting time for the next available freight (inverse of the frequency)

In their analysis of container port efficiency, Tongzon and Heng (2005) initially started with three significant factors: use of land, labour and capital. However, due to lack of data, the labour and capital factors were eliminated. The detailed proxies they used were as shown in Table 4.3.

Table 4.3 Proxies for port efficiency factors

Items	Contents
Category Perspective / Object	Port efficiency and competitiveness - Perspective focused: Major shipping companies - Object evaluated: 25 container terminals in Asia
Factors selected	1) Reliability 2) Port selection 3) Preference 4) Adaptability 5) Product differentiation
Proxies	1) Average delayed time 2) Total number of direct call 3) Total number of direct call 4) Extent to which a certain port satisfies demands from their customers 5) The investment in marketing of ports

4.2 Main Difficulties in Solving Port Competitiveness

4.2.1 Major obstacles to obtaining data provided by proxies for evaluation factors

In previous research, very limited and abstracted input factors and their proxies have been used to investigate port competitiveness. Nevertheless, to obtain these data, major obstacles still remain.

Kent and Ashar (2001) stated that difficulties existed in the acquisition of data by means of proxies because a number of assumptions had been made for the construction of standards and also as such standards varied from country to country.

Cullinane *et al.* (2002) have also suffered from the problem of collecting port cost data because there were no secondary sources for given targeted areas. Therefore, they adopted alternative approaches using the physical characteristics of the port.

In the same vein, Sanchez *et al.* (2003) also had problems with obtaining data on the transport cost charged to the shipper. Consequently, they excluded this factor from their analysis.

For the lack of information, Tiwari *et al.* (2003) also eliminated the shipping line service factors and variables i.e. marketing, advertising, frequency and service from their input factors.

Malchow and Kanafani (2004) also stated that they had difficulties in finding data on port charges, the cost of transportation services and the intermodal transfer process due to the complexities of port tariffs and data availability.

For reasons of confidentiality and certain technological difficulties, Tongzon and Heng (2005) were forced to omit certain factors i.e. cargo handling charges, average delayed time and product differentiation.

In addition, Ohashia *et al.* (2005) noted the elimination of factors they had to make from their model i.e. international regulations, congestion and technological advance, because they are not directly observable.

To summarize, business secrets, complexities for evaluation, confidentiality, difficulties with measurement, non-observability, scarcity of data and unavailability of data emerged as the major obstacles in acquiring data. Hence, further, more accurate judgement, and integrated evaluation are needed using experts' knowledge and/or opinions to be fully utilized (Bevilacqua and Petroni, 2002).

4.2.2 Difficulties in dealing with fuzziness

In addition to the above mentioned obstacles, further difficulties exist in measuring uncertainty and ambiguity in evaluation, knowledge quantification, extracting influential factors, etc., so-called fuzziness.

Tiwari *et al.* (2003.p.28) claim fuzziness can exist in the evaluation process, as stated in the following:

> *"When a shipper says that shipping through port A, rather than port B, is efficient, he may or may not know the number of berths, cranes etc., but he definitely knows that shipping through port A would be quicker and efficient. The shipper is actually internalising the port characteristics in his decision process. Similarly, rational behaviour by a shipper would mean that he has chosen a port by internalising various service factors"*

From the above statement, experts' opinions do not focus on exact factors, but also seem to rely on their experience, which consists of subjective and qualitative dimensions (Chen et al., in press). To deal with such problems, natural language, which can express the experts' thinking and preference, and/or semantic words, have been employed within the fuzzy evaluation methodologies (Lirn *et al.*, 2003; Chiou *et al.*, 2005).

To summarize, fuzzy logic enables the formulation of the experts' reasoning and decision making processes, even though the experts' judgements on port competitiveness are often influenced by uncertainty and ambiguity (Bevilacqua and Petroni, 2002). A more detailed discussion will be provided in Section 5.1.2.

4.3 Existing Studies: Methodological Limitations

Many methodologies for evaluating port competitiveness have been introduced and used, as shown in Chapter 3. However, the ones used have both advantages and drawbacks for solving complicated problems such as port competitiveness.

Regarding the methods for the evaluation of competitiveness, Bevilacqua and Petroni (2002, p.239) provide the following definition:

"Some are best suited for the problem definition and criteria formulation phases, while others are expressly designed for pre-qualification (sorting methods) and others are used for the final choice (ranking methods)"

As for the methods for problem definition and sorting, very simple methods such as factor analysis (FA), principal components analysis (PCA), interpretive structural modelling (ISM) and fuzzy structural modelling (FSM) can be used. However, these methods cannot yield overall meaningful results for competition and selection problems, but only support in sorting out the criteria (Bevilacqua and Petroni, 2002).

As for the choice of ranking methods, analytic hierarchy process (AHP), data envelope analysis (DEA), logit model (LM) and stochastic frontier model (SFM), among others, are usually utilized in attempts to solve the problems involved in port competition and selection. However, these methodologies have certain limitations.

Firstly, in the case of AHP, the issues of rank reversal and validity have arisen as major problems (Lirn *et al.*, 2003). The former indicates that the order of alternatives can be changed when they are added or eliminated, while the latter can occur in pair-wise comparison between factors. Linguistic scale is regarded as more effective compared to the one-to-nine point scale in AHP. A more detailed discussion will be provided in Chapter 5.

Secondly, regarding the limitations of the DEA model, Barros and Athanassiou (2004, p. 137) note the following:

"The DEA does not impose any functional form on the data, neither does it make distributional assumptions for the inefficiency term, nor does it make a prior distinction between the relative importance of any combination of inputs and outputs"

Thirdly, with respect to the limitations of the LM, Veldman and Buckmann (2003, p. 21) state the following:

"The major constraint of the logit model concerns knowledge of the proper model specification and related coefficients, as it is not always possible to calibrate the model"

Finally, SFM has two major drawbacks, which Cullinane *et al.* (2002, p. 750) clearly summarize in the following:

"Stochastic frontier models suffer from two other difficulties. One is the requirement of specific assumptions about the distributions underlying productive inefficiency (e.g. half-normal and exponential) and statistical noise (e.g. normal). The other is the required assumption that the input and productive inefficiency are independent. This may well be an unrealistic assumption since if a firm knows its level of inefficiency, this should affect its input choices"

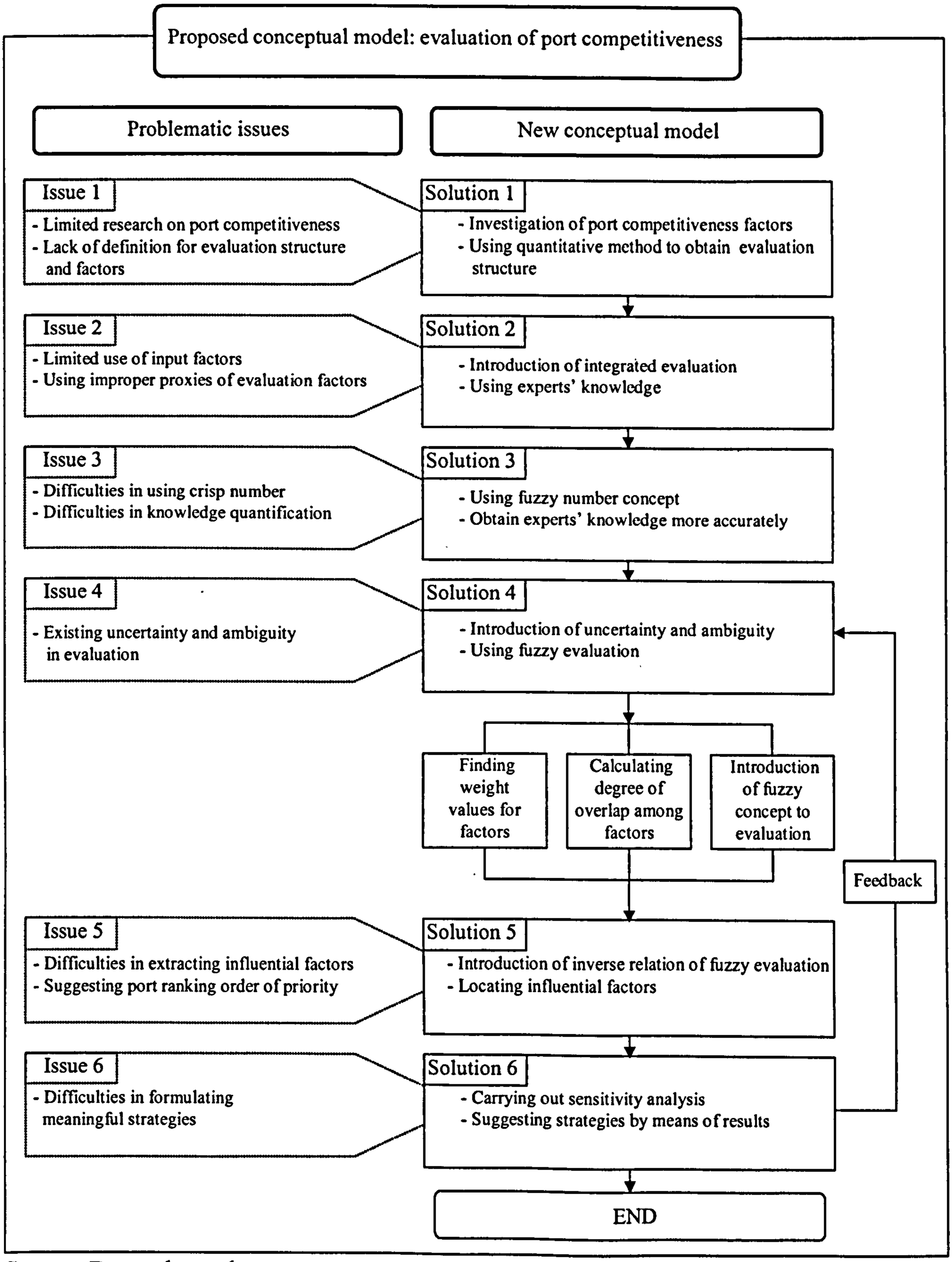
From Sections 4.2 and 4.3, it has become clear that, for the evaluation of port competitiveness, a more integrated methodology which can overcome all the drawbacks and difficulties is needed.

As suggested by Lirn *et al.*, (2003), the fuzzy approach has been considered as capable of addressing these problems related to port competitiveness also in this study. This will be discussed fully in Chapter 5.

4.4 Proposed Conceptual Model

From the above reviews, it can be concluded that quantitative methodologies have certain limitations in solving dynamic and complicated problems such as the evaluation of port competitiveness. The fuzzy evaluation method is regarded as a particularly suitable methodology for dealing with data which has characteristics of uncertainty, ambiguity, non-observability and scarcity. The other difficulties observed in the review, i.e. extracting influential factors and formulating meaningful strategies, can also be solved within the boundaries of fuzzy evaluation. Figure 4.1 provides a diagram of the proposed conceptual model. A more detailed discussion on the development of the methodology will be provided in Chapter 5.

Figure 4.1 Proposed conceptual model



Source: Drawn by author

CHAPTER 5

Research Methodology

The evaluation of port competitiveness has been considered as a complicated problem, which has many difficult characteristics to solve using the existing methods. In this respect, the aim of this chapter is to design and suggest a exploratory methodology to overcome this problem. The chapter has five sections. In the first one, the characteristics of port evaluation will be investigated, and the fuzzy evaluation concepts introduced. In addition, the justification and development process of using fuzzy evaluation are to be explained. Finally, an entire overview of the methodology will be provided. The second section is related to operational definition and deals with 'the definition of variables', 'the characteristics of factors' and 'the factor measuring method using fuzzy numbers'. The third section is 'an explanation of the data input part'. It discusses 'the detailed data collection method', including sample sizes, the sample frame and the questionnaire structure, and the definition of detailed input data. The fourth section provides 'an explanation of the calculation part'. It is largely divided into two sub-sections i.e., the method of fuzzy evaluation and that of the inverse relation of fuzzy relation. Finally, the whole chapter will be summarised in the fifth section.

5.1 Introduction to Fuzzy Evaluation

5.1.1 Evaluation of complex multiple attributes and multiple-hierarchies

An evaluation consists of the object, the criteria, the structure and the evaluator and is closely related to evaluation time. In general, the object of evaluation has several criteria, and this problem is called multiple criteria decision making (MCDM), or multiple attribute decision making (MADM). When attempting to solve this problem, it is difficult to establish which of the criteria are important and which have high priority. Furthermore,

they are also divided according to their quantitative and qualitative attributes, which increases the difficulty. Problems with multiple criteria with quantitative and qualitative attributes are called 'complex multiple attribute evaluation problems' (Yang et al., 1994a, 1994b).

Besides this, when a large system or a number of objects are evaluated, the evaluation structure has several hierarchies, each with several criteria. Consequently, the evaluation process becomes increasingly complicated.

The above-mentioned characteristics are often associated with many social problems, and thus become problems of complex multiple-attributes multiple-hierarchies (CMAMH). The evaluation of port competitiveness is also a complicated problem, where a number of alternatives and actions or stakeholders need to be chosen based on a given set of criteria and hierarchies (Aouam T. et al., 2003), and, therefore, it becomes a CMAMH problem.

5.1.2 Existing ambiguity in the real world and fuzzy evaluation

An additional difficulty associated with the CMAMH problem is that of the 'ambiguity', 'vagueness' and 'uncertainty' of evaluation. Human judgements always suffer from lack of sufficient information, definition and knowledge against the target of evaluation. Frequently, by using statistical methods, this ambiguity can be quantified in the case of physical and/or mechanical systems. However, in the case of social systems, difficulties have been experienced in solving the problem because they contain factors of human judgement defined by subjective preferences. Furthermore, often an overlap exists among the evaluation factors.

To solve such problems, fuzzy evaluation has been adopted in many studies. Fuzzy theory was developed by Zadeh in 1965 to deal with imprecise and uncertain problems. Later on,

this theory has been adapted to many fields such as classification (Chi et al., 1996), modelling (Driankov and Hellendoorn, 1993) and control (Pedrycz, 1996), and, more recently, it has been applied to complex decision problems that can be controlled by human judgements because the approach is able to link human perceptions expressed as linguistic expressions (Zadeh, 1975; Mansur, 1995).

The evaluation of port competitiveness is a representative of such cases which contain ambiguity and subjective preferences expressed by port stakeholders. As with other social problems, the sea port issue has 'uncertainty' in the evaluation process, and it needs the fuzzy concept to be introduced in order to solve the problem.

5.1.3 Justification for using Fuzzy Evaluation

Fuzzy evaluation has been adapted to solve problems associated with various social environments with social contexts. Many successful results have been obtained, and, therefore, fuzzy evaluation has been suggested as a suitable methodology by the following authors.

Chiou et al.(2005), argued that *"in many areas, human judgment, evaluation and decisions often employ natural language to express thinking and subjective preferences. The problem is that human judgments may be significantly different based on individuals' subjective perceptivity or personality, even when using the same words"*. In addition, they also claimed that "*many studies have used additive techniques to evaluate the synthetic utilities of each criterion meeting the assumption of independent relationship among criteria. However, the criteria are not independent situations, the non-additive fuzzy integral is an effective method for evaluation"*.

Chen et al. (2006) stated that "In *many existing decision models only quantitative criteria are considered for evaluation. However, several influence factors are often not taken into*

account in the decision making process, such as incomplete information, additional qualitative criteria and imprecise preferences". They concluded that under these conditions, fuzzy evaluation is a suitable method for problems which involve several different types of criteria, group decision-making and various forms of uncertainty.

There have been a number of debates on the limitations in the existing methods such as complexity (Yu et al., 2005), overlap between criteria (Chou et al., in press), uncertainty in evaluation (Chen, 2001; Sonmez, 2002; Haralambides and Yang, 2003) and methodological limitation (Konstandinidou, in press). Consequently, fuzzy evaluation has been suggested as an optimal method to solve these problems. It can be used in the following cases:

- CMAMH problems with ill-defined, ambiguous, vague or uncertain characteristics.
- When human (expert) judgements, perceptions and/or subjective preferences are involved.
- When the criteria (factors) are not independent, in which case non-additive fuzzy integral is an effective method.
- When it is difficult to quantify the criteria due to incomplete information, imprecise preferences and uncertainty.

Another evaluation of port competitiveness, discussed in Chapter 3 is provided by Yap and Lam (2005), who claimed that *"Port competitiveness could affect the entire regions' viability, opportunity and propensity for growth. Moreover, it encompasses many other spectrums of the human society that include technological, political, ecological and geographical perspectives"*. Based on their definition, port competitiveness can be regarded as a very complex problem.

Haezendonck and Notteboom (2002) divided port competitive factors into quantitative and qualitative ones. The former consist of hinterland accessibility, productivity and cargo generation while the latter comprise quality, reputation and reliability. According to their conclusions, the evaluation of port competition had quantitative as well as qualitative dimensions.

Tongzon and Heng (2005) suggested that "*the port environment in which ports operate has changed dramatically, ports are affected by various new global competitors, including the far reaching unitization of general cargo, the rise of mega-carriers, the market entry of logistics integrators, the creation of network linkages among port operators, the development of inland transport networks and so on*". As a consequence, a wide range of problems can be seen as associated with the evaluation of port competition.

Wang (2004) explained that the evaluation of port competition could be complemented with other information sources and perspectives which include information on container throughput handled by trade route, financial data, operational data and general economic impact. However, few ports in East Asia supply such data. In other words, uncertainty, paucity and methodological limitations are indicated. Furthermore, sometimes situations change rapidly, and decision variables are difficult to quantify. Hence, the evaluation of port competitiveness can be summarized as follows:

- It is a very complex problem which includes many other spectrums of the human society.
- It possesses many qualitative and quantitative dimensions.
- Decision variables are difficult to quantify.
- It is characterised by wide ranging problems.

- It has uncertainty and paucity of data and also methodological limitations, which cannot be solved by using existing methods.

The findings from the above literature review on fuzzy evaluation and the characteristics of the evaluation of port competitiveness point out that there are certain common factors such as complexity, overlap between criteria and uncertainty in evaluation. Therefore, a new method is needed to overcome the existing methodological limitations. Consequently, in this research, it has been decided to employ fuzzy evaluation, more specifically the integrated fuzzy evaluation (IFE) as an all-encompassing methodology.

5.1.4 Development process of fuzzy evaluation

Fuzzy evaluation has developed to solve complex, ambiguous and ill-defined problems. Among these emerging methods, hierarchical fuzzy integrals (HFI) has been regarded as a successful evaluation method for the 'introduction of experts' opinions' (Shizuka and Sugiyama, 1992; Sugeno and Fujimoto, 1995; Fujimoto, 1996; Petri and Smith, 1996; Amano et al., 2000; Lee et al., 2001). However, it has problems such as the large amount of calculations and complications involved. To improve these problems, hierarchical fuzzy process (HFP) was developed (Lee *et al.*, 2001). It has shown good results with the advantage of simple adaptation. However, HFP also has disadvantages as it cannot solve typical multiple decision making group (MDMG) problems. That is, the opinions of one group of experts may contradict those of other groups (Aouam et al., 2003). Such problems cause bias in evaluation (Lim, 2000). To overcome this, MDMG-HFP has been suggested.

These evaluation methods have been successfully adopted and have brought about reasonable results in terms of 'ranking' and 'priority' of target alternatives. However, they have no such procedure as the identification of critical (influential) factors, re-assessment or suggesting improvement strategies. To compensate for this lack, inverse relation of

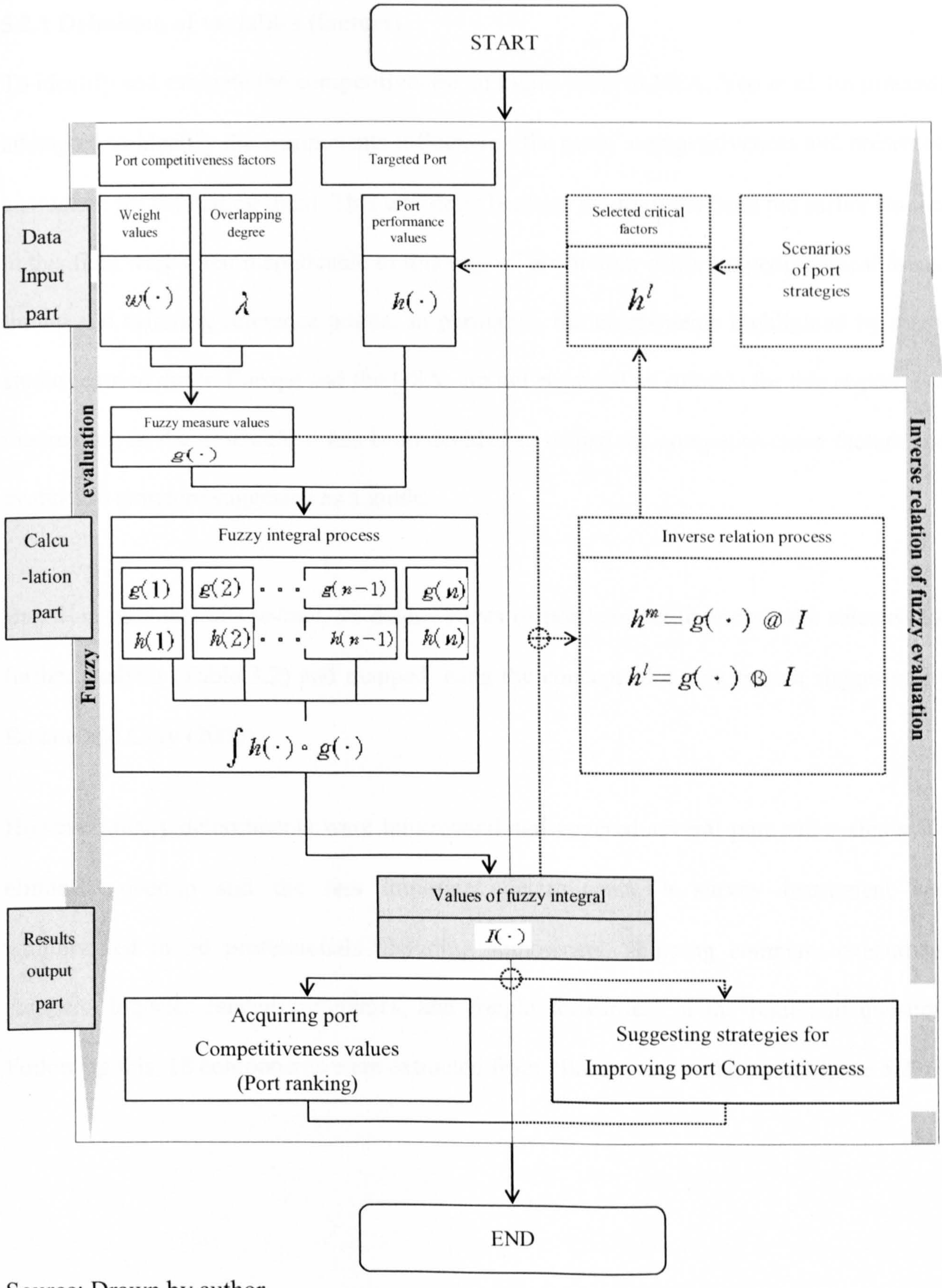
fuzzy evaluation (IRFE) was developed. The concept of IRFE was originally provided by Sanchez (1976), and used in many areas such as knowledge development and system diagnosis. By using the advantages of this method, the weakness points of ports as input factors could be found and improved effects and port strategies as outputs could also be obtained.

5.1.5 Overview of methodology (IFE)

IFE can be divided into three parts: data input, calculation and results output. As for the first, five input data sets are needed: importance weights of port competitiveness factors, $w(\cdot)$; degree of overlap among port competitiveness factors, λ ; scoring rating of factors for each targeted port, $h(\cdot)$; selecting critical factors for the improvement of port competitiveness, h^l ; and scenarios set for sensitivity analysis, of which a detailed explanation will be given in Section 5.3.2.

The second part, calculation, consists of the adaptation procedure of fuzzy evaluation and IRFE. The final part, output, has the function of showing the 'port competitiveness ranking' and 'suggesting strategies for improving port competitiveness'. The entire overview of the methodology is given in the following section.

Figure 5.1 Diagrammatic representation of the methodology



Source: Drawn by author

5.2 Operational Definition

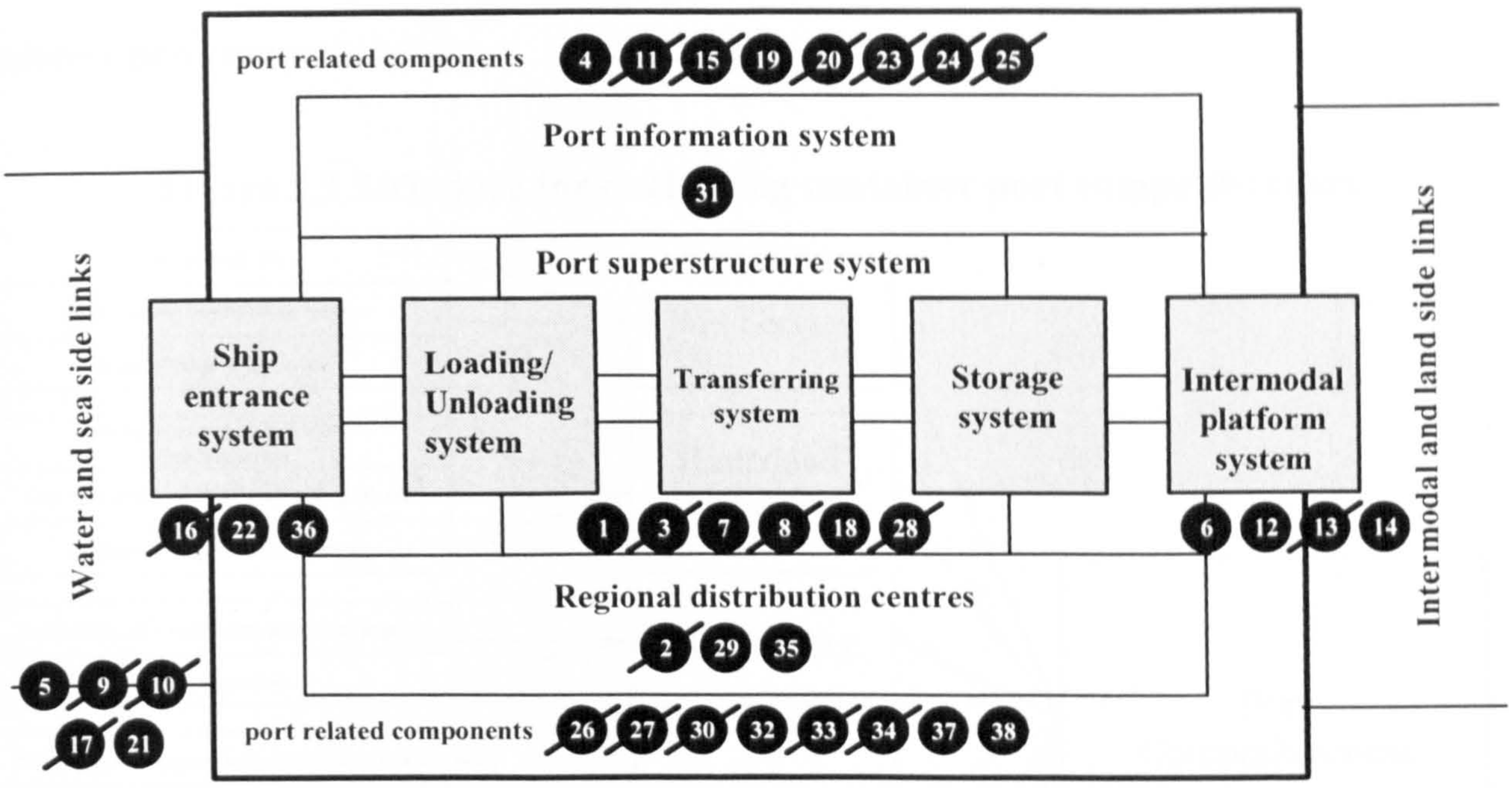
5.2.1 Definition of variables (factors)

To identify and evaluate the competitiveness of major ports in NEA, Yeo *et al.* (in process) attempted to identify the components influencing the ports' competitiveness and presented a structure for evaluating them. This was done because the findings from the earlier studies in this field were often inapplicable to this region, given their differing geographical focus, timing and differing reference points. In particular, the components highlighted by many studies carried out in Europe and the USA, are not regarded as suitable for this region. For this reason, in this research, it has been decided to utilise the competitiveness factors and evaluation structure suggested as a guide.

Based on the literature review, 38 determinants of port competitiveness were selected for further analysis (Table 3.2) and mapped using the concept of a port system suggested by Bichou and Gray (2005).

However, many determinants were interrelated and covered several port sub-systems. To eliminate overlap and the less important determinants, a survey instrument was administered to 30 professionals including shipowners, shipping company executives, shippers, logistics related companies, and freight forwarders in the region in question. Following this, 18 components were extracted from pilot survey as shown in Figure 5.2.

Figure 5.2 Selection of determinants of port competitiveness



Source: Yeo *at al.*(in press), Note: ● indicates eliminated determinants

After the employment of a factor analysis, seven principal factors emerged: port service, hinterland condition, availability, convenience, logistics cost, regional centre and connectivity and a taxonomy for evaluating the structure of port competition in this region, which are shown in Figure 5.3.

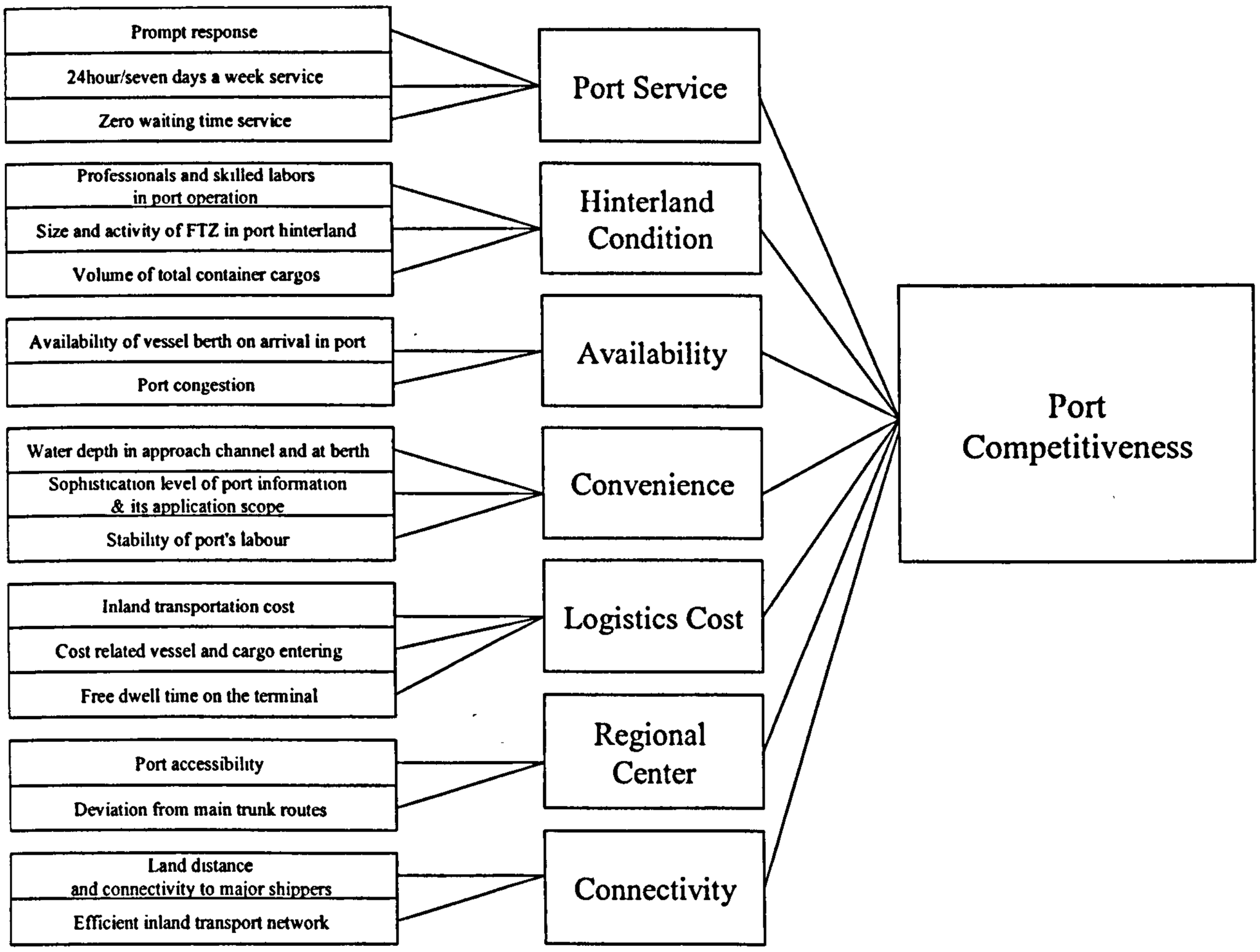
Further details of each factor are, as follows:

Port Service As the overall quality of service provided to users in a port area increases, so does the port's competitiveness. Port service includes "prompt response", "24 hours a day, seven days a week service" and "zero waiting time service".

Hinterland Condition As the condition of the hinterland improves, so does the port's competitiveness. Hinterland condition includes "professionals and skilled labour in port operations", "size and activity of Free Trade Zone (FTZ) in port hinterland" and "volume of total container cargos" of which the last is the most important attribute. This implies that

Busan and Shanghai have huge hinterlands encompassing the Korean peninsula and Chinese mainland respectively. For more efficient treatment of increased cargoes, port operators concentrate on port productivity and investments. This phenomenon acts to increase port competitiveness.

Figure 5.3 Structure for evaluating container port competitiveness



Availability This includes "availability of a vessel berth on arrival in port" and "port congestion". The former element is most highly correlated with this factor. Korean and Chinese ports experience heavy port traffic and for just in time delivery, the availability of berths is a vital attribute for port users.

Convenience This component includes "water depth in approach channels and at berth", "sophistication of port information and its application" and "the stability of port labour".

Logistics Cost The lower the cost, the greater the level of competitiveness. Logistics costs include "inland transportation cost", "costs related to vessels and cargoes entering port" and "free dwell time on the terminal".

Regional Centre Having a good location is deemed to render a port more competitive. The concept of a regional centre includes geographical aspects such as "deviation from main trunk routes" and "port accessibility".

Connectivity The greater the connectivity, the higher the level of competitiveness. Connectivity includes both "land distance and connectivity to major shippers" and "an efficient inland transport network".

5.2.2 Characteristics of factors

The analytical structure for evaluating port competition in NEA includes qualitative components including professionals and skilled labour force and their stability in port operations, and quantitative components including water depth in the approach channel and at berth, inland transportation cost and free dwell time on the terminal. Notably, the role of professionals and skilled labour force in port operations, and the sophistication level of port information and the scope of its application proved to be the most important factors. In a study by Yeo *et al* (in press), hinterland related components such as the size and activity of FTZ, efficient inland transport network and inland transportation cost were considered critical.

These results indicate that key factors for port competitiveness have shifted away from hardware and labour towards software and technology, implying that the most competitive ports rely on efficient hinterland logistics systems. Other interesting components included the availability of a vessel berth on arrival in port. This replaced previous components such

as the number of loading and unloading facilities and the capacity of the container yard. This implies that port competitiveness requires improved infrastructure combined with higher levels of operational management. Enhanced port competitiveness, as is perceived in NEA, requires not simply increased port investment but also high quality port service and technology focused port operations.

5.2.3 Method for factor measuring using fuzzy numbers

The evaluation of port competitiveness in NEA consisted of the seven principal factors and the 18 detailed attributes described in the previous section. As for data collection and the optimal number of input data, Wang (2004) argued that "*to incorporate all variables into the model is almost impossible, not only because of the data collection problems involved, but also because of the analytical intractability of the solution. An ideal compromise solution is to find a few indicators that provide the closest quantitative proxies to the problem.*"

However, there has been increasingly more debate on the definition of input factors and finding quantitative proxies. The 'availability of a vessel berth on arrival in port' and 'port congestion' in terms of availability have been seen as closely related to 'berth availability'. To quantify this into an input factor, Tongzon (2001) used 'number of berths' as a measuring indicator, while Cullinane et al. (2002) and Notteboom et al. (2000) included 'length of berth' as a measurement. It is currently being debated which indicator is more preferable.

With reference to the 'professional and skilled labour' factor in terms of hinterland condition, it is very difficult to estimate these two. Valentine and Gray (2001) also mentioned the problem of inaccuracy of manpower information in the port area. In turn, 'volume of total container cargos' is also difficult to use as an input factor because there

are discrepancies in the reported throughput from each terminal and the operation of the whole port as reported by Wang (2004).

In the light of the convenience factor, 'the sophistication level of port information and its application scope' is also difficult to measure. According to the definition by Song and Yeo (2004), port information can be regarded as a key service item in the current business environment and represented by cargo handling information, cargo tracing information and port management information system (Port-MIS). However, how to indicate the convenience of a system is still a problem.

Apart from the difficulties of measurement, the evaluators in each group of port stakeholders tend to evaluate the sea port according to their need to know which ports are the most competitive for them to select and use. In this case, they use their 'experiences' and 'perceptions' of ports so-called, experts' judgements. These judgements do not rely on detailed variables, and, furthermore, are mostly related to qualitative evaluation. From this point of view, it is unrealistic to use all the 18 detailed attributes, which goes along with the results of Wang (2004). In this research, therefore, seven principal factors suggested by previous research will be used for further analysis. The consideration of expert judgements here is exactly the same as the one using fuzzy evaluation explained in Section 5.1.2.

For the measurement of experts' perceptions (judgements), 'the fuzzy number concept' has been introduced. This method accepts a linguistic expression for judgements from experts such as 'very low' or 'very high' etc (Zadeh, 1975; Zimmermann, 1991). Although there are many shapes of fuzzy numbers, the triangular and trapezoidal ones are the most commonly used (Kaufmann and Gupta, 1988 and 1991). In this research, for more precise measurement, the trapezoidal fuzzy number has been adopted, of which the following are the details:

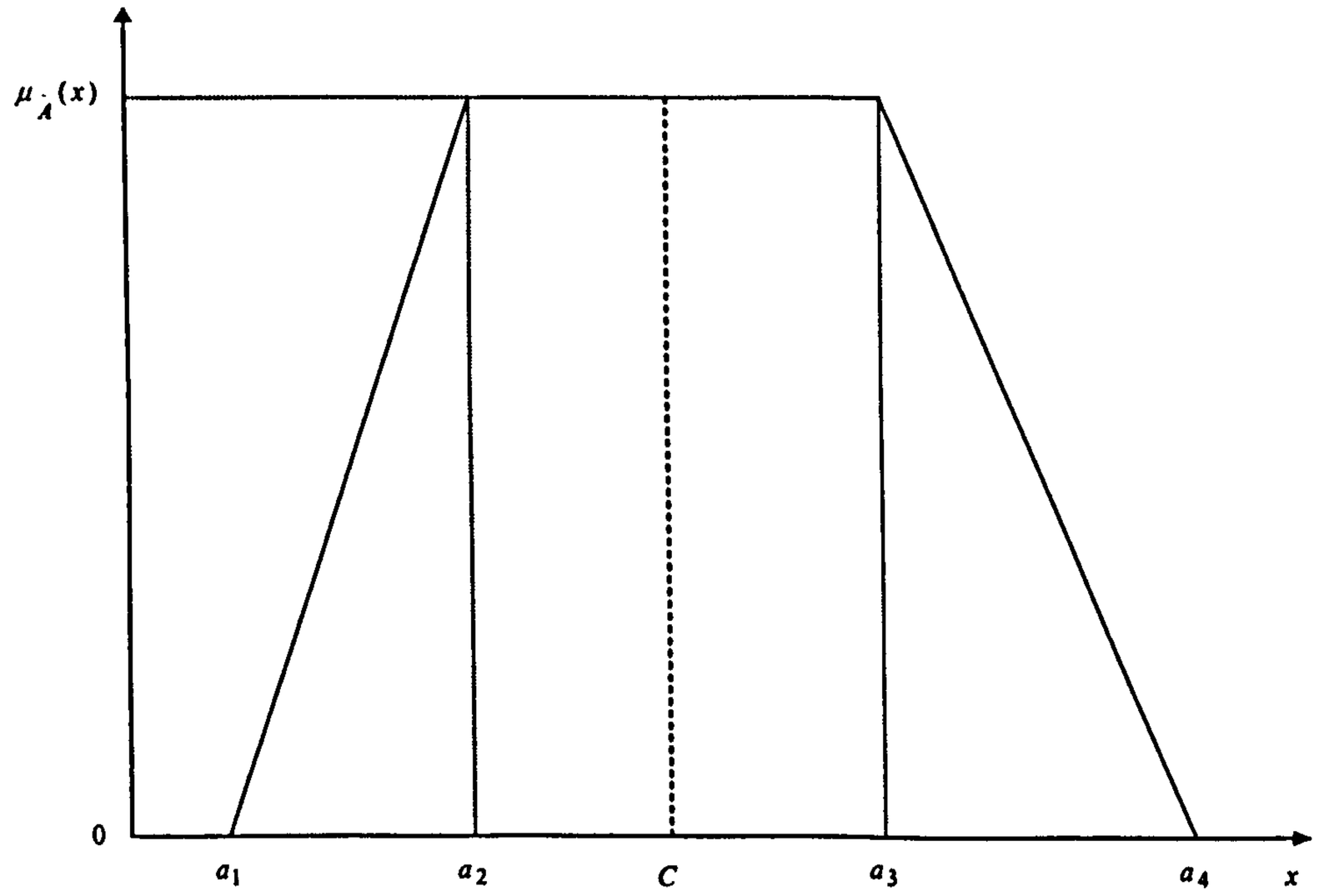
- **Definition of membership function**

A membership function of trapezoidal fuzzy number $\tilde{A}=(a_1,a_2,a_3,a_4)$,

$(a_1 \le a_2 \le a_3 \le a_4)$ is defined to be

$$U_{\tilde{A}}(x)=\begin{cases}0, & x \prec a_1,\\ (x-a_1)/(a_2-a_1), & a_1 \le x \le a_2,\\ 1, & a_2 \le x \le a_3,\\ (x-a_4)/(a_3-a_4), & a_3 \le x \le a_4,\\ 0, & x \succ a_4.\end{cases}$$

Figure 5.4 Trapezoidal fuzzy numbers



- **Definition of operation**

Operation laws of two positive trapezoidal fuzzy numbers $\tilde{A}=(a_1,a_2,a_3,a_4)$ and

$\tilde{B}=(b_1,b_2,b_3,b_4)$ are defined to be

$$\tilde{A}(+)\tilde{B} = (a_1, a_2, a_3, a_4)(+)(b_1, b_2, b_3, b_4) = (a_1 + b_1, a_2 + b_2, a_3 + b_3, a_4 + b_4),$$

$$\tilde{A}(-)\tilde{B} = (a_1, a_2, a_3, a_4)(-)(b_1, b_2, b_3, b_4) = (a_1 - b_4, a_2 - b_3, a_3 - b_2, a_4 - b_1),$$

$$\tilde{A}(\times)\tilde{B} = (a_1, a_2, a_3, a_4)(\times)(b_1, b_2, b_3, b_4) = (a_1 b_1, a_2 b_2, a_3 b_3, a_4 b_4),$$

$$\tilde{A}(\div)\tilde{B} = (a_1, a_2, a_3, a_4)(\div)(b_1, b_2, b_3, b_4) = (a_1 / b_4, a_2 / b_3, a_3 / b_2, a_4 / b_1).$$

- **Definition of defuzzification**

For a defuzzification of trapezoidal fuzzy numbers $\tilde{A} = (a_1, a_2, a_3, a_4)$ is defined to be

$c = (a_1 + a_2 + a_3 + a_4)/4$.

- **Definition of linguistic variables**

A decision maker should be able to use the linguistic variables easily to evaluate the 'degree of overlap' and 'scoring of each port'. The trapezoidal membership functions are adequate for capturing the vagueness of linguistic assessments.

Table 5.1 Membership functions for linguistic variables of 'degree of overlap'

Very Low(VL)	(0.0,0.0,0.1,0.2)
Low(L)	(0.1,0.2,0.2,0.3)
Medium Low(ML)	(0.2,0.3,0.4,0.5)
Medium(M)	(0.4,0.5,0.5,0.6)
Medium High(MH)	(0.5,0.6,0.7,0.8)
High(H)	(0.7,0.8,0.8,0.9)
Very High(VH)	(0.8,0.9,1.0,1.0)

Figure 5.5 Linguistic expression of 'degree of overlap' and fuzzy scale

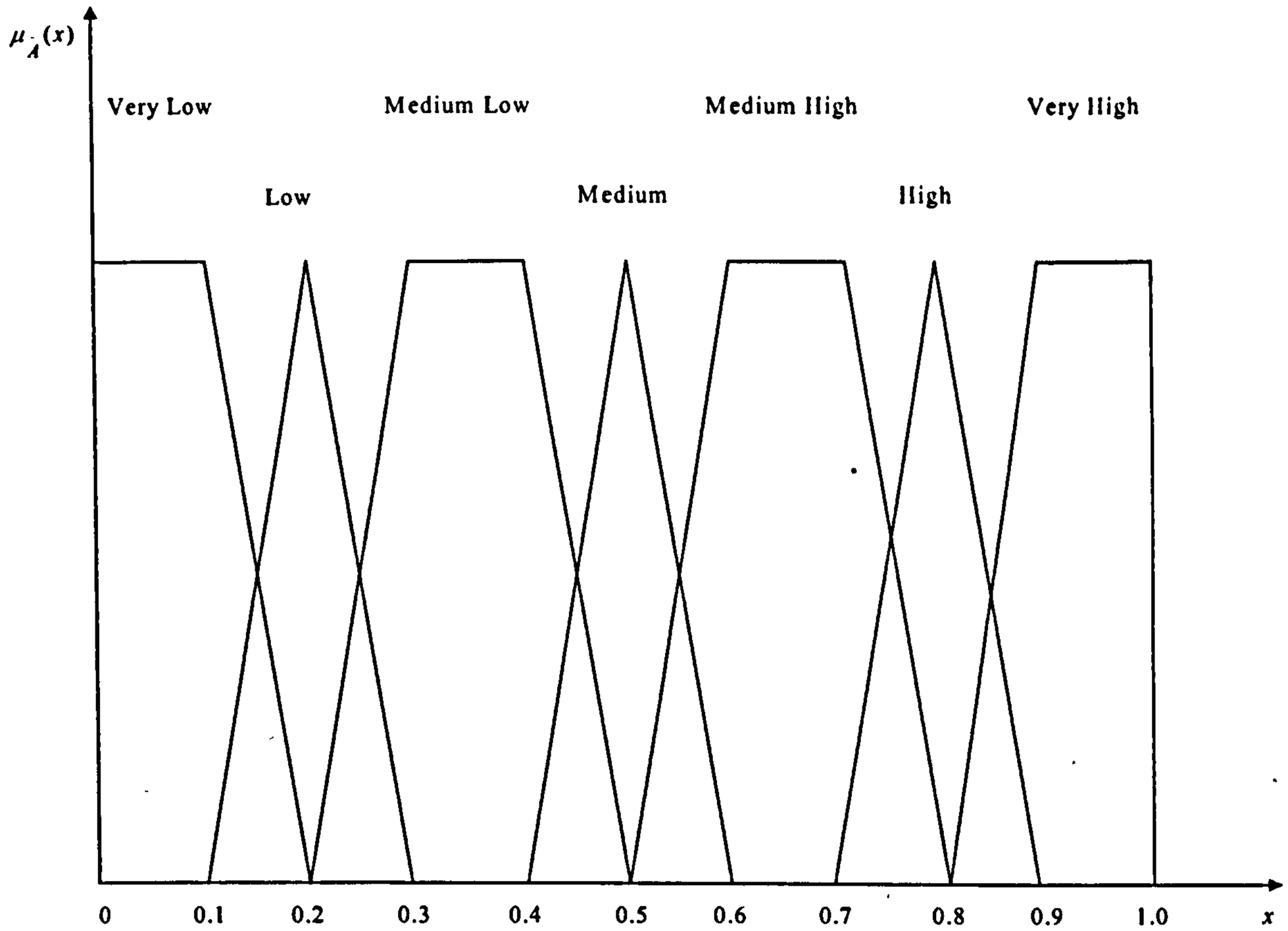
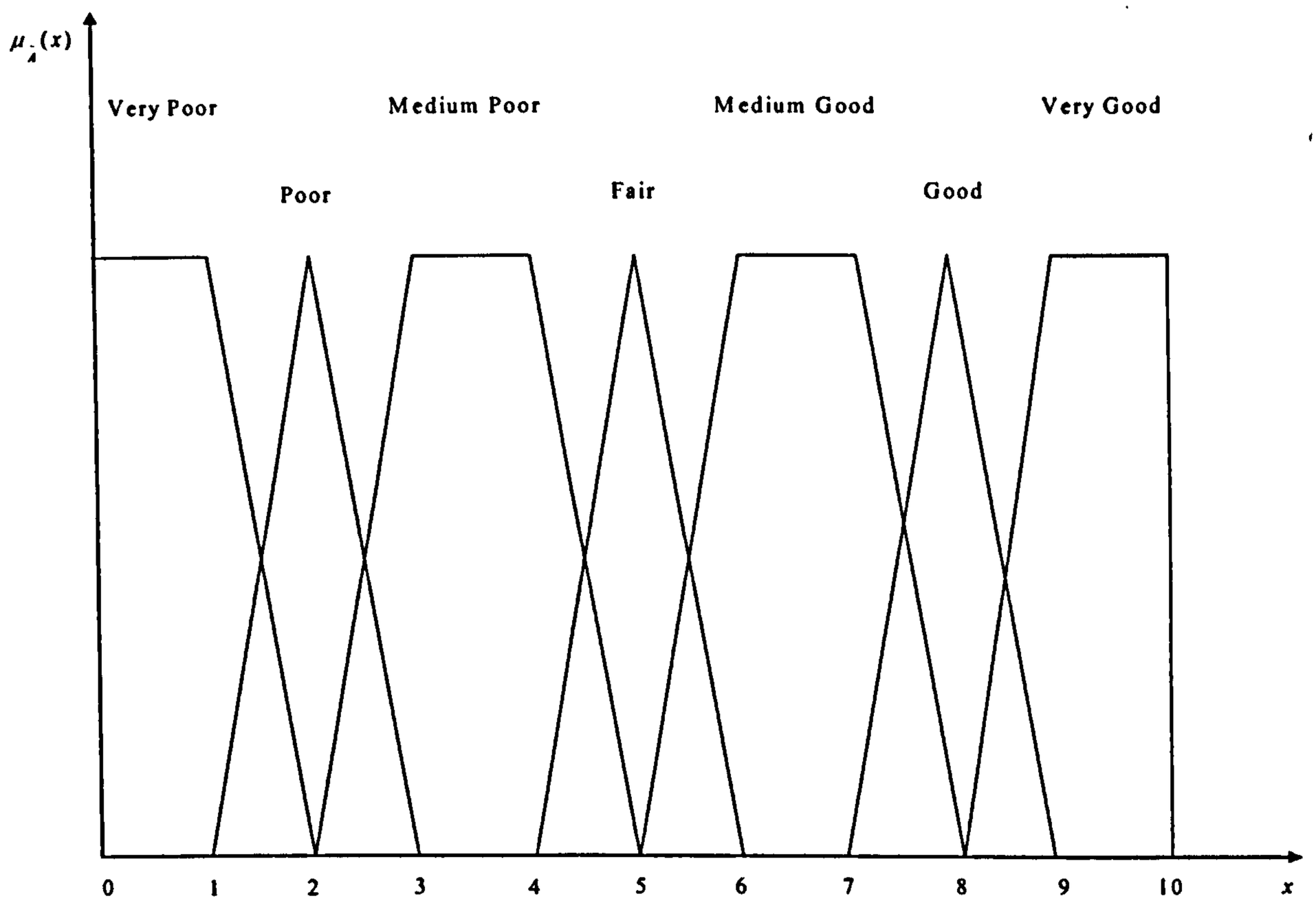


Table 5.2 Membership functions for linguistic variables of 'scoring for each port'

Very Poor(VP)	(0,0,1,2)
Poor(P)	(1,2,2,3)
Medium Poor(MP)	(2,3,4,5)
Fair(F)	(4,5,5,6)
Medium Good(MG)	(5,6,7,8)
Good(G)	(7,8,8,9)
Very Good(VG)	(8,9,10,10)

Figure5.6 Linguistic expression of 'scoring for each port' and fuzzy scale



5.3 Explanation of Data Input

5.3.1 Detailed data collection method

5.3.1.1 Sample Sizes

Based on Kerlinger's definition (1964), larger sample sizes yield smaller standard errors and utilizing samples as large as possible will reduce the failure rate in research. However, sample size needs to be downsized when research has time and cost limitations.

Generally speaking, sample sizes can be adjusted according to the type of investigation, research direction and the methodologies adopted. In the case of fuzzy evaluation, the sample size is largely divided into two parts: evaluators existing in the internal organization and those outside the organization. Cases with the evaluator a part of the internal organization are discussed in the following section.

Using fuzzy evaluation, Kulak and Kahraman (2005) evaluated the choice of freight transportation. The criteria considered in the selection process were transportation costs,

defect rate, tardiness, flexibility and documentation. To evaluate the selected alternatives by using the criteria chosen, several internal company managers were interviewed. They were asked to produce data by using the linguistic expressions from the fuzzy concept. In such a case, several high level members of the organization can be used to carry out the internal evaluation while the sample size also remains small.

Chen (2001) suggested an evaluation method for selecting a suitable city for the establishment of a new distribution centre. After preliminary screening, three candidates remained for further evaluation. The company considered five criteria for the selection of the most suitable candidate: investment cost, expansion possibility, availability of supply materials, human resources and closeness to demand market. In addition, decisions were obtained by using three committee members.

Chen et al., (2006) have recently modelled an evaluation process for selecting a suitable supplier. After preliminary screening, five candidates remained for further evaluation, and a committee of three decision-makers was formed to select the most suitable supplier. Five benefit criteria were considered: profitability of supplier, closeness of relationship, technological capability, conformance quality and conflict resolution. In this case, for decision making, a committee of three high-level decision-makers were involved in the evaluation of the alternatives, i.e. the five suppliers of materials.

In the same vein, Dweiri and Kablan (2006) evaluated the hierarchies of criteria and sub-criteria for the internal efficiency of project management by using a management team.

In addition, Chou et al. (2005) evaluated information technology and information system (IT/IS) investment by using the fuzzy multi-criteria decision making technique. For the evaluation, they formed two teams: one to weight the criteria and the other to score

alternatives. The former comprised different stakeholders, including the executive manager, an IT department manager, one or two IT staff, an accounting department manager and a manager. The latter consisted of IT experts, accounting experts, an executive manager, an auditor and an outside consultant. In this case, they pointed out that several experts from their specialist fields could be successfully used to evaluate problems of this kind.

Further methodological processes utilising external evaluators have been suggested by the following researchers.

First, Chiou *et al.* (2005) evaluated development strategies in the fishing industry using fuzzy multiple criteria decision making (FMCDM). In this policy evaluation problem, they had fifteen evaluators such as government employees, academic experts, executives in related companies, members of interest groups and local residents. Second, Haralambides and Yang (2002) used 100 ship owners in major maritime countries to evaluate Chinese shipping policy in terms of flagging out. Third, in research by Tasi and Lu (2005), 86 evaluators were used to judge the service quality of three e-stores using fuzzy evaluation. In the same field, Kuo and Chen (2005) obtained 264 usable responses from 350 questionnaires to measure mobile value-added services. In this case, data collecting was slightly easier compared to previous studies because all respondents were students aged 20-29.

On the other hand, Yu *et al.* (2005) used 'ideal survey candidates' to evaluate licensing mechanisms. They divided the respondents into four groups: the manufacturing sector, the service sector, the university professor sector and the government sector, and received 69 responses from respondents.

As can be seen from the above research, in the case of external evaluators, the sample size varies from over 15 to nearly 300, depending on the complexity of the problem and the ease of obtaining data. However, they experienced problems with the range of responses being too wide and more complex, which made collecting and receiving experts' opinions very difficult. Examples of this are the above-mentioned evaluations by Chiou *et al.* (2005) of fishing policy and by Haralambides and Yang (2002) of Chinese shipping policy.

This research intends to analyse port competition utilising the knowledge of experts in this field, and there should be a relatively high probability of having a large number of target units available. However, it is impossible to collect data from the whole population, and, even if it were possible, it would not be especially ideal due to the time and cost restrictions, particularly for a PhD project.

On an 'internal evaluation problem', 1-15 experts were requested to answer questions or questionnaires while, in an 'external evaluation case', questionnaires were sent to 15-300 experts or evaluators depending on how difficult it was considered to solve the problems.

Regarding the problem of port competitiveness, this is not so much a case of internal evaluation but closer to the one of external and complex evaluation. Therefore, the ideal range of sample size was seen as between 15 and 300. In this research, 300 questionnaires were sent to stakeholders, as explained in Section 5.3.1.2.

For determining sample size, Roscoe (1975) proposed that, as a rule of thumb, one larger than 30 and smaller than 500 was appropriate for most research. Based on the above suggestions by Roscoe (1975) and considering the previous fuzzy evaluation studies in the external case, returns between 15 and 300 were estimated as capable of providing a proper input data for the methodology of this research.

5.3.1.2 Sample frame

After the discussion on sample size, the target group needed to be decided. For the research object and scope, as explained in the introduction, the target group i.e. ideal survey candidates, was to be made up of experts familiar with the NEA port industry. To determine the sample frame, port and port actors (stakeholders) needed to be defined. First, according to Webster's dictionary, the definition of a sea port is as follows:

"A seaport is a major facility in a city, for the loading, unloading, and movement of cargo to and from oceanic ships. Critical to the functioning of a seaport is:

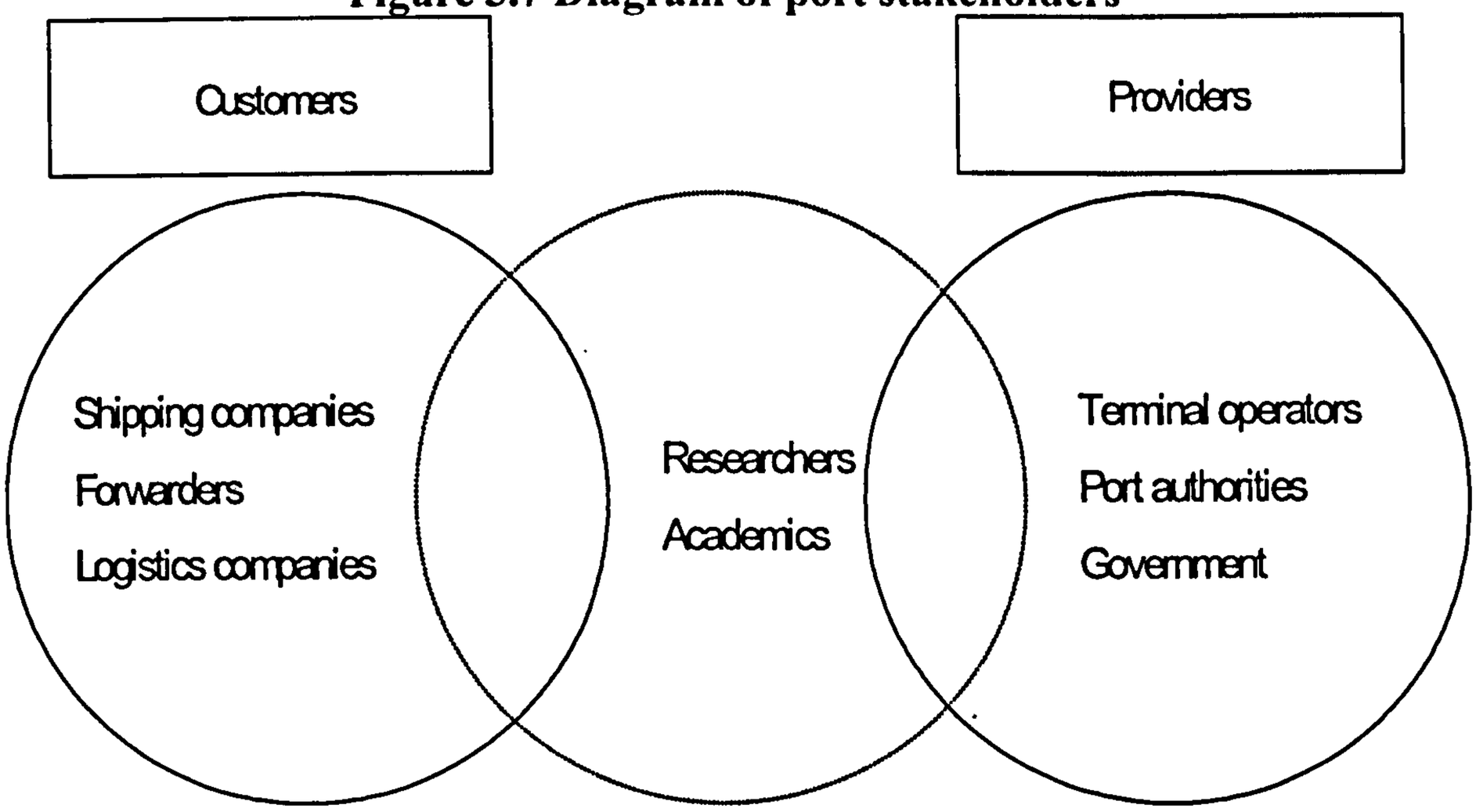
- *Presence of deep water channels (40 feet minimum) and berths*
- *Protection from wind, wave, and surge*
- *Access to intermodal transportation (trains and trucks)*

Seaports are often equipped with large cranes for the loading and unloading of containers from container ships. These are usually operated by members of the longshoremen's union. Pilots and tugboats are also used to safely manoeuver the ships in tight quarters".

As for port actors, it was stated by UNCTAD (2004) that *"many of traditional sea-interface users may become potential customers for inland facilities, e.g. shipping lines as logistics companies and forwarders, and port authorities and terminal operators may need to become more proactive and play an important role as providers".*

Using the above two definitions, a diagram for the port stakeholders' role could be depicted. That is, the shipping company, the freight forwarder and the logistics company have a customer's role while the port authority, the terminal operator and the government play a provider's role. Finally, researchers and academics have interests on both counts. From this aspect, the evaluation structure is very similar to 'the scoring team for alternatives' in the analysis by Chou *et al.* (2005). As guided by this analysis, it was decided to use a 'port scoring team' as a sample frame, consisting of port stakeholders, as explained in the previous section.

Figure 5.7 Diagram of port stakeholders



Source: adapted from Alderton (1999) and UNCTAD (2004)

After targeted sample groups (stakeholders) were identified, the next step was to collect the data from the representative groups (contact points). However, in research in the social sciences, one of the hardest things to achieve is to maintain a high sampling representation of the population. In the case of this research, no representative database of port stakeholders related to NEA existed.

Therefore, 'Containerisation International Yearbook' (2004), a well-known yearbook of container ports containing detailed information on stakeholders, was used for the selection of the sampling frames of customers and providers. The sample of researchers and academics was selected from the journals dealing with ports and international shipping. However, as discussed previously, it was expected that the limited resources available for a PhD project might cause low representation, which could be seen as a limitation of the research work carried out.

5.3.1.3 Questionnaire structure

Miller (1956) and Wilkinson (1965) argued that the optimal number of factors to be used in evaluation is (7 ± 2), that is, the maximum allowable number. As too much information

may lead to a meaningless choice or outcome, a controlled amount of information, in this case 'factors', is desirable.

According to the above guidelines, seven principal factors were used in the questionnaire, explained in more detail in Section 5.2.3, to provide pair-wise comparison. Otherwise, the main purpose of the questionnaire was to obtain 'scoring of each port' and 'overlapping degrees', to be discussed in Section 5.3.2. As explained in the previous section, a port scoring team was to used for the investigation of 'scoring of each port', and requested to answer questions in pair-wise comparison.

Pair-wise comparisons are to be made for the factors (Saaty, 1977, 1980, 1984). If n is the number of comparative factors, a decision-maker will make pair-comparisons as many times as n (n-1)/2. The present research has seven factors and, therefore, the total number of pair-wise comparisons is 21.

Moreover, trapezoidal fuzzy numbers were decided to be used as 'scales', as explained in section 5.2.3. The 'scales' in this method are very poor, poor, medium poor, fair, medium good, good or very good because a range value can express opinions and feelings more accurately and make it easier for experts to give their opinions in linguistic variables.

The following table is part of the questionnaire form using pair-wise comparison and trapezoidal fuzzy numbers. For example, when experts think about port performance of Busan and Hong Kong as 'fair' or 'medium good', they tick the boxes in the table as follows.

Table 5.3 Sample question asking for opinions on 'availability' factor

Container ports in Northeast Asia	What are your thoughts on the port performance of each port in respect of **availability**? (tick one box on each row)						
	very poor	poor	medium poor	fair	medium good	good	very good
Busan				V			
Hong Kong					V		

Next, let us consider 'overlapping degrees'. When we look at the evaluation structure in Section 5.2, the factors are ideally divided into seven principal factor groups. This means that all the factors are independent from each other. However, in reality, this assumption is impossible. Every factor and criterion overlaps in concept. In the table 5.4, an example is provided of how to give expert answers. If experts think that overlap exists between 'port service' and 'convenience' and its degree is considered as 'medium low', they tick the boxes as shown in the example. Similarly, if they think that overlap doesn't exist between 'port service' and 'availability', they tick only 'yes/no overlap column' in the second answer row.

Table 5.4 Sample question asking for opinions on overlapping phenomena

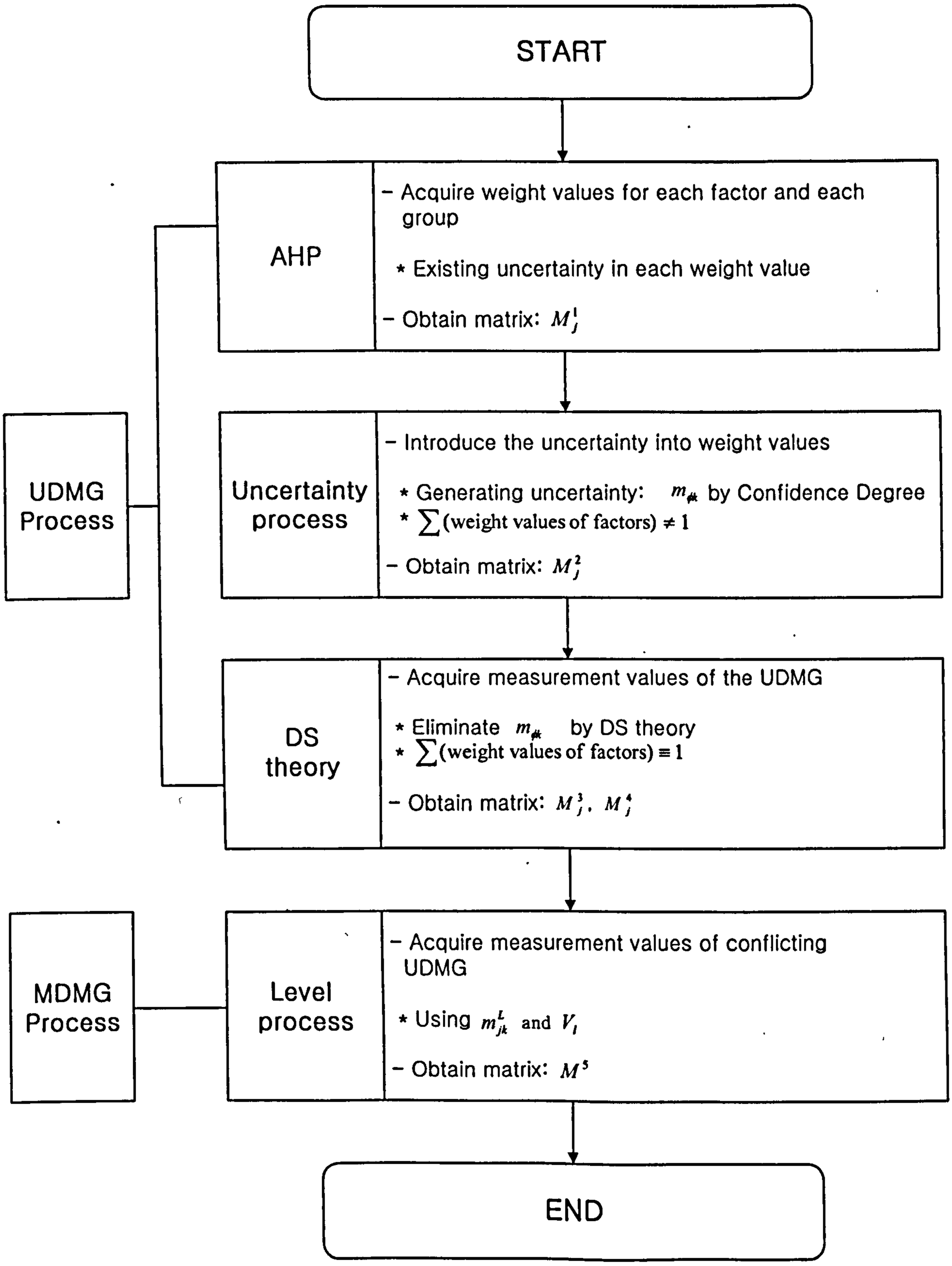
Questions : pair-wise comparison	Overlap exist /not exist		The extent of overlaps:						
Is there overlap between *[/] ?	No	Yes	very low	low	medium low	medium	medium high	high	very high
*[Port service / Convenience]		V			V				
*[Port service / Availability]	V								

5.3.2 Definition of input data

Weight values of port competitiveness factors, $w(\cdot)$, indicate the relative importance of each of the principal factors. However, to obtain the weight values of port competitiveness

factors involves multiple decision makers, including shipping companies, freight forwarders, logistics companies, academics and researchers. This complex evaluation problem is characterized by multiple strata and attributes (Frankel, 1992; Brooks, 2000; Malchow and Kanafani, 2001; Kumar, 2002; Haralambides and Yang, 2003). Analysis must also acknowledge that because such evaluations are usually wide-ranging, and although experts may offer reliable judgements in their own specializations, their judgments may become less reliable and consistent outside of their field of expertise. Inevitably, expert evaluations of port competitiveness factors involve a degree of uncertainty which empirical evaluation processes must accommodate (Simon and Burstein, 1985). Further, the opinions on one group of experts may contradict with those of other groups (Aouam *et al.*, 2003). This typical multiple decision making group (MDMG) problem causes bias in evaluation (Lim, 2000). To compensate for this, evaluation requires that judgment values are weighted to unify rationally the heterogeneous preferences of each group. To solve these complicated problems, Yeo *et al.* (in process) proposed adjustments to the weights attributed to port competitiveness factors, considered an MDMG problem, by introducing uncertainty, Dempster-Shafer (DS) theory and a levelling process as shown in Figure 5.8.

Figure 5.8. Evaluation Algorithm for MDMG Problems

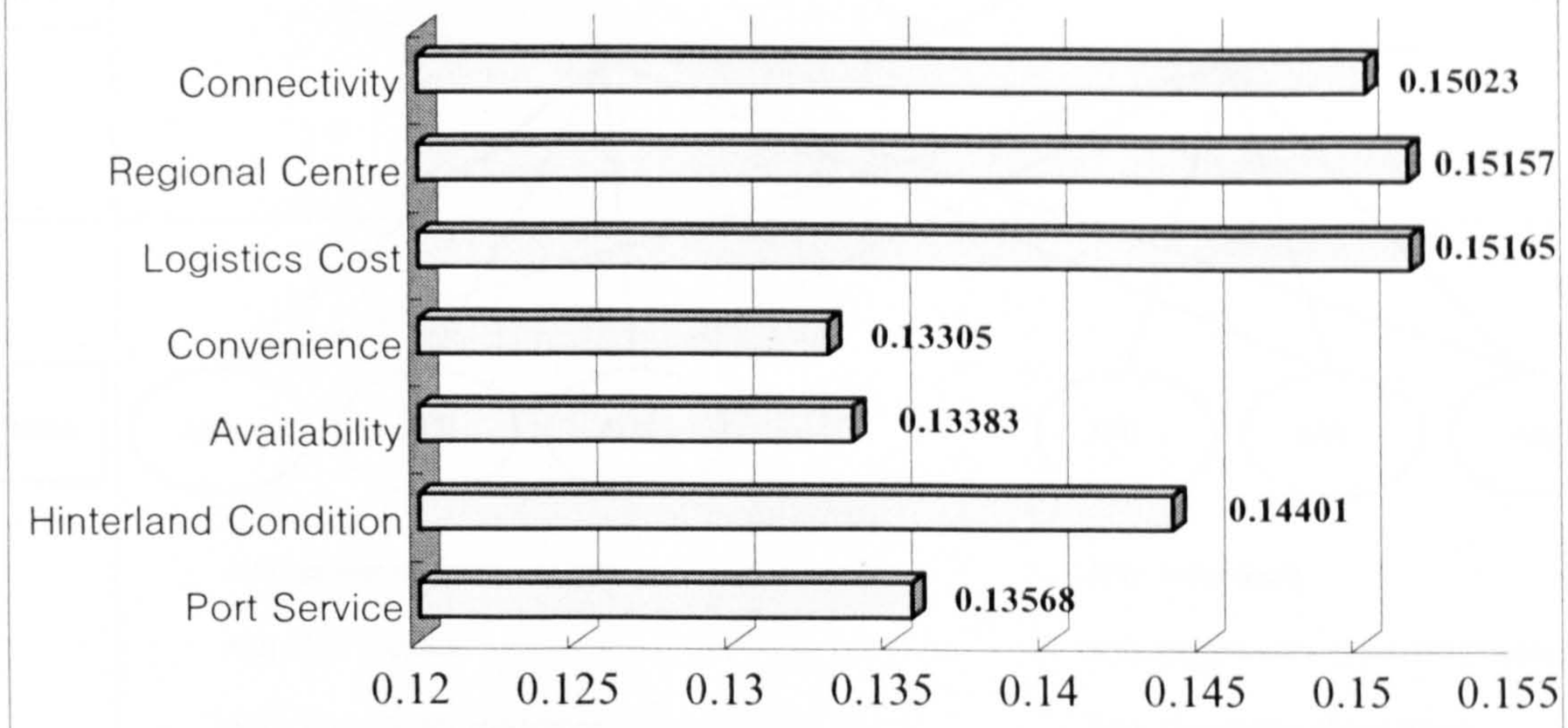


Source: Yeo *at al.* (in process)

As a result, they acquired integrated weight values showing that logistics cost was the key factor reflecting severe port competition in NEA. That is, lower port costs would be the most attractive factor. Another interesting finding was the significance of 'regional centre'

and 'connectivity', indicating that port experts emphasized the centre of the network and its connectivity as selection criteria. Hinterland condition was seen as more important than availability and convenience, reflecting interest in Free Trade Zones (FTZ) at the hinterland of sea ports on the east coast of China and south and west coast of Korea, which enjoy more tax breaks and efficient logistics flows.

Figure 5.9 Final weighted values of port competitiveness factors



Using these results as guidance, the input matrix of weight values is as follow:

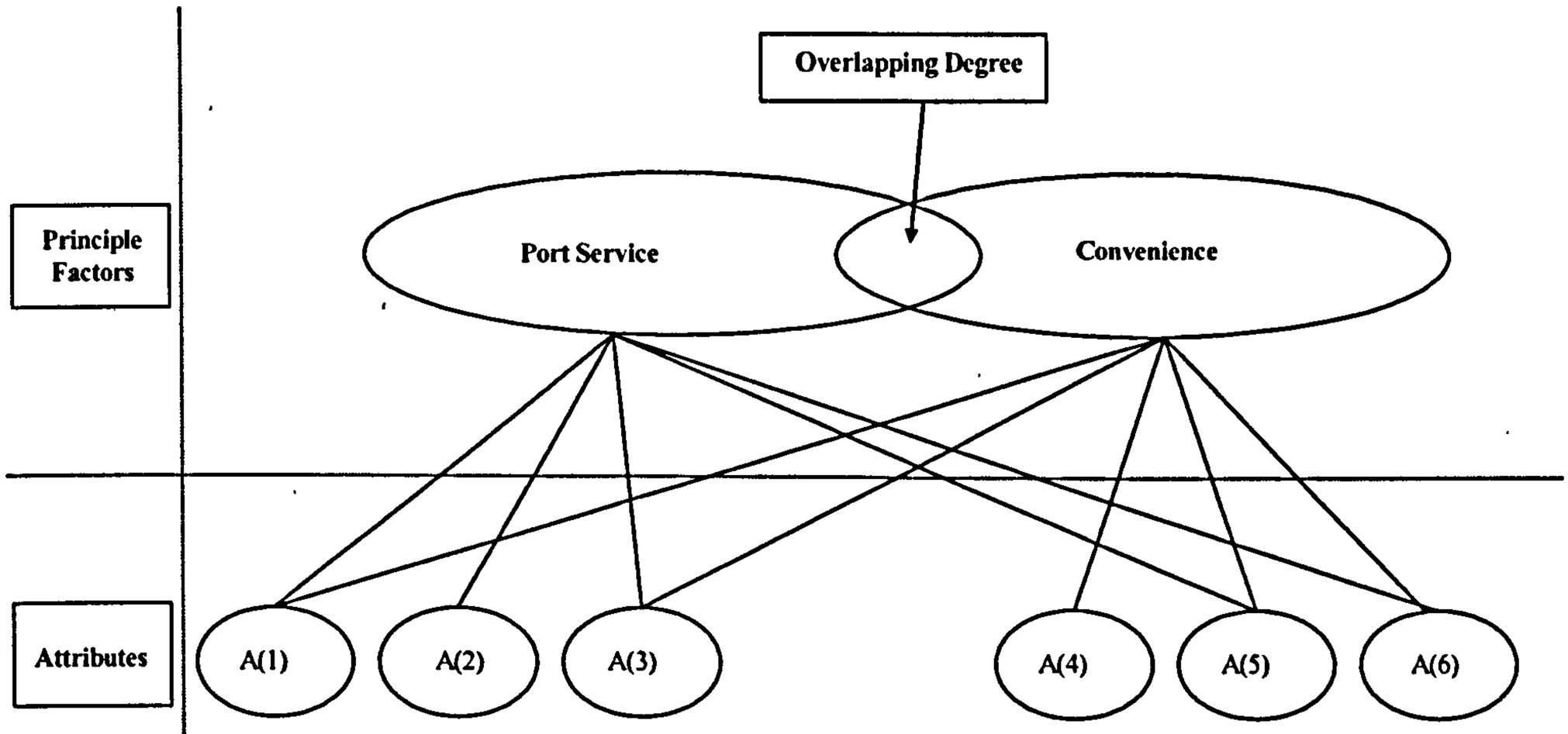
$w(\cdot)$ = [Port service, Hinterland condition, Availability, Convenience, Logistics cost, Regional centre, Connectivity]

$w(\cdot)$ = [0.13568, 0.14401, 0.13383, 0.13305, 0.15165, 0.15157, 0.15023]

On the other hand, as mentioned in Section 5.3.1.3, the evaluation factors always included a certain amount of overlap (λ). This becomes a non-additive problem and is different from traditional additive problems (Chiou, 2005). This phenomenon needs to be adjusted to avoid bias. For example, 'port service' and 'convenience' overlap to a certain extent in

definition and concept. To compensate for this, using the questionnaire, the responses from experts are transferred into the mathematical form given in Section 5.2.3.

Figure 5.10 Concept of overlap between factors



Source: Drawn by author

Among the input variables, $h(\cdot)$ means scoring each port according to the experts' operation in Section 5.4.2. Finally, the scenarios sets were used for a sensitivity analysis of port competitiveness.

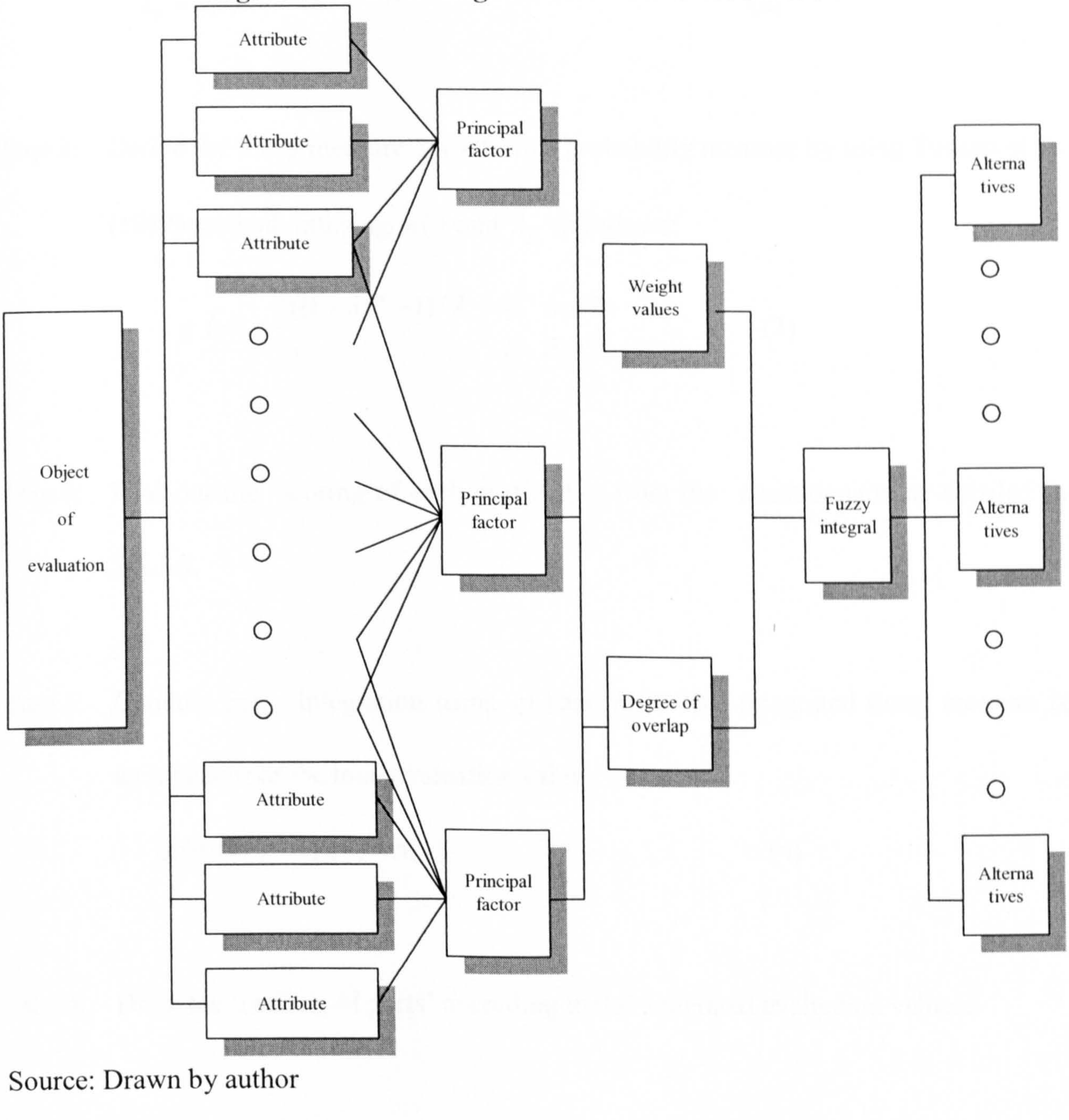
β

5.4 Explanation of Calculation

5.4.1 Fuzzy evaluation: output-oriented models

Let us suppose function $h(\cdot)$ and $g(\cdot)$ are $h(\cdot) \rightarrow [0,1]$ and $g(\cdot) \rightarrow [0,1]$ respectively. In this case, the evaluation procedure of the MDMG-HFP can be defined as shown in Figure 5.11.

Figure 5.11 Flow diagram for MDMG-HFP Model



Source: Drawn by author

Step 1: Draw the weight values of port competitiveness factors, $w(\cdot)$, using MDMG method as detailed in Section 5.3.2.

Step 2: Calculate the 'degree of overlap' from the questionnaire using the equation below, where λ_{ij} means 'degree of overlap' between port competitiveness factors.

$$u_i = \sum_{j=1}^{n} \lambda_{ij} / n - 1 \quad (i \neq j) \tag{1}$$

$$\lambda_{ij} = u_i / n \tag{2}$$

Step 3: Derive the fuzzy measure $g_i(\cdot)$ from a probability measure by using Tuskamoto's (1982) method, utilising $w(\cdot)$ and λ_{ij} as follows:

$$g\ (w) = \begin{cases} ((1+\lambda)^w - 1)/\lambda & if \quad \lambda \neq 0 \\ w & if \quad \lambda = 0 \end{cases} \tag{3}$$

Step 4: Find out the 'scoring of each port', $h(\cdot)$, from the questionnaire as detailed in 5.3.1.3.

Step 5: Conduct fuzzy integration using $g(\cdot)$ and $h(\cdot)$. This integrated fuzzy measure is an indicator of the total evaluation value.

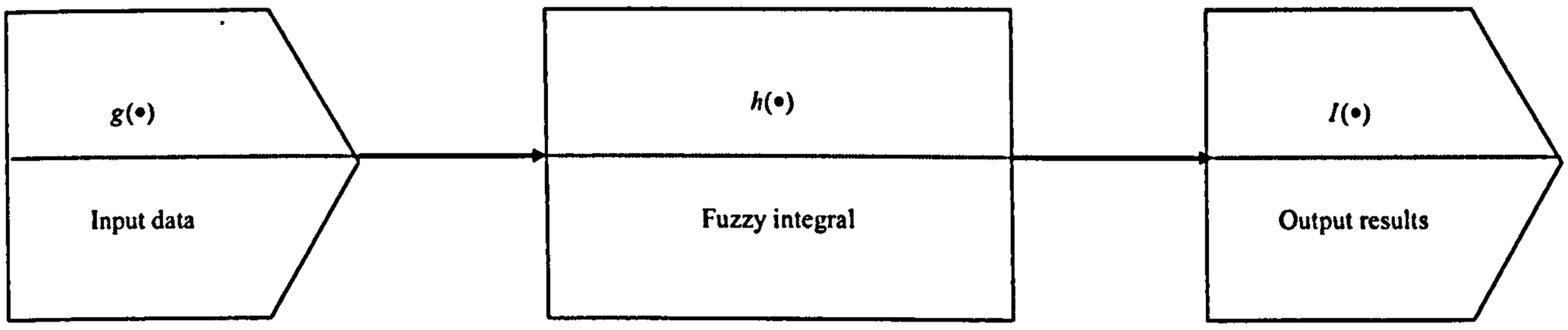
$$\int g(\cdot) \circ h(\cdot) = \vee[g(\cdot) \wedge h(\cdot)] \tag{4}$$

Step 6: Draw the 'ranking of ports' according to the integrated evaluation values.

5.4.2 Inverse relation of fuzzy evaluation (IRFE): added input control process on the existing method

Fuzzy evaluation consists of a process which has $g(\cdot)$, fuzzy measure values as input data and $I(\cdot)$, fuzzy integral values as output results as in Figure 5.12.

Figure 5.12 Fuzzy evaluation process



Source: Drawn by author

That is, $I(\cdot)$, fuzzy integral values, acquired by using the $g(\cdot)$ and $h(\cdot)$ values as in the next equation.

$$g(\cdot) \wedge h(\cdot) = I(\cdot)$$

This process is called the fuzzy integral process with 'direct relation'. In this paper, this method provided 'the priority' or 'ranking' of alternatives (targeted ports). However, that did not suggest which factors among the input data, $h(\cdot)$, were the most influential to improve port competitiveness, and how much competitiveness would be obtained by improving the influential factors. To solve this problem, the 'inverse relation' of the existing fuzzy integral was needed. This meant that the $h(\cdot)$ values were estimated from $g(\cdot)$ and $I(\cdot)$.

The estimation of $h(\cdot)$ can be divided into two categories: super-solutions, h^m, and sub-solutions, h^l. First, the procedures, so-called α operation, for super-solutions are as follows:

$$h^m = g(\cdot) \underline{\alpha} I$$

where, $g(\cdot) \underline{\alpha} I = \begin{Bmatrix} h^m(x_i) = 1 & if\ g(\cdot) \le I \\ h^m(x_i) = I & if\ g(\cdot) \succ I \end{Bmatrix}$

Accordingly, the procedures, so-called β operation, for sub-solutions are as follows:

$$h^l = g(\cdot) \underline{\beta} I$$

where $g(\cdot) \underline{\beta} I = \{h^l(x_i) = I \quad if\ g(\cdot) \prec I\}$

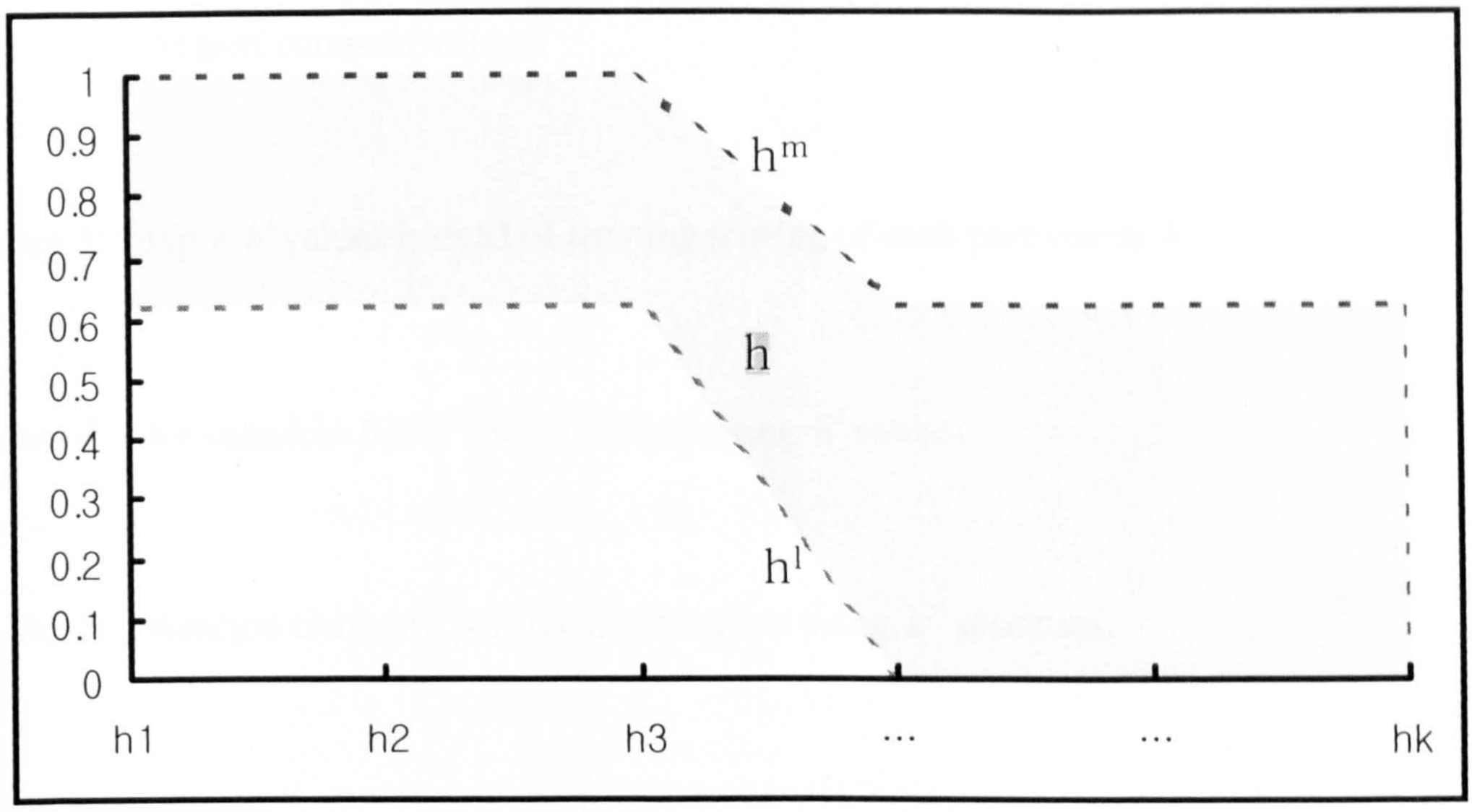
$$g(\cdot) \underline{\beta} I = \begin{Bmatrix} h^l(x_i) = 0 & if\ g(\cdot) \ge I \\ h^l(x_i) = I & if \min_{x_i} |g(x_i) - I| \end{Bmatrix}$$

Therefore, the relations of h, h^l and h^m are as follows:

$$h^l \subset h \subset h^m$$

Numerous possible solutions of h exist, as shown in the above equation.

Figure 5.13 Possible solutions of h



Source: Drawn by author

In the case of selecting the influential factors, super-solutions, h^m, and sub-solutions, h^l, yielded significant indications, i.e. factors x_i, which have values as $h^m(x_i)=1$, were not improving the system, while the factors x_i, with values as $h^l(x_i)=0$, could be seen as improving the system.

Super-solutions (h^m) and sub-solutions (h^l) have a range of value as follows.

$$0 \le h^l \le I, \quad I \le h^m \le 1$$

To synthesise the above explanations, the IRFE procedures can be summarized as follows:

Step 1: Acquire the 'fuzzy integral values' using the fuzzy integral process with 'direct relation'.

Step 2: Draw the super-solutions (h^m) and sub-solutions (h^l) using the α operation and β operation. h^l values are regarded as 'influential factors' which can be improve the port competitiveness.

Step 3: Input h^l values instead of existing scoring of each port values h.

Step 4: Re-calculate fuzzy integral values using h^l values.

Step 5: Analyse changing port competitiveness using h^l scenarios.

5.5 Summary

The evaluation of port competitiveness can be regarded as one containing problems of complex multiple-attributes and multiple-hierarchies (CMAMH). In addition, it also has difficulties concerning certain characteristics of evaluation such as complexity, uncertainty and ambiguity. To deal with such problems, it was decided to employ IFE, an exploratory methodology. So as to adapt this methodology to the targeted ports, the following detailed steps were taken: 'the definition of variables', 'the factor measuring method', 'the detailed data collection method', and 'an explanation for the overall calculation part', which consists of the method of fuzzy evaluation and that of the inverse relation of fuzzy relation. By using this suggested methodology, an evaluation of the targeted port competitiveness will be carried out in Chapter 6. To follow, in Chapter 7, critical competitive factors will be drawn out, and Chapter 8 focuses on sensitivity analysis using the critical factors extracted.

CHAPTER 6

Evaluating Port Competitiveness using Fuzzy Evaluation

The main object of this chapter is the evaluation of ranking in terms of competitiveness for the targeted ports. Using the factors and the evaluation structure suggested in Chapter 5, the sea ports in NEA were thoroughly evaluated. This chapter consists of three sections. In the first section, the survey process will be explained, including port selection for the analysis, questionnaire development, the pilot survey, the comments from respondents, the sample selection and the respondent profiles. The second section analyses port competitiveness using fuzzy evaluation, including the specific calculation processes concerned i.e. fuzzy evaluation value, overlap degree, fuzzy measure value and fuzzy integral. In the third section, insights and implications of the results arising from the use of the model will be provided.

6.1 Assessment of survey results

6.1.1 Port selection for analysis

For the selection of leading ports in their targeted area, Lirn *et al.* (2004) used the total container throughput as the major index. Also in this study container throughputs obtained from the data in Containerisation International Yearbook (2004) were adopted as the selection criteria. Accordingly, ports located in NEA and ranked within the top 20 were selected for fuzzy evaluation.

Table 6.1 Top 20 ports selected

Ranking	Ports	Container throughputs	Country
1	Hong Kong	19,140,000	China
2	Singapore	16,800,000	Singapore
3	Busan	9,436,307	South Korea
4	Shanghai	8,610,000	China
5	Kaohsiung	8,493,000	Taiwan
6	Shenzhen	7,613,754	China
7	Rotterdam	6,515,449	Netherlands
8	Los Angeles	5,273,863	USA
9	Hamburg	5,373,099	Germany
10	Antwerp	4,777,387	Belgium
11	Port Klang	4,533,212	Malaysia
12	Long Beach	4,526,356	USA
13	Jebel Ali	4,194,264	UAE
14	Yantian	4,181,478	China
15	New York/New Jersey	3,749,014	USA
16	Qingdao	3,410,000	China
17	Bremen	3,031,587	Germany
18	Gioia Tauro	2,954,571	Italy
19	Felixstowe	2,750,000	UK
20	Tokyo	2,712,348	Japan

Source: Containerisation International Yearbook (2004)

The selected ports are Hong Kong (1^{st}), Busan (3^{rd}), Shanghai (4^{th}), Kaohsiung (5^{th}), Shenzhen (6^{th}), Yantian (14^{th}), Qindao (16^{th}) and Tokyo (20^{th}). With respect to the ports being representative for the region, the selected ports were major hub ports for each nation i.e. Busan from South Korea, Kaohsiung from Taiwan, and Tokyo from Japan. However, in the case of China, three ports were selected. The extent to which each provides fair representation of each region of China is reviewed follows the work of Cullinane *et al.* (2004, p.38) who divided mainland Chinese ports into three groups as follows:

"Southern China: Shenzhen, Guangzhou, Zhongshan.
Central China: Shanghai, Ningbo.
Northern China: Qingdao, Tianjin and Dalian"

In this vein, the selected Chinese ports are representative of each region i.e. Shenzhen for southern China, Shanghai for central China and Qingdao for northern China.

However, the elimination of Yantian port from the evaluation was regarded as reasonable because Shenzhen comprises the container terminals of Yantian, Shekou and Chiwan (Cullinane *et al.*. 2004).

6.1.2 Questionnaire development

As mentioned in Section 5.3.1, 'detailed data collection method', the questionnaire included two parts: scoring the performance of each port and scoring the degree of overlap among the evaluation factors. The questionnaire was initially developed by the researcher and then reviewed by certain members of organizations including the International Shipping and Logistics Group at the University of Plymouth Business School in the U.K. and Korea Maritime University in South Korea. Certain reviewers suggested translating the questionnaires from English into Chinese and Korean for the participants from those countries in order to obtain more exact and effective answers and a better reply rate, which was done. The English version is in Appendix A and B, the Korean in Appendix C and D and the Chinese in Appendix E and F. To familiarise the respondents with pair-wise comparison and fuzzy number answering, clear examples of how to answer the questions were given.

The first part of the questionnaire consisted of three Sections: the introduction, the explanation of the factors and the structure of port competitiveness and, an explanation of the degree of overlap and a request for opinions. The second part was also divided into three Sections: introduction and requesting details from respondents, the explanation of the factors and the structure of port competitiveness and, asking the participants to provide scores for port performance.

6.1.3 Pilot survey

Regarding pilot tests, Xu and Quaddus (2005, p.322) stress the importance of procedure as follows:

"The pilot test has to design to test the validity of the factors and variables in the final comprehensive model. Through the pilot test, it could be decided whether the questionnaire was valid for the subsequent national survey"

In this part, initial questionnaires were sent to five experts in each group, and two were received from the academic/researcher group, two from the customer group and one from the provider group. The return rate was 8.3% and to obtain more valuable comments on content validation and their perceptions on the questionnaire, extensive telephone interviews were used to obtain respondents' answers. From the above procedure, the following meaningful issues emerged.

6.1.4 Comments from respondents

Through the pilot test, the following comments were received.

First, concerning the content validation test, the experts pointed out that Yantian port should be eliminated from the group of targeted evaluation ports due to the reason mentioned in Section 6.1.1.

Second, the respondents stressed the selection of 'exact targeted population' i.e. those respondents involved in the bulk cargo business were not able to provide proper answers, even though their organizations dealt with the container business.

Third, regarding the selection of customer group, it was found that the smaller companies focusing on freight forwarding and inland logistics transport, found it difficult to answer the questions due to their lack of information on the whole process comprising container

business, which is in line with the following arguments presented by UNCTAD (2004, p.4):

"Today's mega liner shipping companies which were focused on sea-leg transport have functions of warehousing, multimodal and distribution activities as well as trading and financial services. Therefore, the demarcation line is obscure on division of shipping company, freight forwarder, and logistics companies".

To overcome this issue, the shipping companies were selected to represent the customer group.

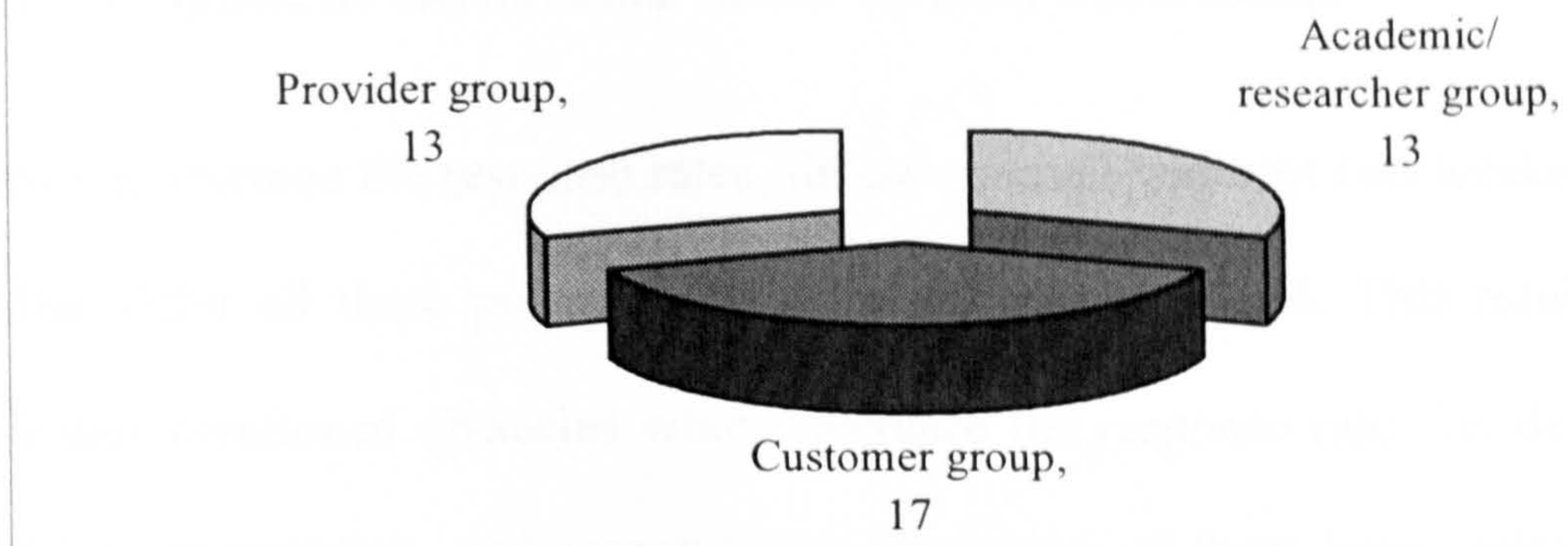
Fourth, in reference to the provider group, obtaining replies was expected to be limited due to the issue of data confidentiality for each container terminal and that of governmental bureaucracy. Hence, to tackle these problems, the targeted populations were to focus on global terminal operators (GTOs).

6.1.5 Sample selection

For the purpose of selecting respondents, the sample frame was divided into three groups, i.e. the academic/researcher group, the customer group and the provider group, and the selection of the sample was done as explained in Section 5.3.1.

Using an on-line questionnaire format on the Internet, a total of 300 questionnaires were posted to each expert from October 2005 to January 2006 and the valid response rates for each group varied from 13% to 17%.

Figure 6.1 Response rate for each group



The detailed business areas and numbers of respondents are shown in Table 6.2 below.

Table 6.2 Detailed status of response

	Academic /researcher Group		Customer group		Provider group		
Usable responses	UN	RI	SC	FF	TO	PA	GO
Total distributed	100		100		100		
Total received	10	4	19	4	8	4	2
Usable responses	9	4	13	4	7	4	2
Usable response rate (%)	13		17		13		

Notes: UN; University, RI; Regional Institute, SC; Shipping Company, FF; Freight Forwarder, TO; Terminal Operator, PA; Port Authority, GO; Government

Regarding the response rate, Larson and Poist (2004) noted that they have been declining year by year, and suggested the following four types of survey methods and return rates:

1) No incentive, no follow-up; 8.4%
2) No incentive, follow-up mailing with replacement questionnaire; 19.6%
3) $ 1.00 prepaid monetary incentive, no follow-up; 17.2%
4) $ 1.00 prepaid monetary incentive, follow-up up mailing with replacement questionnaire; 23.5%

The authors stressed that offering a monetary incentive doubled the return rates compared to the no incentive method. In the present study, due to the limitations set on PhD research, the second option, no incentive and follow-up mail, was selected.

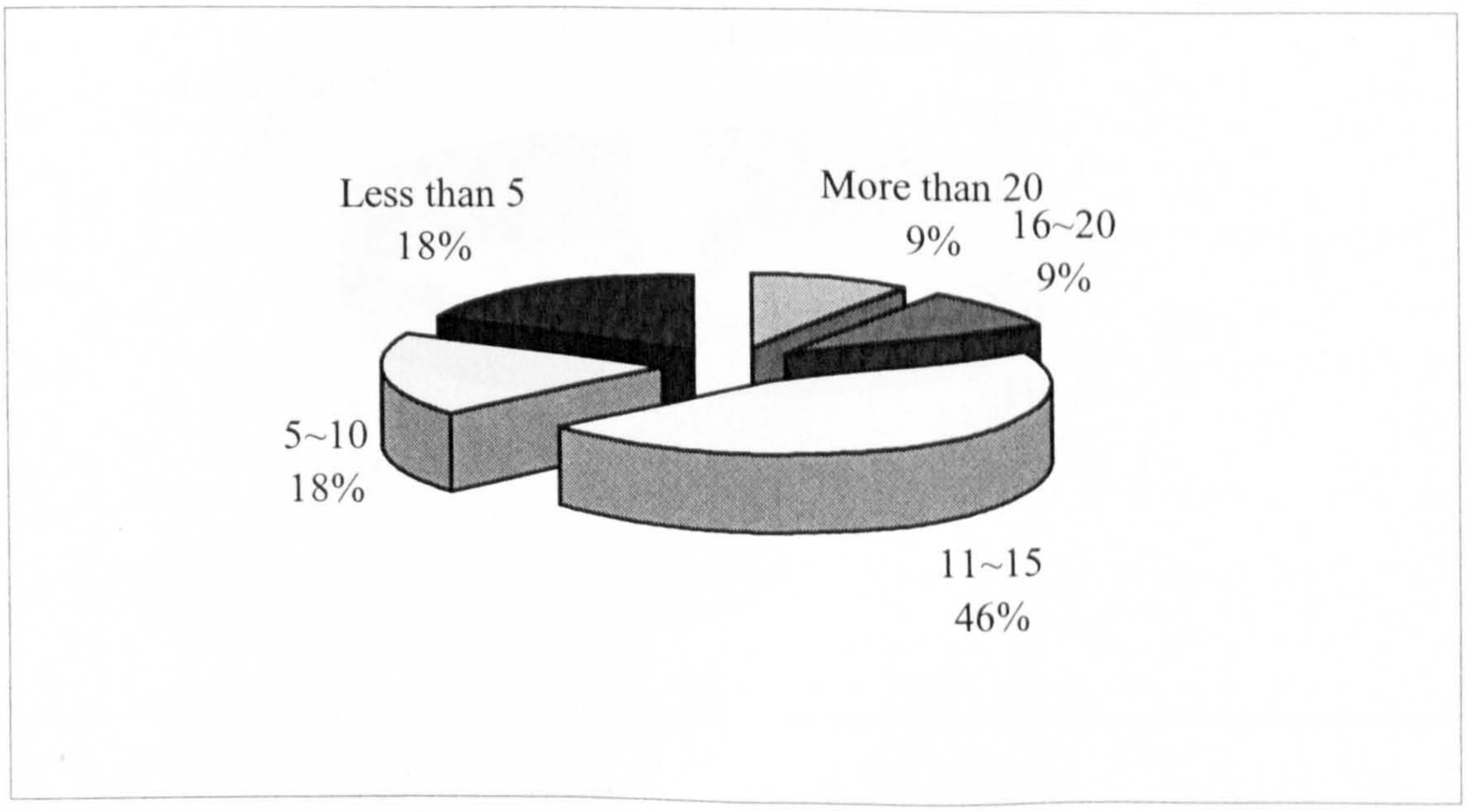
In order to increase the response rates, follow-up mail was sent two weeks after the initial mailing. After all these procedures, the rates stood at 14.3%. This result is due to the previously mentioned obstacles which decrease the response rate, i.e. delicate questions related to competition, and respondents' perception of them being related to corporate operational secrets.

However, as suggested in Section 5.3.1, the number of experts' responses received can be regarded as an acceptable sample size for fuzzy evaluation.

6.1.6 Respondents' profiles

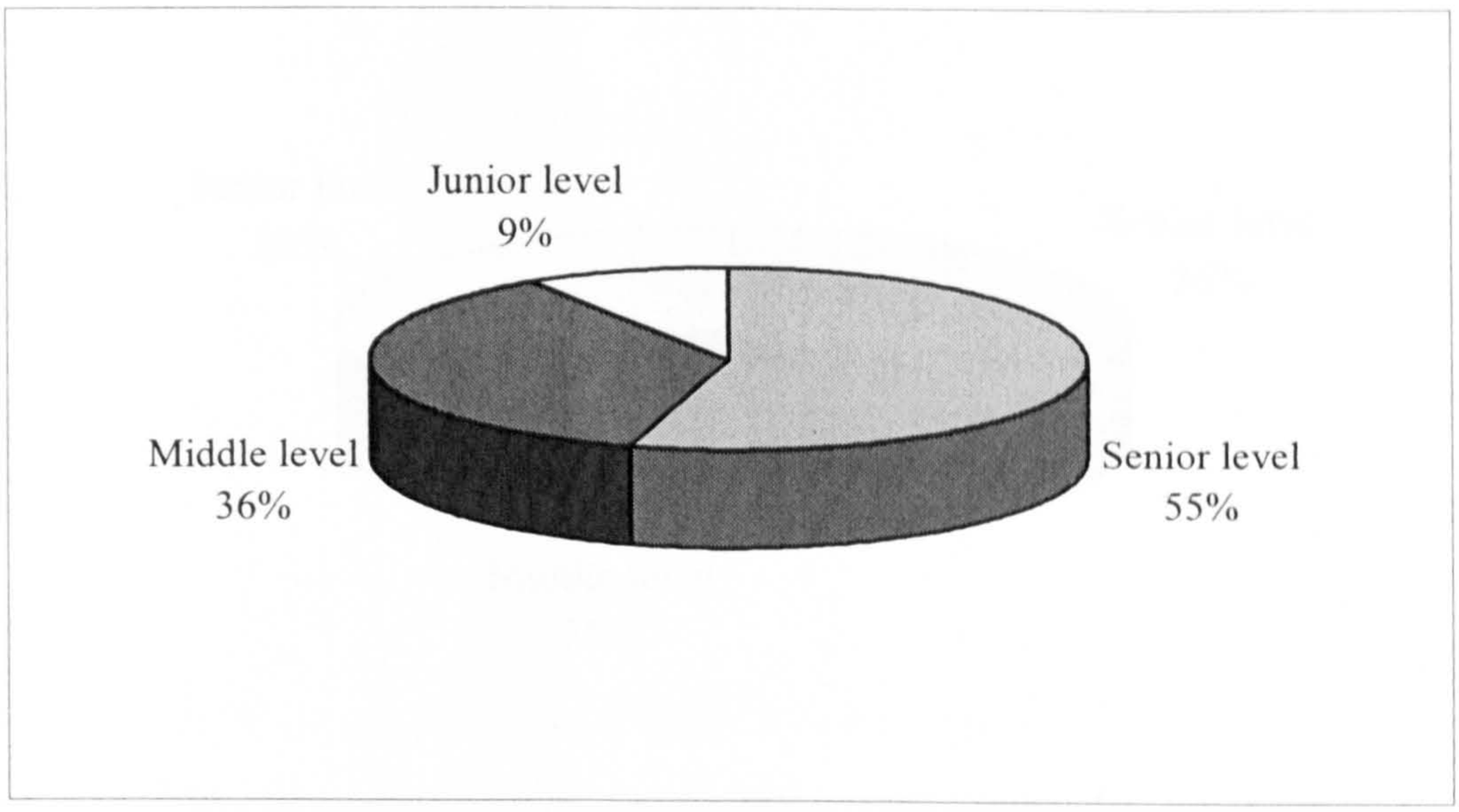
For the academic/researcher group, 46 % of the experts in the sample started their research work between 11 and 15 years ago, with 18 % engaged in business between 5 and 10 years ago, 9 % between 16 and 20 years ago, and 9% having been in business for more than 20 years.

Figure 6.2 Years in business for academic/researcher group



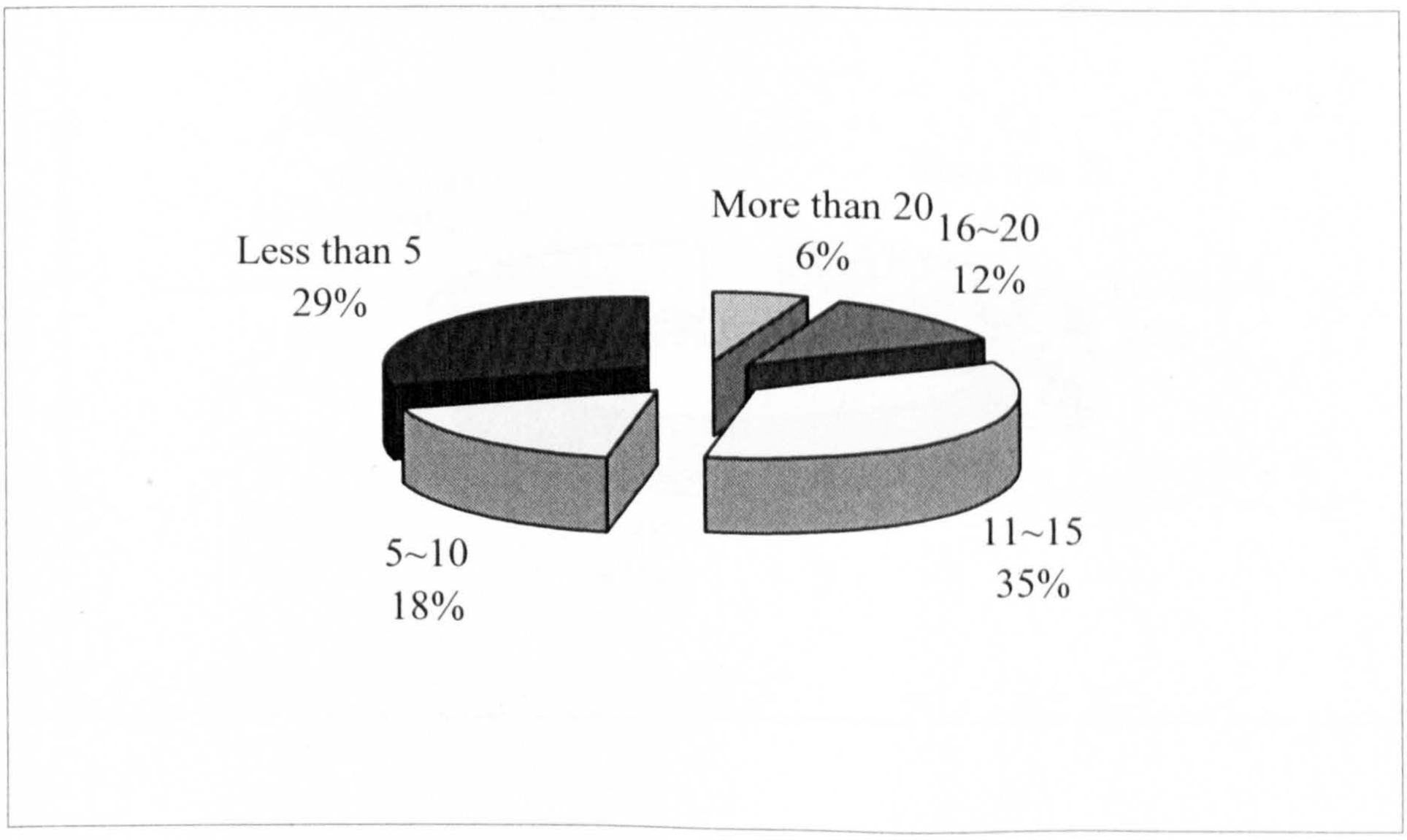
Regarding the business positions, 55% of the respondents stated that they were at the senior level, 36% at the middle level and 9% at the junior level.

Figure 6.3 Respondents' positions for academic/researcher group



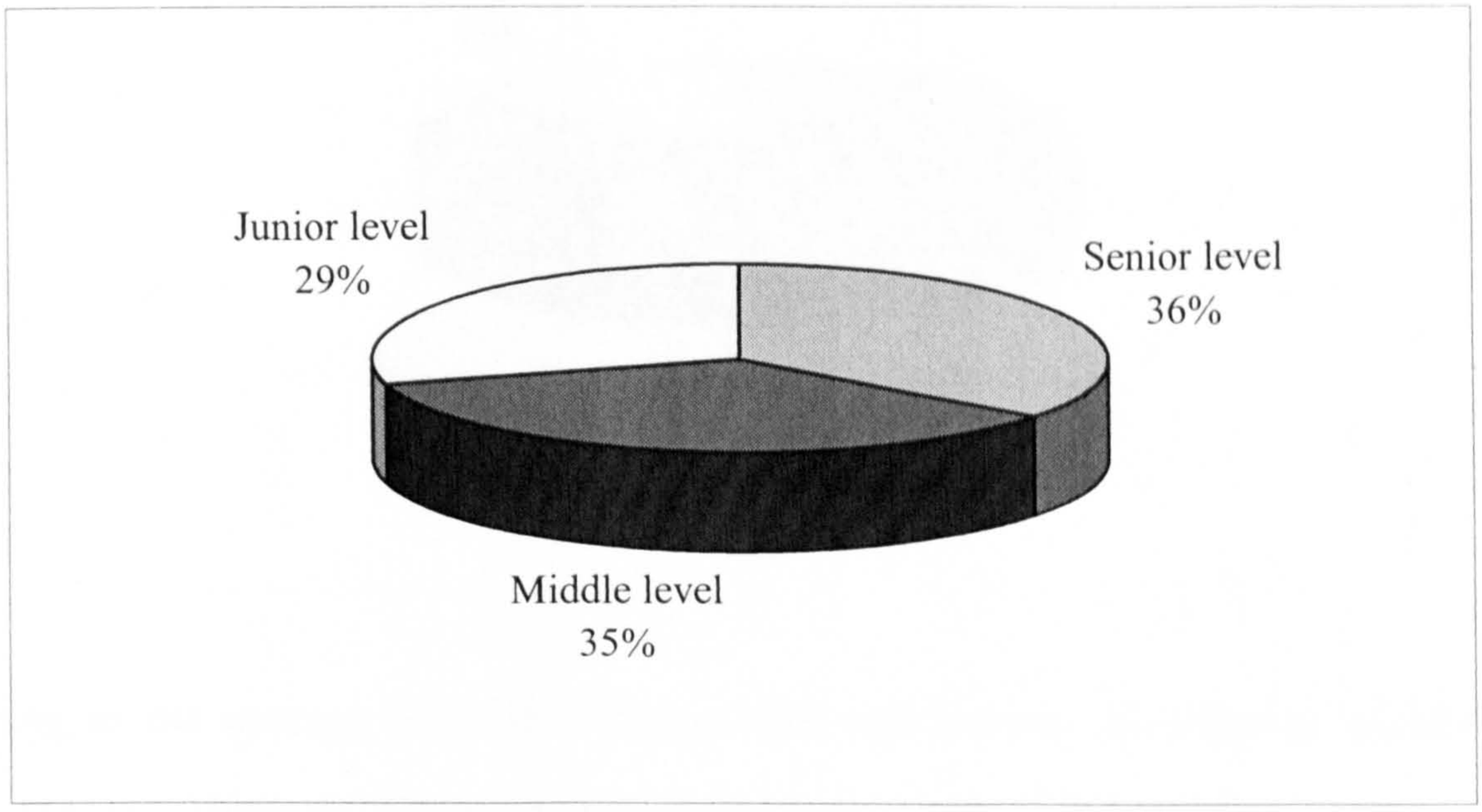
With regard to the customer group, 35% of the experts in the sample had entered the business between 11 and 15 years ago, with 18% entering the business between 5 and 10 years ago, with 12% between 16 and 20 years ago, and 6% having been in the business for more than 20 years.

igure 6.4 Years in business for customer group



With regard to their business positions, 36% of the respondents answered that they were at the senior management level, 35% at the middle level and 29% at the junior level.

Figure 6.5 Respondents' positions for customer group



As for the provider group, 15% of the experts in the sample had entered the field between 11 and 15 years ago, with 47% between 5 and 10 years ago, and 15% working for more than 20 years. With reference to their business positions, 8% of the respondents gave their position as senior management level, 77% middle management and 15% of junior level.

Figure 6.6 Years in business for provider group

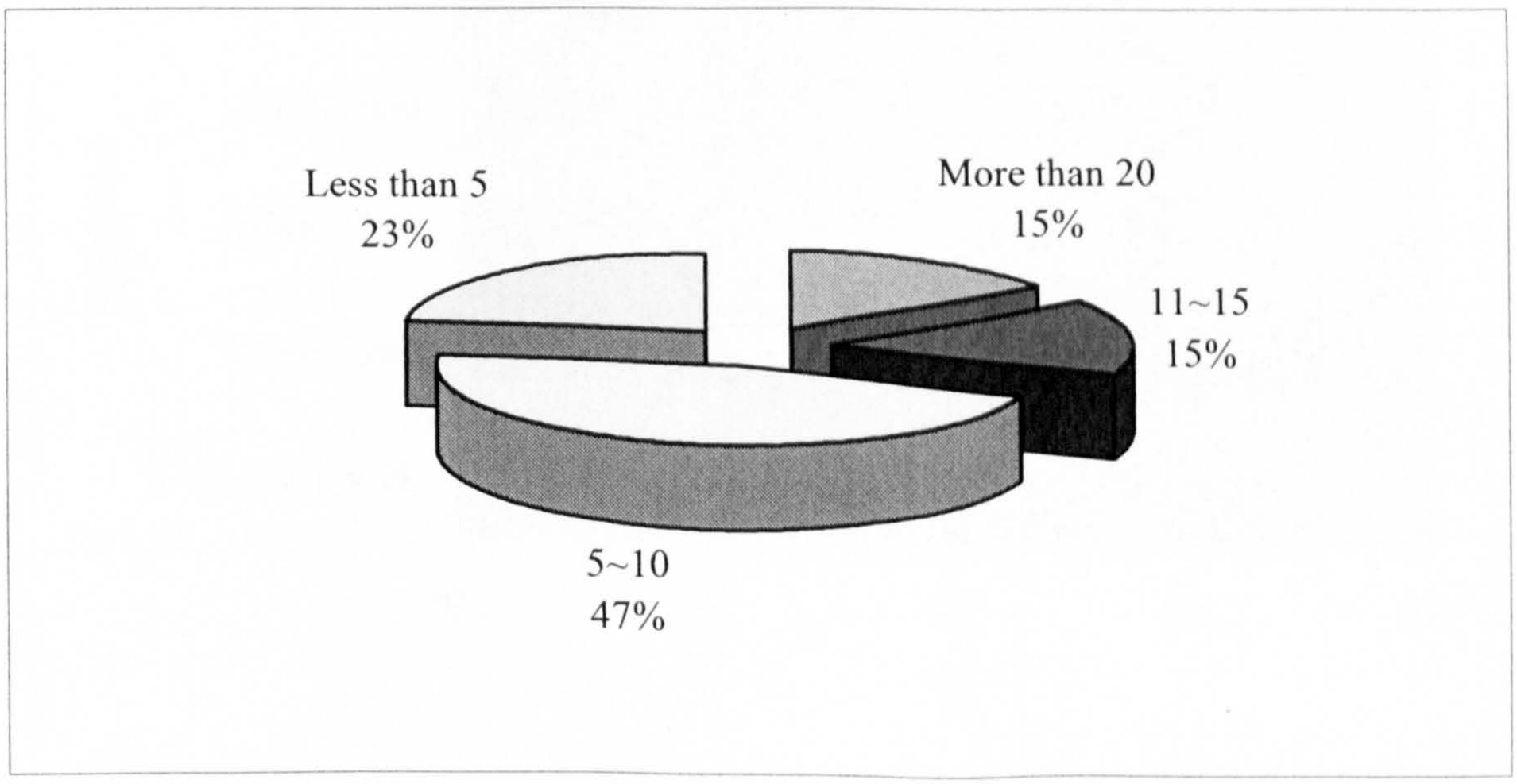
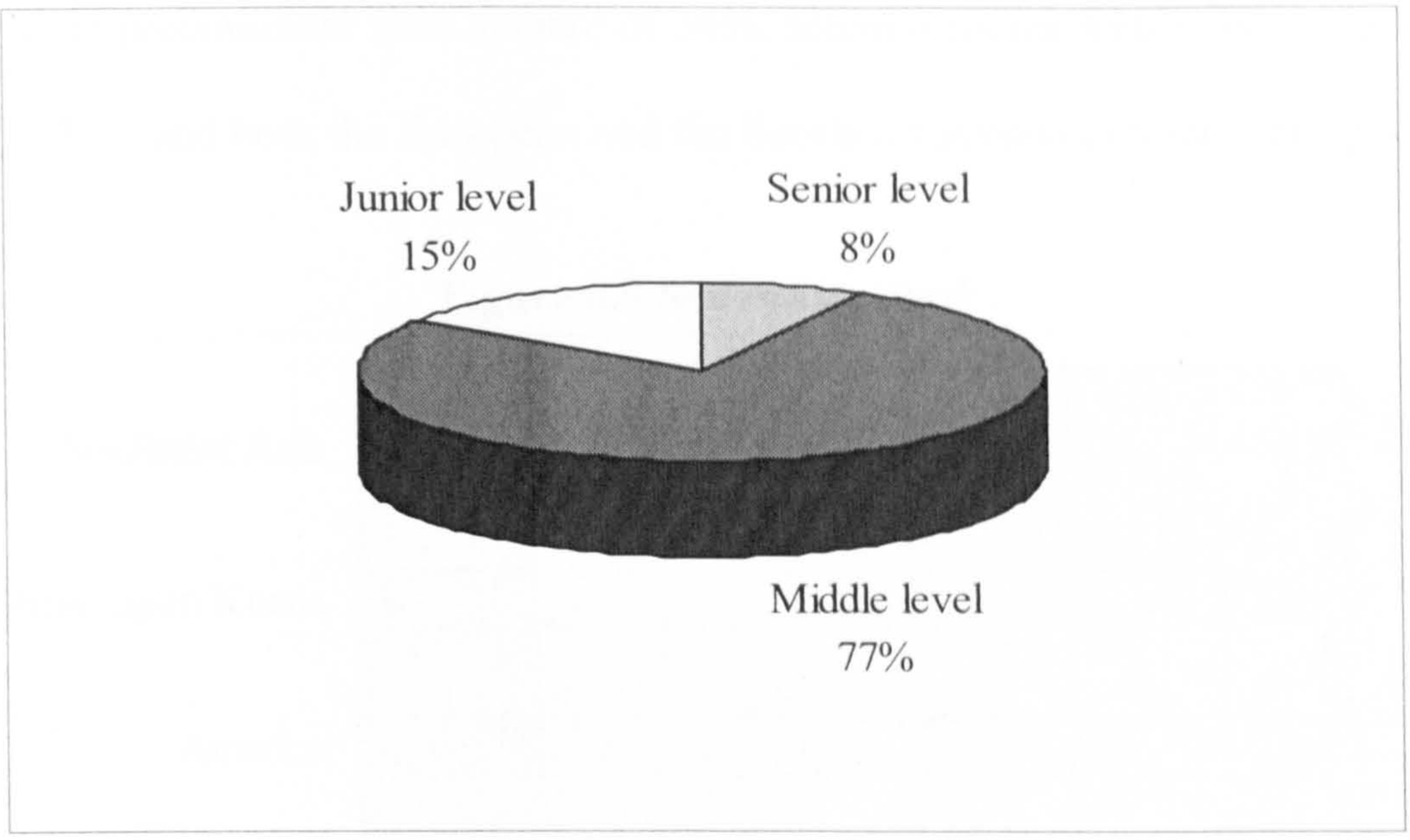
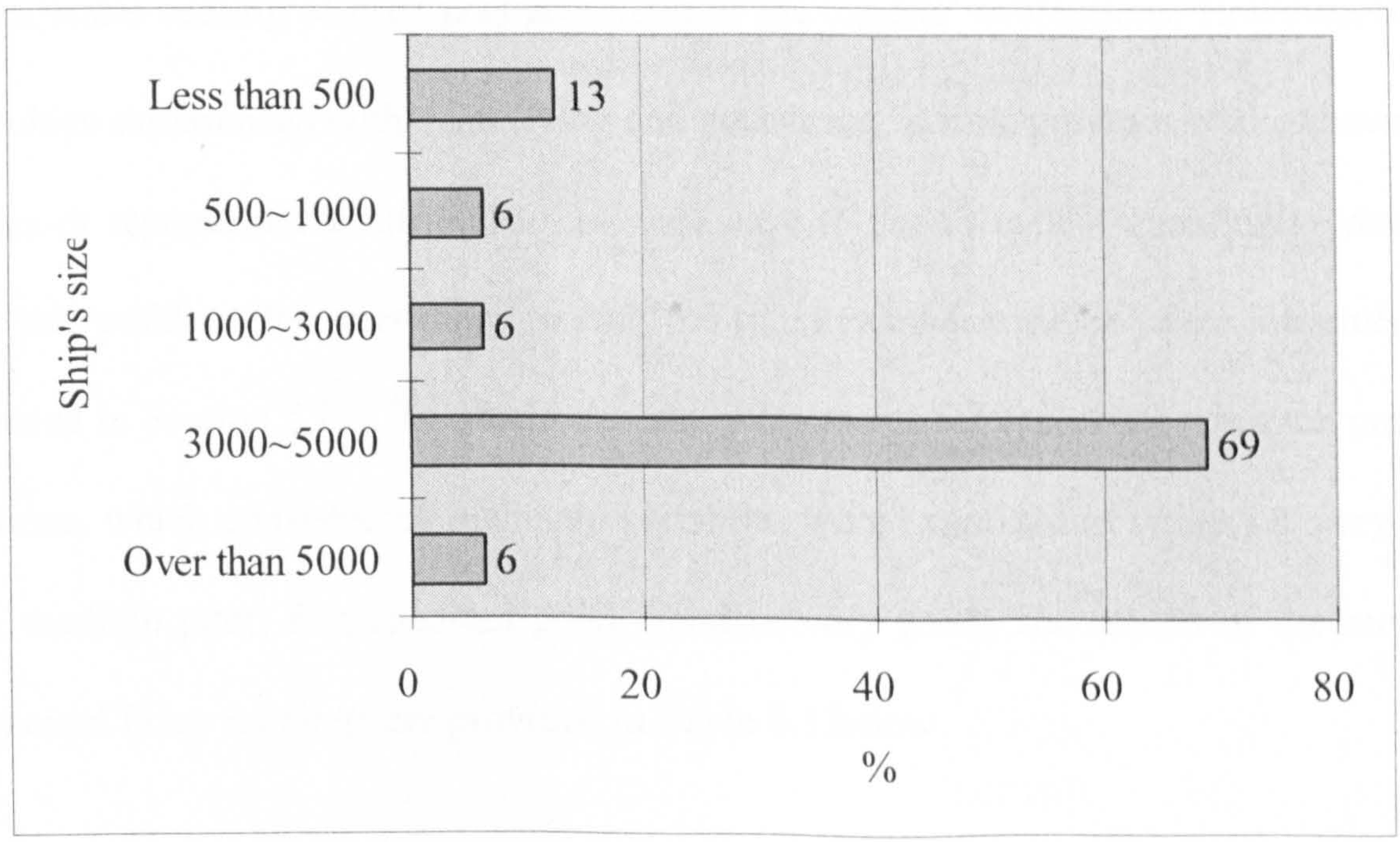


Figure 6.7 Respondents' positions for provider group



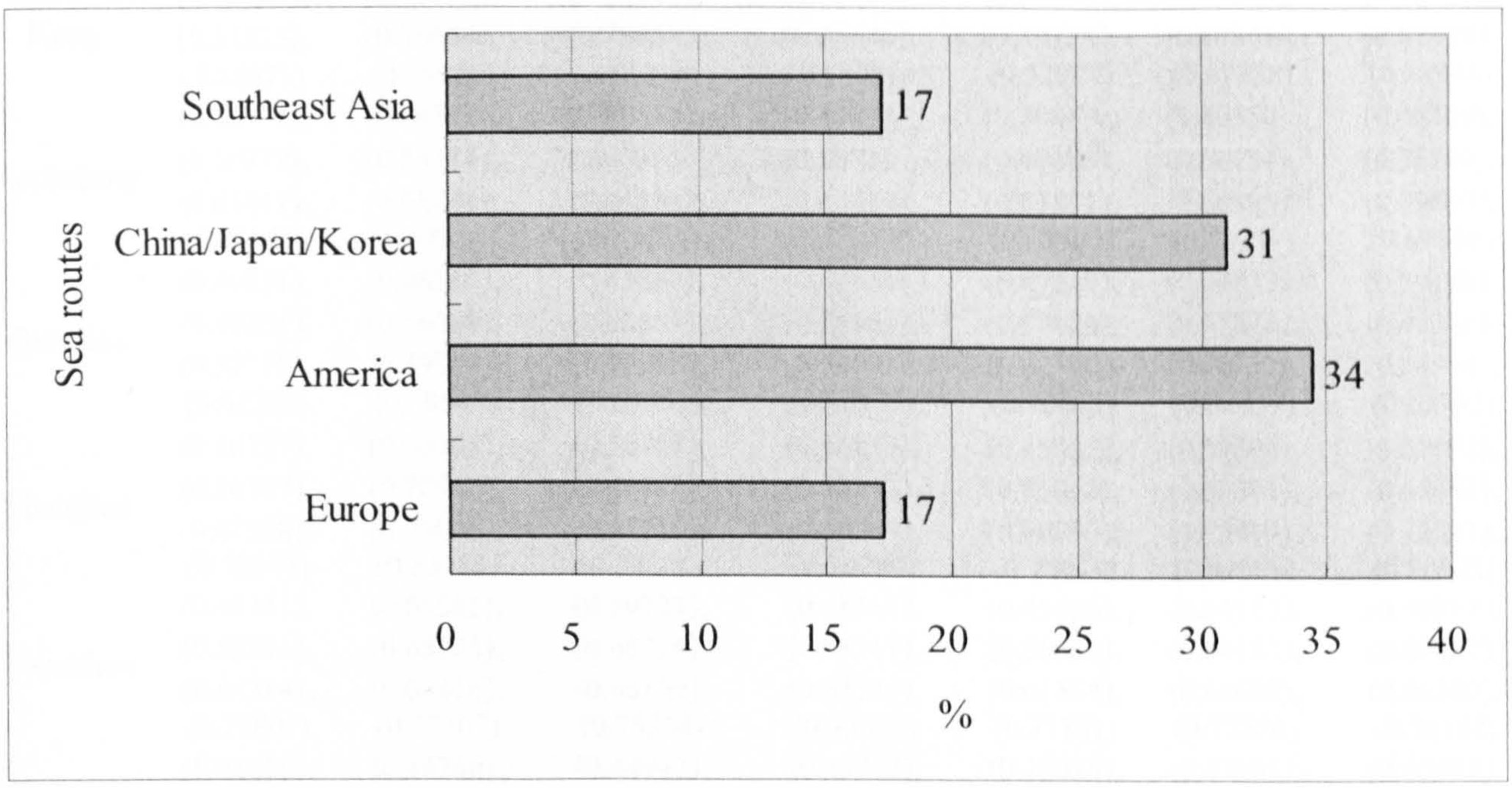
Turning to the average ship size, 69% of the organisations investigated usually used containerships of between 3,000 and 5,000 TEUs, 6% over 5,000 TEUs and 13% less than 500 TEUs. This means that various classes of containership were being used in the targeted organisations. Hence, reflections of various aspects could be obtained in the assessment of port competitiveness.

Figure 6.8 Average ship size used



Regarding the sea routes used by the targeted organizations, the routes from NEA to America were predominant with a share of 34%, internal routes within the targeted region standing at 31% and both the European and the Southeast Asian ones accounting for 17%.

Figure 6.9 Sea routes used



6.2 Evaluating Port Competitiveness

6.2.1 Computation of Fuzzy evaluation value $h(\cdot)$

$h(\cdot)$ indicates scoring of each port according to the experts' evaluations. However, due to difficulties experienced with quantifying and measuring factors, previous studies have used proxies or representative attributes that were easy to use to collect quantitative data. To solve this problem, the questionnaire and 'the fuzzy number concept' were introduced, as suggested in Section 5.2.3. To obtain experts' judgements for each factor on each port, the questions, which consisted of linguistic variables, were expressed in scales i.e. very poor, poor, medium poor, fair, medium good, good or very good. The results of the mean by trapezoidal fuzzy numbers are provided in Table 6.3 below.

Table 6.3 Mean of each port score using fuzzy number

	Port service	Hinterland Condition	Availability	Convenience	Logistics Cost	Regional Centre	Connectivity
Busan	(0.53198), (0.63198), (0.68612), (0.77707)	(0.41388), (0.50875), (0.56365), (0.65656)	(0.53137), (0.63137), (0.69849), (0.78808)	(0.49321), (0.59321), (0.63575), (0.73122)	(0.46968), (0.56968), (0.62398), (0.71357)	(0.58160), (0.68160), (0.71840), (0.80483)	(0.57707), (0.67707), (0.72293), (0.81644)
Hong Kong	(0.66727), (0.76727), (0.81825), (0.88673)	(0.55173), (0.65173), (0.70664), (0.78220)	(0.62745), (0.72745), (0.76350), (0.84359)	(0.60060), (0.70060), (0.75686), (0.83756)	(0.29804), (0.38582), (0.43228), (0.52971)	(0.65943), (0.75943), (0.80845), (0.87888)	(0.66109), (0.76109), (0.82489), (0.88944)
Kaohsiung	(0.46772), (0.56772), (0.61011), (0.70045)	(0.44314), (0.54314), (0.58446), (0.67934)	(0.50513), (0.60513), (0.64238), (0.73982)	(0.49729), (0.59729), (0.64434), (0.73469)	(0.39683), (0.49683), (0.52851), (0.62594)	(0.46350), (0.56154), (0.60995), (0.70739)	(0.46169), (0.56169), (0.59849), (0.69849)
Qingdao	(0.39231), (0.49231), (0.52715), (0.62202)	(0.46380), (0.56380), (0.59864), (0.69608)	(0.45867), (0.55867), (0.59608), (0.69351)	(0.41961), (0.51961), (0.56591), (0.66139)	(0.47029), (0.57029), (0.62700), (0.72443)	(0.37873), (0.47873), (0.52715), (0.62459)	(0.39186), (0.49186), (0.54344), (0.63952)
Shanghai	(0.46727), (0.56727), (0.61508), (0.70543)	(0.60965), (0.70965), (0.75098), (0.83288)	(0.50784), (0.60784), (0.64781), (0.74525)	(0.46833), (0.56833), (0.60769), (0.70769)	(0.45943), (0.55943), (0.60890), (0.70633)	(0.59306), (0.69306), (0.73499), (0.81629)	(0.55882), (0.65882), (0.72081), (0.80528)
Shenzhen	(0.48311), (0.58311), (0.64314), (0.73801)	(0.55385), (0.65385), (0.68416), (0.77707)	(0.50724), (0.60724), (0.66199), (0.75354)	(0.48311), (0.58311), (0.63725), (0.73529)	(0.45686), (0.55686), (0.61554), (0.71101)	(0.54163), (0.64163), (0.68688), (0.77526)	(0.50317), (0.60317), (0.66380), (0.76184)
Tokyo	(0.43650), (0.53650), (0.58612), (0.68160)	(0.44766), (0.54766), (0.58582), (0.68069)	(0.44947), (0.54947), (0.59261), (0.68808)	(0.44962), (0.54962), (0.59925), (0.69155)	(0.22036), (0.29849), (0.35581), (0.45581)	(0.47466), (0.57466), (0.62443), (0.71086)	(0.45083), (0.55083), (0.58627), (0.67919)

Regarding the defuzzification, Roman and Chalco (2006, p.231) clearly defined it:

"The defuzzification is the ultimate step in approximate reasoning and it consists of in the replacement of a fuzzy set with a suitable nonnegative real number"

Using the equation suggested in Section 5.2.3, the above mean of each port score can be changed from trapezoidal fuzzy numbers to crisp numbers, as shown in the table below.

Table 6.4 Crisp values of each port scoring using defuzzification

	Port service	Hinterland Condition	Availability	Convenience	Logistics Cost	Regional Centre	Connectivity
Busan	0.65679	0.53571	0.66233	0.61335	0.59423	0.69661	0.69838
Hong Kong	0.78488	0.67308	0.74050	0.72391	0.41146	0.77655	0.78413
Kaohsiung	0.58650	0.56252	0.62311	0.61840	0.51203	0.58560	0.58009
Qingdao	0.50845	0.58058	0.57673	0.54163	0.59800	0.50230	0.51667
Shanghai	0.58876	0.72579	0.62719	0.58801	0.58352	0.70935	0.68594
Shenzhen	0.61184	0.66723	0.63250	0.60969	0.58507	0.66135	0.63299
Tokyo	0.56018	0.56546	0.56991	0.57251	0.33262	0.59615	0.56678

The final stage for each port score was the level process between zero and one. To obtain these values, the largest crisp values were set to be one and each evaluation value by port was obtained as a relative ratio against this which is illustrated in Table 6.5 below.

Table 6.5 Final scoring for each port

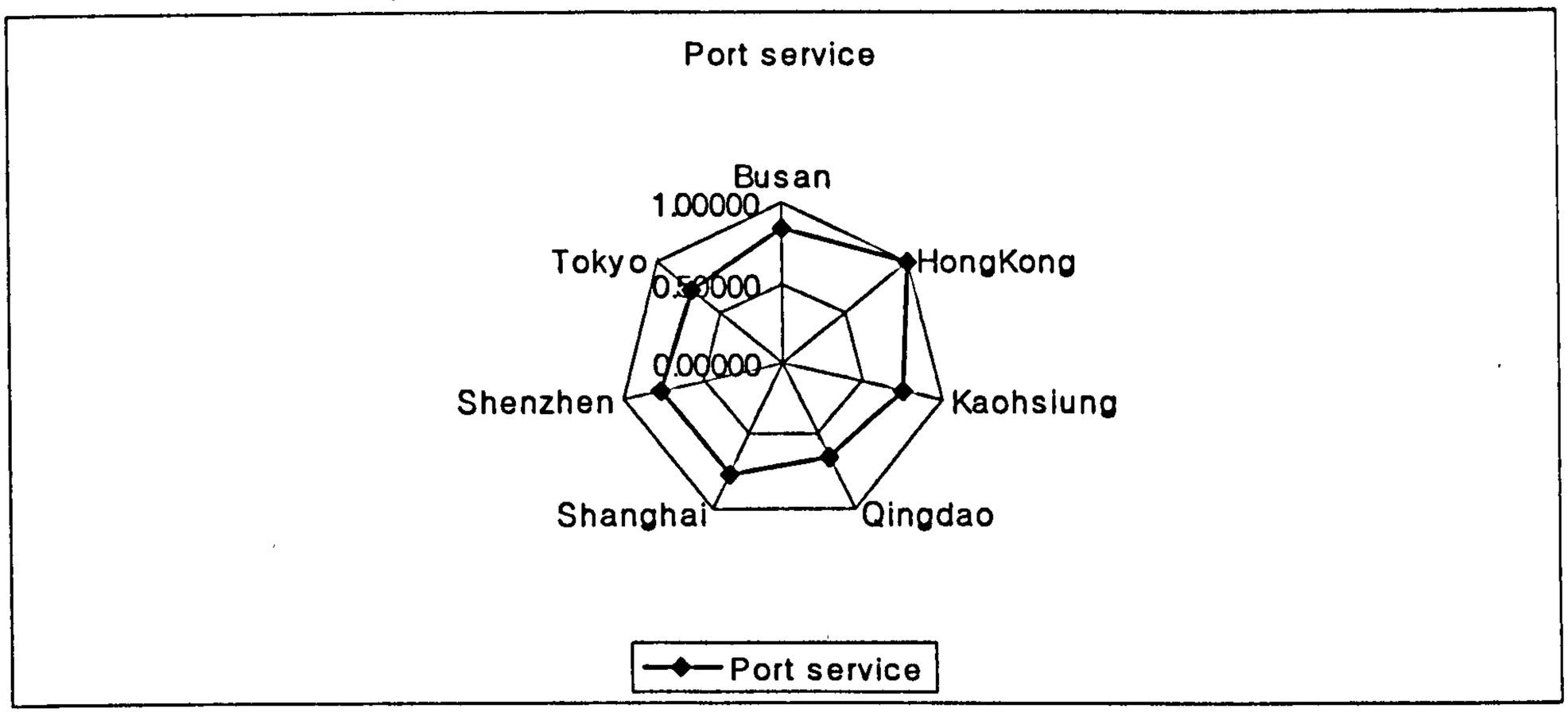
	Port service	Hinterland Condition	Availability	Convenience	Logistics Cost	Regional Centre	Connectivity
Busan	0.83680	0.73810	0.89444	0.84728	0.99369	0.89706	0.89065
Hong Kong	1.00000	0.92737	1.00000	1.00000	0.68806	1.00000	1.00000
Kaohsiung	0.74725	0.77504	0.84148	0.85426	0.85623	0.75410	0.73979
Qingdao	0.64780	0.79993	0.77885	0.74820	1.00000	0.64684	0.65891
Shanghai	0.75013	1.00000	0.84698	0.81227	0.97579	0.91347	0.87478
Shenzhen	0.77953	0.91932	0.85416	0.84222	0.97837	0.85166	0.80726
Tokyo	0.71372	0.77909	0.76963	0.79086	0.55621	0.76770	0.72282

A more detailed interpretation of the above evaluation results in seven principal factors i.e. port service, hinterland condition, availability, convenience, logistics cost, regional centre and connectivity, is provided in the following section.

As mentioned in Section 3.5, port service can be defined as 'the global issues and the local responses' (McCalla, 1999). More specifically, the detailed definition for port service suggested in Section 5.2.1, included "prompt response", "24 hours a day, seven days a week service" and "zero waiting time service". Using the integrated experts' judgements, each port service score could be obtained as shown in Figure 6.10.

Experts perceived that Hong Kong had the highest score (1.00000), followed by Busan (0.83680) and Shenzhen (0.77953).

Figure 6.10 Scoring for port service on each port



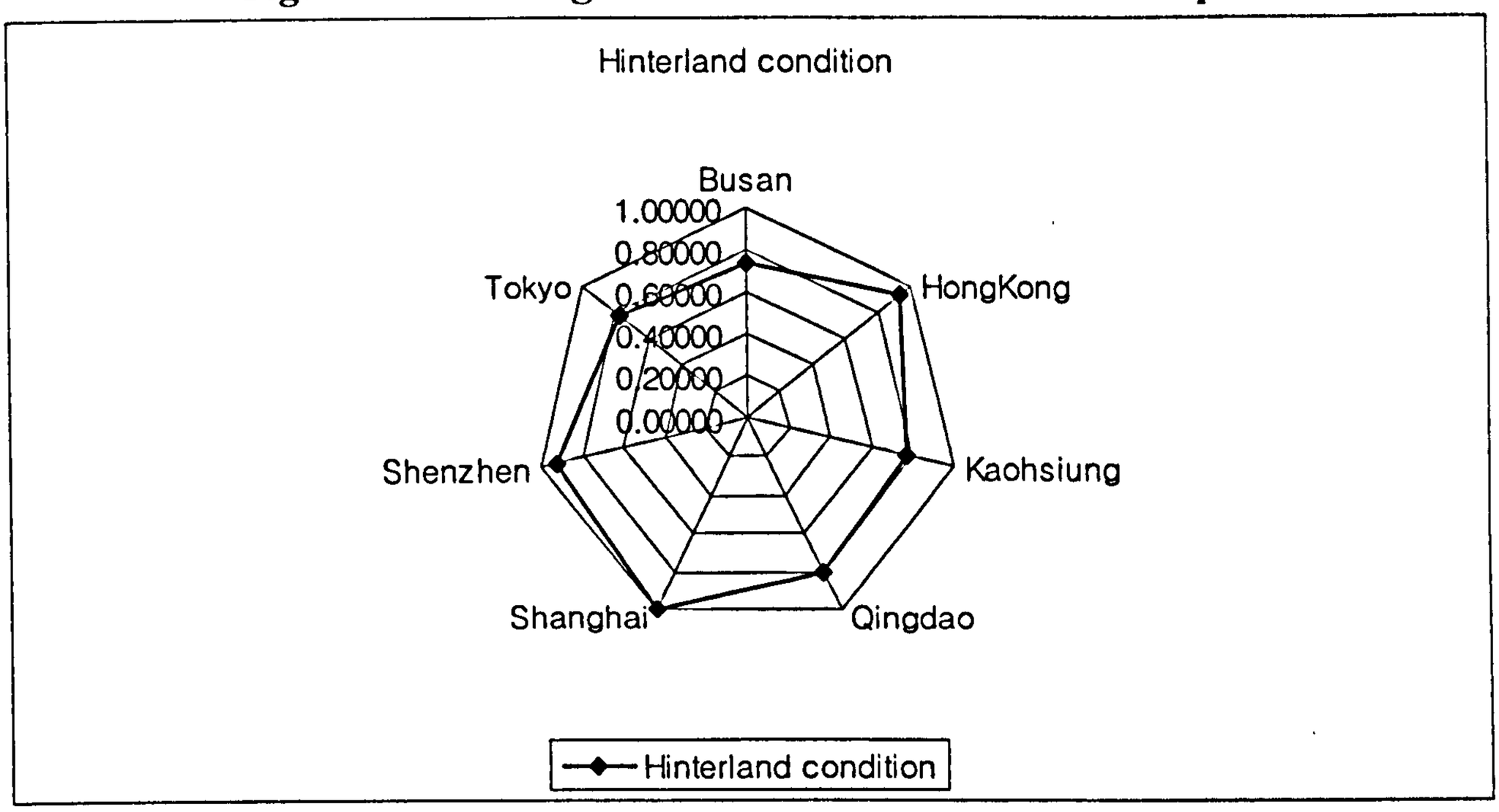
To measure the hinterland condition as a principal factor, experts were asked to consider three attributes i.e. "professionals and skilled labour in port operations", "size and activity of Free Trade Zone (FTZ) in port hinterland" and "volume of total container cargos" simultaneously. Very interestingly, Busan had the lowest score while Shanghai had the highest. Due to the closeness of a mountain to the major container terminals, the very nearness of the city centre and road traffic congestion, the hinterland condition acts as a major disadvantage to Busan port. Furthermore, to cover the lack of area for container terminals, Busan operates off-dock container yards (ODCY).

Fremont and Ducruet (2005, p.427) note the inefficiency of Busan's hinterland by stating that

"Port traffic is dispersed all over the urbanised area because 37 off-dock container yards are scattered around the city. In 2000, they handled 3.1 million import/export containers"

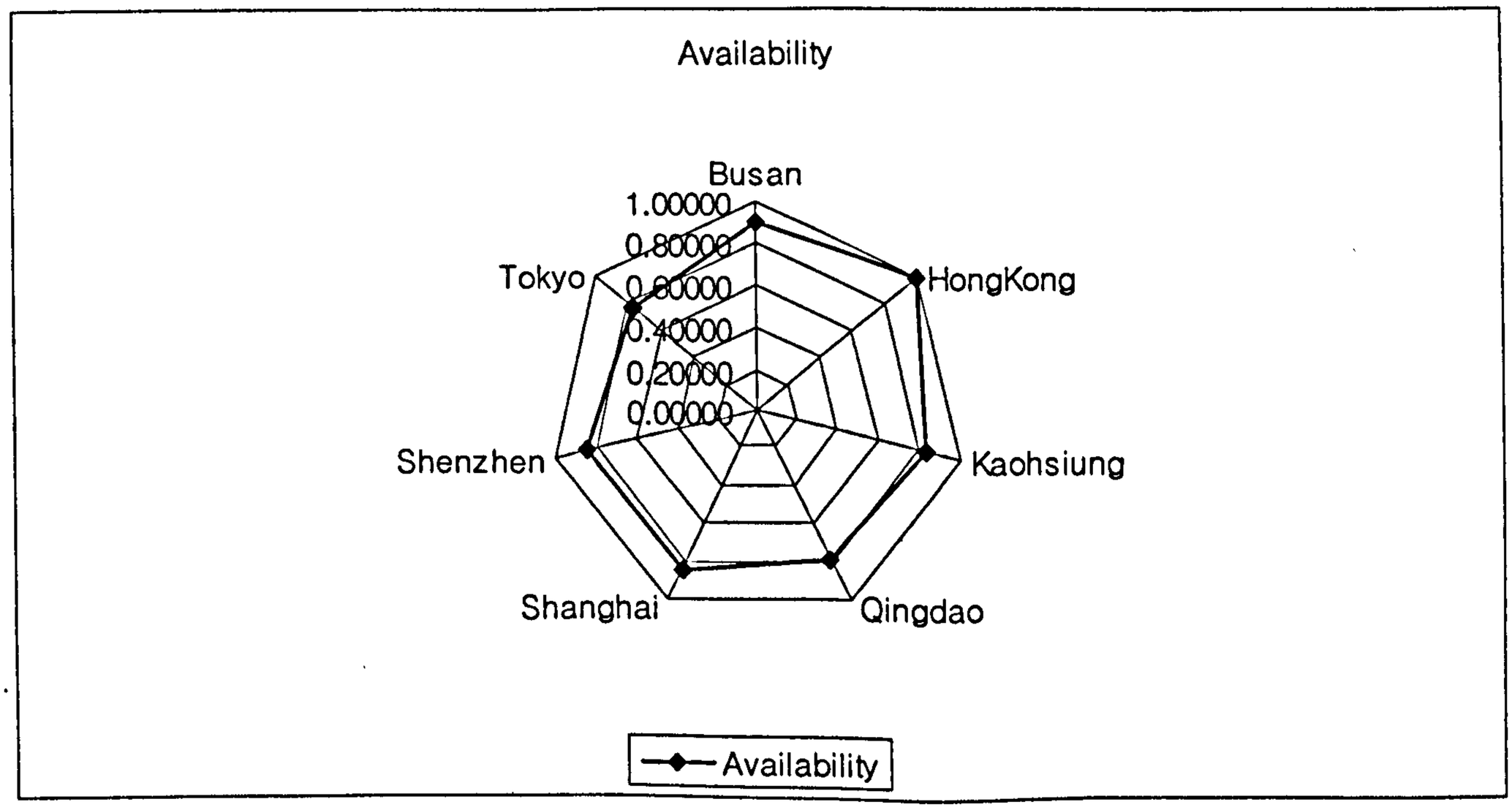
In contrast, in order to attract foreign direct investment (FDI), Shanghai has created four special zones i.e. the Lujiazui Finance and Trade Zone, the Jinqiao Export Processing Zone, the Waigaoqiao Free Trade Zone and the Zhangjiang Hi-Tech Park (Wu and Radbone, 2005). From this point of view, hinterland condition plays a role that is of major advantage to Shanghai.

Figure 6.11 Scoring for hinterland condition on each port



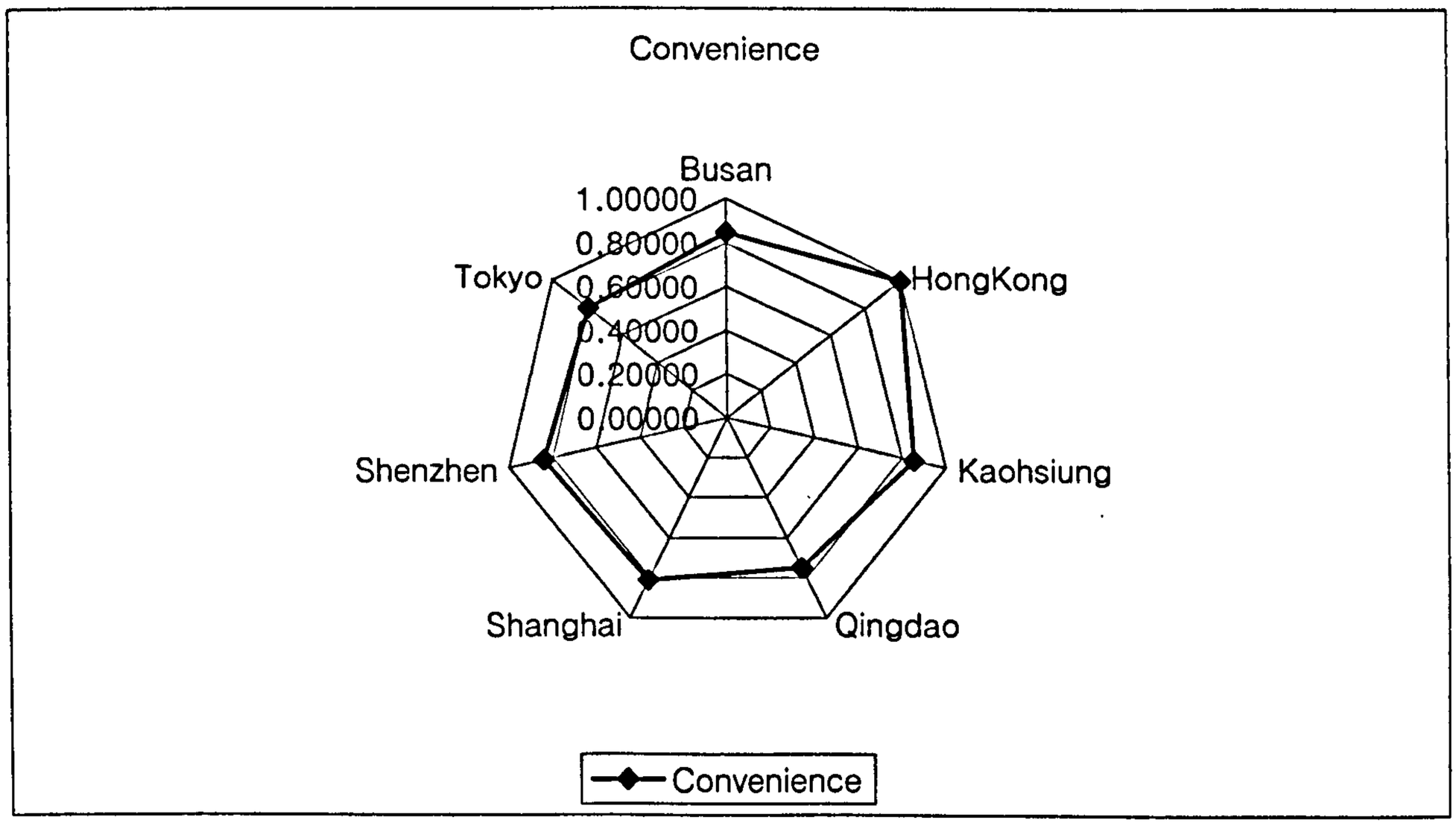
In this study, availability included two factors: "availability of a vessel berth on arrival in port" and "port congestion". In NEA, these two factors are regarded as the most important attributes, which is in line with the factors suggested by Ha (2003) with regard to the availability of facilities e.g. provision of vessel traffic system, availability of adequate container yards and backup facilities and availability of container handling equipment. Regarding availability, Hong Kong occupied the top position over the other ports.

Figure 6.12 Scoring for availability on each port



The evaluation of scoring for convenience on each port was processed by using integrated judgement, that is, experts simultaneously considering the three attributes i.e "water depth in approach channels and at berth", "sophistication of port information and its application" and "the stability of port labour" and providing a score for the convenience factor. As a result, Hong Kong had the highest value followed by Kaohsiung, Busan and Shenzhen, which had similar scores to each other.

Figure 6.13 Scoring for convenience on each port

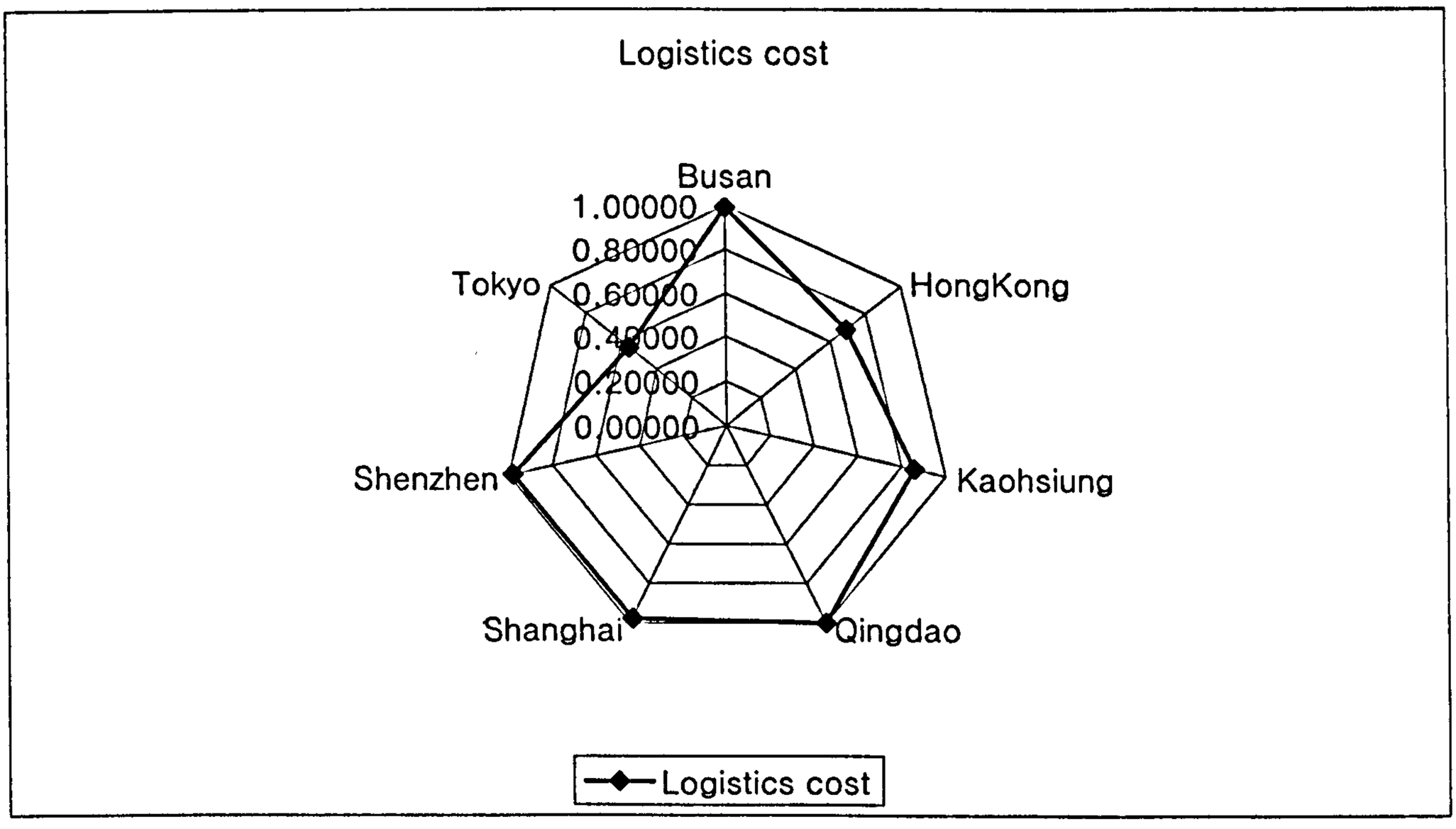


As reviewed in Section 4.2.1, Cullinane *et al.* (2002), Sanchez *et al.* (2003), Malchow and Kanafani (2004) and Tongzon and Heng (2005) experienced difficulties assessing the logistics cost factor due to various reasons. This is especially true for NEA, due to severe competition and the ports' operational secrecy, where obtaining secondary data for this factor still remains a problematic issue. To overcome this, the fuzzy number concept was introduced and resulted in a successful evaluation. Except for Hong Kong, the Chinese ports (Qingdao, Shanghai and Shenzhen) and Busan had a high ranking. However, Hong Kong, which was in the top position for port service, availability, convenience, regional centre and connectivity, had the lowest score, thus making it the port's weakest point.

This result is in line with the following analysis by Seabrooke et al. (2003, p55):

"Hong Kong's terminal handling charges are the highest in the world. Terminal handling charges at Hong Kong are at least 63% more expensive than other Asian ports and in many cases much higher than that"

Figure 6.14 Scoring for logistics cost on each port

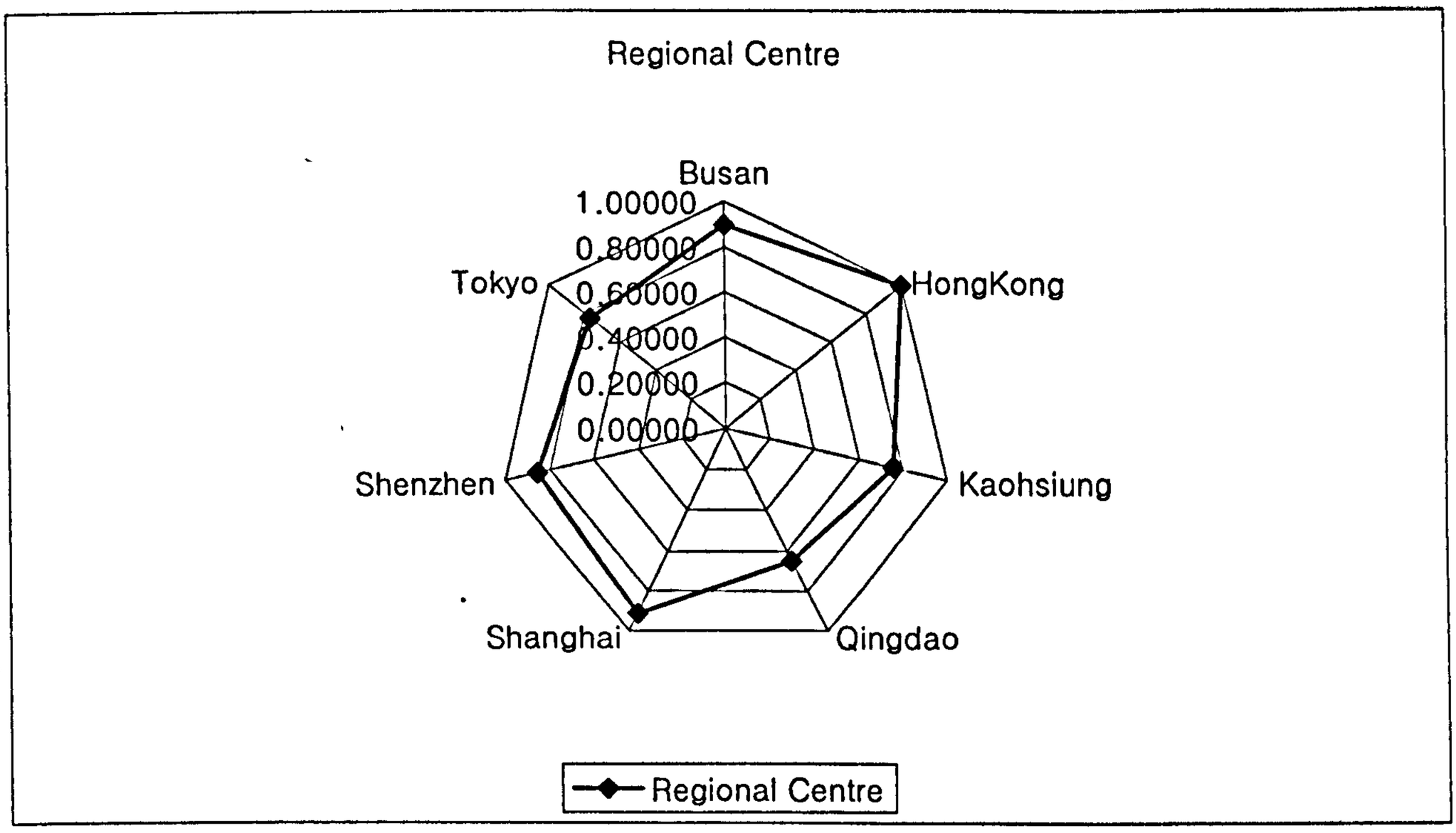


The regional centre as an evaluation factor is defined as a sea port having a good location combined with the attributes of 'deviation from main trunk routes' and 'port accessibility'. According to the results from the experts' judgements, Hong Kong received the highest score followed by Shanghai and Busan.

In the case of Busan, the Korean government has been focusing on spatial strategy recently, as mentioned by Park (2005, p851):

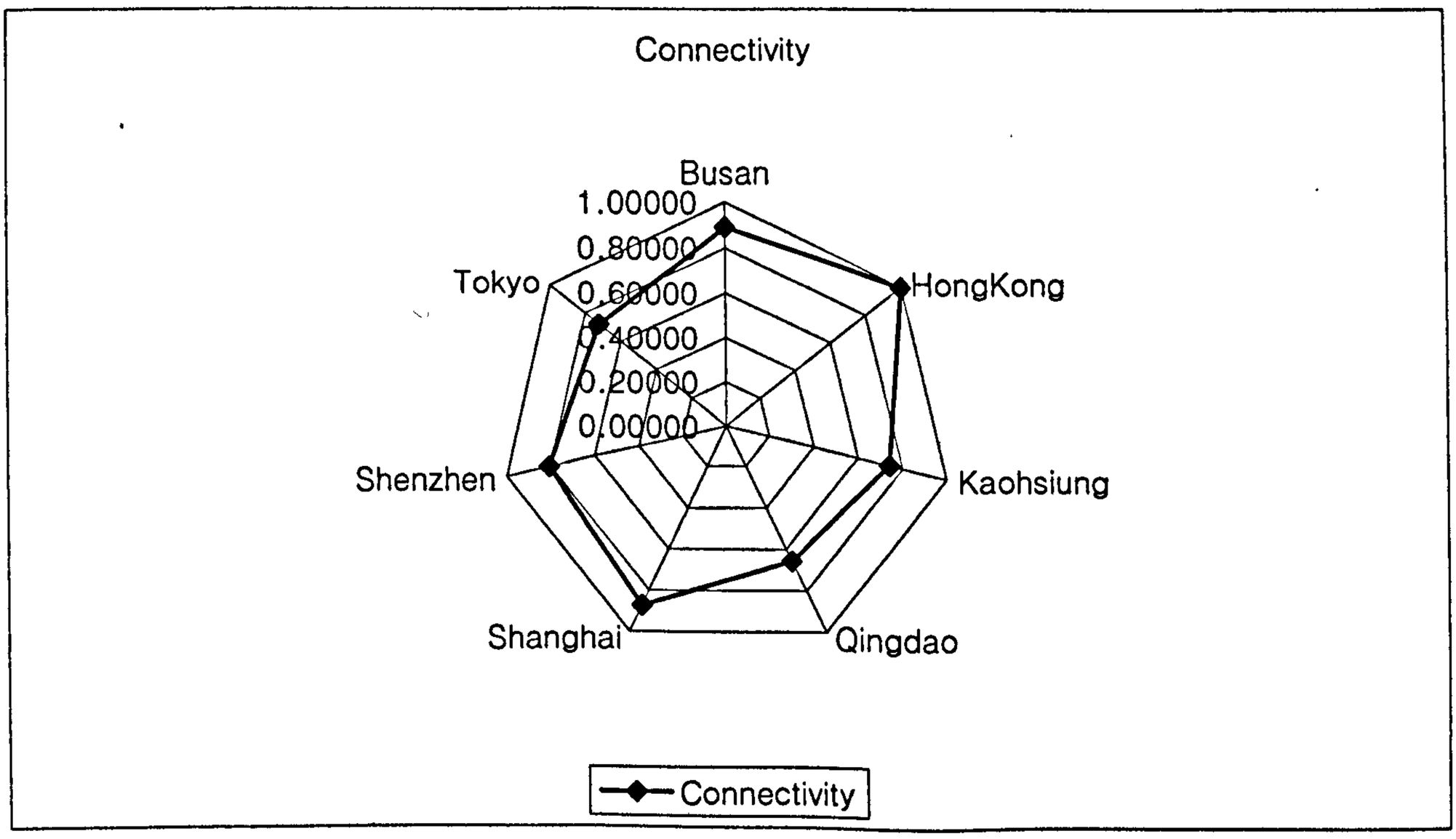
"The South Korean government recently announced an ambitious plan to develop global hubs of international movement of capital and skilled labour in several localities, designating these special economic zones, economic free zones, and international free cities"

Figure 6.15 Scoring for regional centre on each port



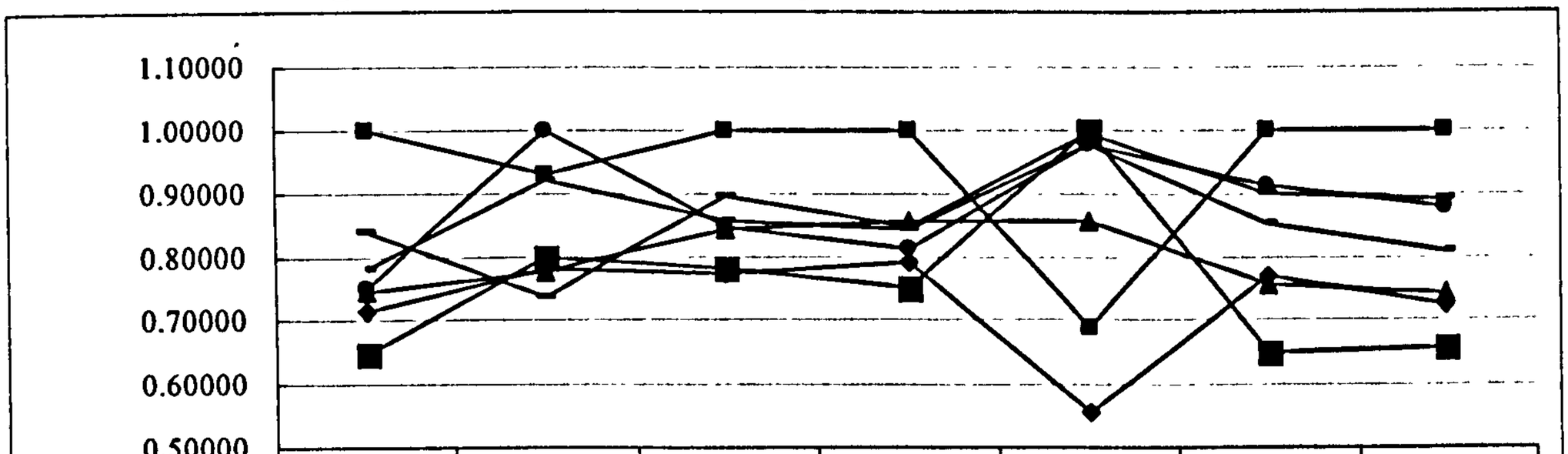
As stated in Section 5.2.1, connectivity is equal to the statement 'the greater it is, the higher is the level of competitiveness'. Experts concluded that Hong Kong, Shanghai and Busan formed a higher ranking group, from which factor Qingdao, Kaohsiung and Tokyo had suffered.

Figure 6.16 Scoring for connectivity on each port



An overall picture of factors used on each port provided in Figure 6.17.

Figure 6.17 Overall Scoring for factors on each port



	Port service	Hinterland condition	Availibility	Convenience	Logistics cost	Regional centre	Connectivity
Busan	0.83680	0.73810	0.89444	0.84728	0.99369	0.89706	0.89065
HongKong	1.00000	0.92737	1.00000	1.00000	0.68806	1.00000	1.00000
Kaohsiung	0.74725	0.77504	0.84148	0.85426	0.85623	0.75410	0.73979
Qingdao	0.64780	0.79993	0.77885	0.74820	1.00000	0.64684	0.65891
Shanghai	0.75013	1.00000	0.84698	0.81227	0.97579	0.91347	0.87478
Shenzhen	0.77953	0.91932	0.85416	0.84222	0.97837	0.85166	0.80726

6.2.2 Computation of overlap degree (λ)

In general, selecting perfectly independent factors for an evaluation is realistically impossible. In other words, some overlap is bound to exist in the comparison of factors. This problem may cause unexpected bias in the evaluation, and, therefore, to adjust for this, the overlap degree, λ, has been introduced.

The λ can be determined from the questionnaire by exploring the overlap in pairwise comparison between each of two factors. Consequently, in this process, the respondents' judgements were acquired using the fuzzy number concepts and the results of pairwise comparison.

The responses from experts could be converted using the mathematical form introduced in Section 5.2. The mean of overlap degree results are shown in Table 6.6.

To simplify the mathematical process, the long factor names were replaced by the following: x_1 for port service, x_2 for hinterland condition, x_3 for availability, x_4 for convenience, x_5 for logistics cost, x_6 for regional centre and x_7 for connectivity.

Table 6.6 Mean of overlap degree using fuzzy numbers

	x_1	x_2	x_3	x_4	x_5	x_6	x_7
x_1	(0.00000), (0.00000), (0.00000), (0.00000)	(0.20714), (0.25714), (0.29286), (0.33571)	(0.40000), (0.49286), (0.54286), (0.62857)	(0.52857), (0.61429), (0.67143), (0.73571)	(0.29286), (0.36429), (0.42857), (0.50714)	(0.19286), (0.22857), (0.23571), (0.27143)	(0.23571), (0.29286), (0.32143), (0.37857)
x_2		(0.00000), (0.00000), (0.00000), (0.00000)	(0.30714), (0.37857), (0.42143), (0.48571)	(0.20000), (0.24286), (0.25714), (0.30714)	(0.32143), (0.39286), (0.42857), (0.49286)	(0.43571), (0.50714), (0.55000), (0.61429)	(0.52143), (0.61429), (0.65714), (0.72857)
x_3			(0.00000), (0.00000), (0.00000), (0.00000)	(0.42143), (0.50714), (0.54286), (0.62143)	(0.26429), (0.32857), (0.35714), (0.42143)	(0.27857), (0.32857), (0.34286), (0.38571)	(0.27857), (0.35000), (0.39286), (0.47143)
x_4				(0.00000), (0.00000), (0.00000), (0.00000)	(0.37857), (0.45714), (0.50714), (0.59286)	(0.27143), (0.32857), (0.35000), (0.40714)	(0.31429), (0.38571), (0.41429), (0.47857)
x_5					(0.00000), (0.00000), (0.00000), (0.00000)	(0.22143), (0.27857), (0.31429), (0.36429)	(0.39286), (0.47143), (0.50714), (0.57143)
x_6						(0.00000), (0.00000), (0.00000), (0.00000)	(0.42857), (0.50000), (0.53571), (0.59286)
x_7							(0.00000), (0.00000), (0.00000), (0.00000)

To obtain the real number, the defuzzification process was employed (Table 6.7).

Table 6.7 Crisp values of overlap degree on each factor using defuzzification

	x_1	x_2	x_3	x_4	x_5	x_6	x_7
x_1	0.00000	0.27321	0.51607	0.63750	0.39821	0.23214	0.30714
x_2		0.00000	0.39821	0.25179	0.40893	0.52679	0.63036
x_3			0.00000	0.52321	0.34286	0.33393	0.37321
x_4				0.00000	0.48393	0.33929	0.39821
x_5					0.00000	0.29464	0.48571
x_6						0.00000	0.51429
x_7							0.00000

The final mean of overlap degree was computed at -0.08715, which means that the evaluation factors were overlapping by 8.715%. This degree of interaction is reflected in the computation procedure of the fuzzy evaluation.

Table 6.8 Degree of overlap by each factor

Factors	Overlap degree
x_1	-0.08692
x_2	-0.09409
x_3	-0.07889
x_4	-0.10563
x_5	-0.07089
x_6	-0.06610
x_7	-0.10753
Mean	-0.08715

6.2.3 Computation of fuzzy measure $g(\cdot)$

As explained in Section 5.4.1, the formula in step 3 was used in the calculation of fuzzy measure $g(\cdot)$, utilising the overlap degree λ, as suggested in Section 6.2.2, and weight value $w(\cdot)$, introduced in Section 5.3.2. Table 6.9 shows the results from the application of the fuzzy measure.

Table 6.9 Fuzzy measure $g(\cdot)$

	$g(\cdot)$
$g(x_1)$	0.13572
$g(x_2)$	0.14400
$g(x_3)$	0.13388
$g(x_4)$	0.13311
$g(x_5)$	0.15159
$g(x_6)$	0.15151
$g(x_7)$	0.15018

6.2.4 Evaluation of port ranking using a fuzzy integral

To obtain port rankings, the process of fuzzy integration was needed. As mentioned in Section 5.4.1, fuzzy integration uses the fuzzy evaluation value $h(\cdot)$ and fuzzy measure value $g(\cdot)$. The procedures for obtaining the evaluation values for Busan Port are as follows.

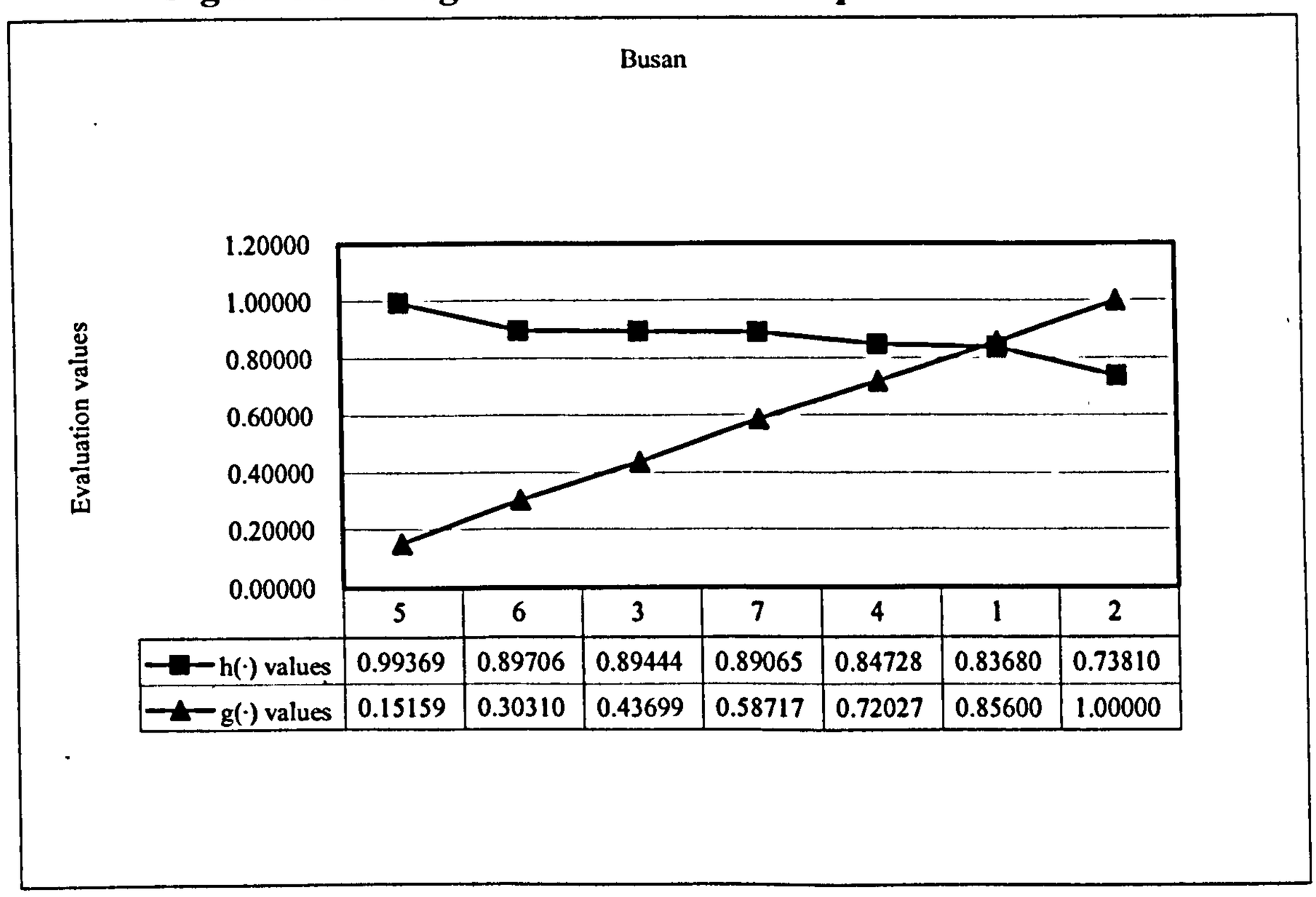
Table 6.10 $h(\cdot)$ for Busan Port

$h(\cdot)$	$h(5)$	$h(6)$	$h(3)$	$h(7)$	$h(4)$	$h(1)$	$h(2)$
Values	0.99369	0.89706	0.89444	0.89065	0.84728	0.83680	0.73810

Table 6.11 Evaluation process of port ranking for Busan Port

Fuzzy evaluation value $h(\cdot)$		Fuzzy measuring value $g(\cdot)$		Evaluation value
$h(5)$	0.99369	$g(x_5)$	0.15159	
$h(6)$	0.89706	$g(x_5, x_6)$	0.30310	
$h(3)$	0.89444	$g(x_5, x_6, x_3)$	0.43699	
$h(7)$	0.89065	$g(x_5, x_6, x_3, x_7)$	0.58717	0.83680
$h(4)$	0.84728	$g(x_5, x_6, x_3, x_7, x_4)$	0.72027	
$h(1)$	0.83680	$g(x_5, x_6, x_3, x_7, x_4, x_1)$	0.85600	
$h(2)$	0.73810	$g(x_5, x_6, x_3, x_7, x_4, x_1, x_2)$	1.00000	

Figure 6.18 Diagram of the evaluation process for Busan



The evaluation value for port ranking could be computed by applying a fuzzy integral for each port using the above procedures. In the case of Busan, the fuzzy evaluation value was 0.8368. For the purpose of acquiring and comparing relative competitiveness, the calculation processes for the other ports were as follows.

To adapt fuzzy integration to Hong Kong, the same procedures as with Busan port were adopted, and the following were the evaluation processes. As for the results, the evaluation value for Hong Kong was 0.84841. This result indicates higher ranking compared to Busan port.

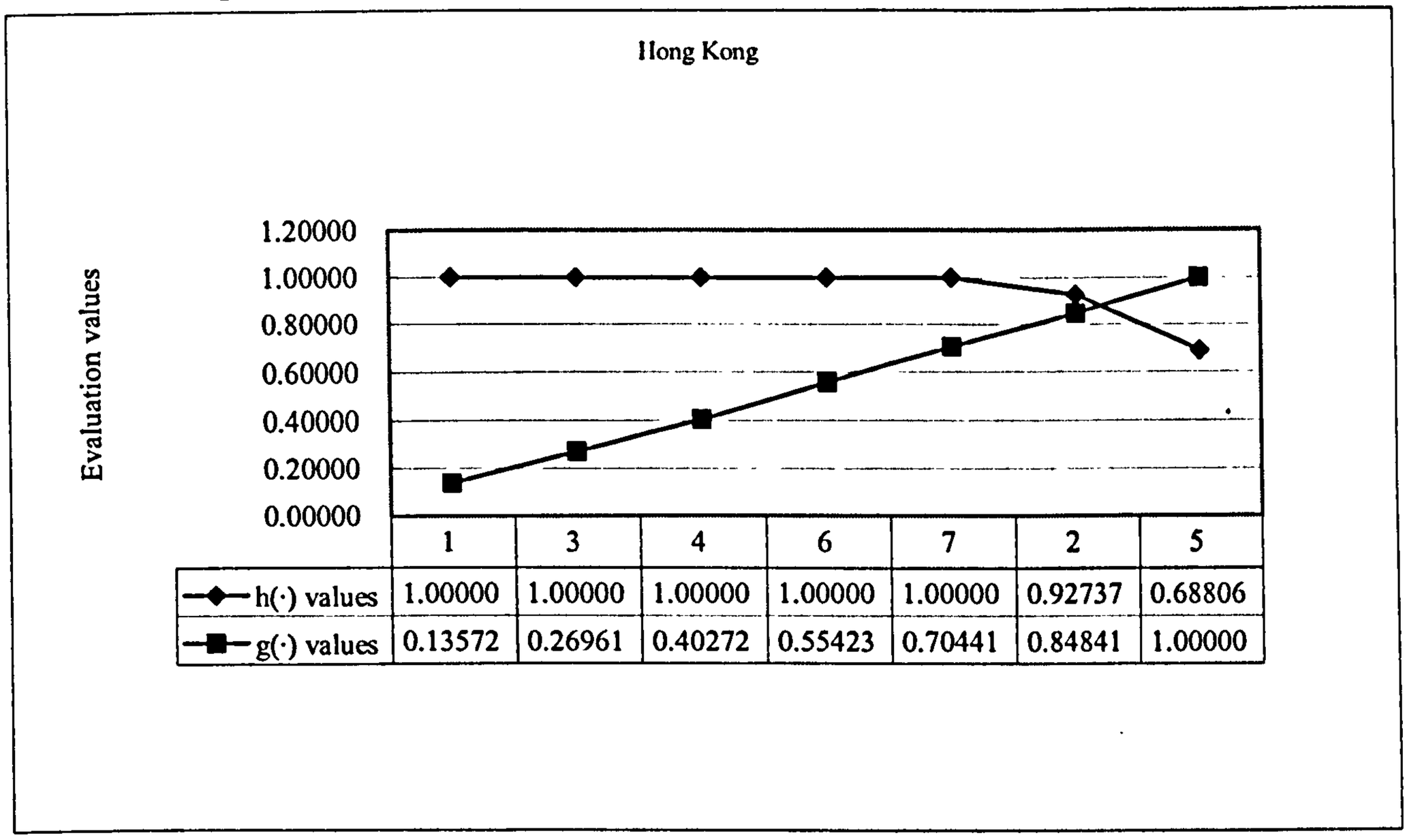
Table 6.12 $h(\cdot)$ for Hong Kong Port

$h(\cdot)$	$h(1)$	$h(3)$	$h(4)$	$h(6)$	$h(7)$	$h(2)$	$h(5)$
Values	1.00000	1.00000	1.00000	1.00000	1.00000	0.92737	0.68806

Table 6.13 Evaluation process of port ranking for Hong Kong Port

Fuzzy evaluation value $h(\cdot)$		Fuzzy measuring value $g(\cdot)$		Evaluation value
$h(1)$	1.00000	$g(x_1)$	0.13572	
$h(3)$	1.00000	$g(x_1, x_3)$	0.26961	
$h(4)$	1.00000	$g(x_1, x_3, x_4)$	0.40272	
$h(6)$	1.00000	$g(x_1, x_3, x_4, x_6)$	0.55423	0.84841
$h(7)$	1.00000	$g(x_1, x_3, x_4, x_6, x_7)$	0.70441	
$h(2)$	0.92737	$g(x_1, x_3, x_4, x_6, x_7, x_2)$	0.84841	
$h(5)$	0.68806	$g(x_1, x_3, x_4, x_6, x_7, x_2, x_5)$	1.00000	

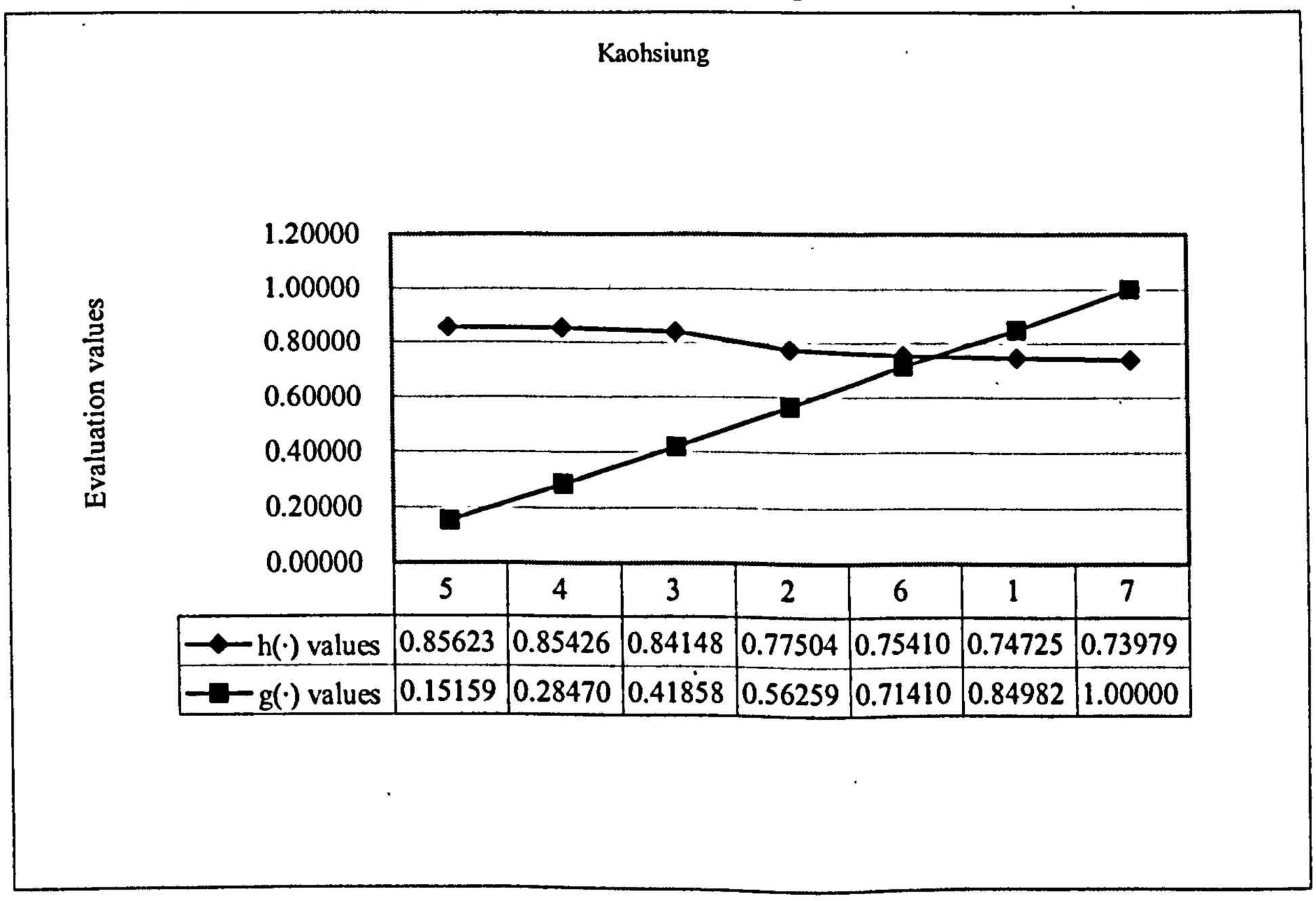
Figure 6.19 Diagram of the evaluation process for Hong Kong



	1	3	4	6	7	2	5
h(·) values	1.00000	1.00000	1.00000	1.00000	1.00000	0.92737	0.68806
g(·) values	0.13572	0.26961	0.40272	0.55423	0.70441	0.84841	1.00000

The calculation process and results for Kaohsiung are shown in Figure 6.20, the port's evaluation value being 0.74725. This means that Kaohsiung had lower competitiveness power compared to Hong Kong and Busan.

Figure 6.20 Diagram of the evaluation process for Kaohsiung



	5	4	3	2	6	1	7
h(·) values	0.85623	0.85426	0.84148	0.77504	0.75410	0.74725	0.73979
g(·) values	0.15159	0.28470	0.41858	0.56259	0.71410	0.84982	1.00000

With the adoption of the same procedure to Qingdao, Shanhai, Shenzhen and Tokyo, the overall fuzzy evaluation values, shown in Table 6.14 below, were obtained.

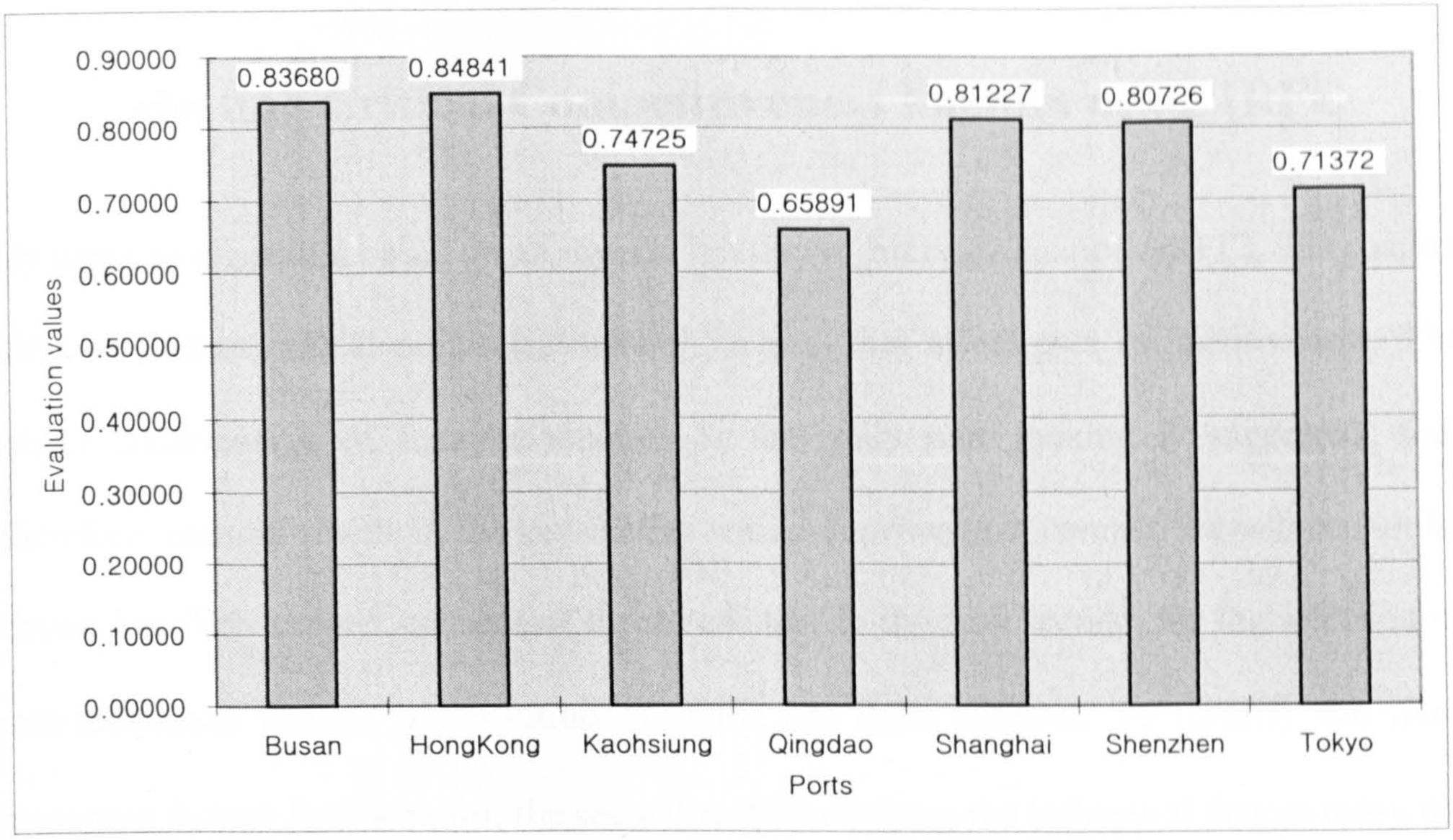
Table 6.14 Overall fuzzy evaluation process and integral values

Ports	Evaluation criteria	Fuzzy evaluation							Integral values
Busan	Factors	x_5	x_6	x_3	x_7	x_4	x_1	x_2	0.83680
	h(·) values	0.99369	0.89706	0.89444	0.89065	0.84728	0.83680	0.73810	
	g(·) values	0.15159	0.30310	0.43699	0.58717	0.72027	0.85600	1.00000	
Hong Kong	Factors	x_1	x_3	x_4	x_6	x_7	x_2	x_5	0.84841
	h(·) values	1.00000	1.00000	1.00000	1.00000	1.00000	0.92737	0.68806	
	g(·) values	0.13572	0.26961	0.40272	0.55423	0.70441	0.84841	1.00000	
Kaohsiung	Factors	x_5	x_4	x_3	x_2	x_6	x_1	x_7	0.74725
	h(·) values	0.85623	0.85426	0.84148	0.77504	0.7541	0.74725	0.73979	
	g(·) values	0.15159	0.28470	0.41858	0.56259	0.7141	0.84982	1.00000	
Qingdao	Factors	x_5	x_2	x_3	x_4	x_7	x_1	x_6	0.65891
	h(·) values	1.00000	0.79993	0.77885	0.74820	0.65891	0.64780	0.64684	
	g(·) values	0.15159	0.29559	0.42948	0.56259	0.71277	0.84849	1.00000	
Shanghai	Factors	x_2	x_5	x_6	x_7	x_3	x_4	x_1	0.81227
	h(·) values	1.00000	0.97579	0.91347	0.87478	0.84698	0.81227	0.75013	
	g(·) values	0.14400	0.29559	0.44710	0.59728	0.73117	0.86428	1.00000	
Shenzhen	Factors	x_5	x_2	x_3	x_6	x_4	x_7	x_1	0.80726
	h(·) values	0.97837	0.91932	0.85416	0.85166	0.84222	0.80726	0.77953	
	g(·) values	0.15159	0.29559	0.42948	0.58099	0.71410	0.86428	1.00000	
Tokyo	Factors	x_4	x_2	x_3	x_6	x_7	x_1	x_5	0.71372
	h(·) values	0.79086	0.77909	0.76963	0.7677	0.72282	0.71372	0.55621	
	g(·) values	0.13311	0.27711	0.41099	0.56251	0.71269	0.84841	1.00000	

6.3 Summary and Implications

The integral values and port rankings were identified by using the experts' knowledge and the fuzzy evaluation method. As a result, Hong Kong, which had the top position for five other factors i.e. port service, availability, convenience, regional centre and connectivity, could be regarded as the most competitive port. However, the logistics cost for Hong Kong showed the lowest score when compared with the other ports.

Figure 6.21 Port ranking



The port of Busan emerged as the second most competitive port. In contrast to Hong Kong, Busan has attained attractive port tariffs while having good conditions for the other factors. However, as mentioned in Section 6.2.1, the hinterland condition for Busan port lags behind its competitors in Northeast Asia.

The next most competitive ports were the newly emerged Chinese ports Shanghai, and Shenzhen. They showed good performance in terms of hinterland condition, logistics cost and availability while their weak point was port service. However, recently, they have been focusing on enhancing service and convenience, and their potential to overtake Busan is regarded as a high possibility. Regarding this phenomenon, a description of a sensitivity analysis will be provided later on in Chapter 8.

The ports located in the group with lower competitive power are Tokyo and Qingdao. However, of the two, Qingdao has more potential to proceed into the higher group due to the development strategies adopted by the Chinese government to cover the port's weaknesses i.e. port service, connectivity and regional centre.

CHAPTER 7

Selecting Critical Competitiveness Factors using IRFE

By using an algorithm based on an inverse relation of fuzzy evaluation (IRFE), this chapter aims to present critical points (influential factors) that affect port competitiveness. The major disadvantage of fuzzy evaluation is that only port ranking is suggested, and, therefore, with this method, the key factors which improve port competitiveness cannot be drawn out. This chapter consists of three sections. In the first section, for the selection of non-influential factors, $\underline{\alpha}$ operation of IRFE has been adapted. To identify the most important factors for each port, the second section analyses the influential factors using the $\underline{\beta}$ operation of IRFE. After the analysis, the most important key factors will be suggested. Finally, in the third section, overall implications for each targeted port will be given.

7.1 Selecting Non-influential Factors

In general, influential factors are seen as the most important factors determining choice, having a significant impact on systems and being able to develop society (Webster's Dictionary, 2005). Searching for and finding these factors has been attempted in many areas using various methods e.g. airport choice, travel motivation, e-commerce etc (Gardiner et al., 2005; Hong and Zhu, 2006; Jang and Wu, 2006).

As described in Chapter 6, the rankings on competitiveness for container ports were obtained by means of the factors selected. However, the evaluation algorithm, fuzzy evaluation, is a methodology that only calculates ranking of ports by competitiveness level and, therefore, critical weak points and/or influential factors affecting current port competitiveness cannot be extracted fully.

With this in mind, IRFE, as suggested in Section 5.4.2, was adopted to identify influential factors, which were then used for the scenario analysis provided in Chapter 8.

First of all, to select non-influential factors, a super-solution, $\underline{\alpha}$ operation of IRFE, was introduced as stated in Section 5.4.2.

In the case of Busan, fuzzy measure values were calculated in the previous Chapter as follows:

$$g(\cdot) = \{0.15159, 0.30310, 0.43699, 0.58717, 0.72027, 0.85600, 1.00000\}$$

In addition, the fuzzy integral value, $I(\cdot)$, was 0.83680. Using the values of these two variables, a super-solution for h^m could be formulated as:

$$\begin{aligned} h^m &= g(\cdot) \,\underline{\alpha}\, I(\cdot) \\ &= \{0.15159 \,\underline{\alpha}\, 0.83680,\ 0.30310 \,\underline{\alpha}\, 0.83680,\ 0.43699 \,\underline{\alpha}\, 0.83680,\ 0.58717 \,\underline{\alpha}\, 0.83680,\ 0.72027 \\ &\quad \,\underline{\alpha}\, 0.83680,\ 0.85600 \,\underline{\alpha}\, 0.83680,\ 1.00000 \,\underline{\alpha}\, 0.83680\} \\ &= \{1.00000, 1.00000, 1.00000, 1.00000, 1.00000, 0.83680, 0.83680\} \end{aligned}$$

The results of h^m were replaced with the maximum values of $h(\cdot)$. That is, logistics cost (x_5), regional centre (x_6), availability (x_3), connectivity (x_7) and convenience (x_4) were changed into the maximum value of one, and hinterland condition (x_2) is raised to the same value as that of the fuzzy integral.

Table 7.1 Maximum values of $h(\cdot)$ for Busan

Factors	x_5	x_6	x_3	x_7	x_4	x_1	x_2
h values	0.99369	0.89706	0.89444	0.89065	0.84728	0.83680	0.73810
	↓	↓	↓	↓	↓	↓	↓
h^m values	1.00000	1.00000	1.00000	1.00000	1.00000	0.83680	0.83680

To use these increased values as new input, the previous fuzzy evaluation suggested in Chapter 6 should be replaced as:

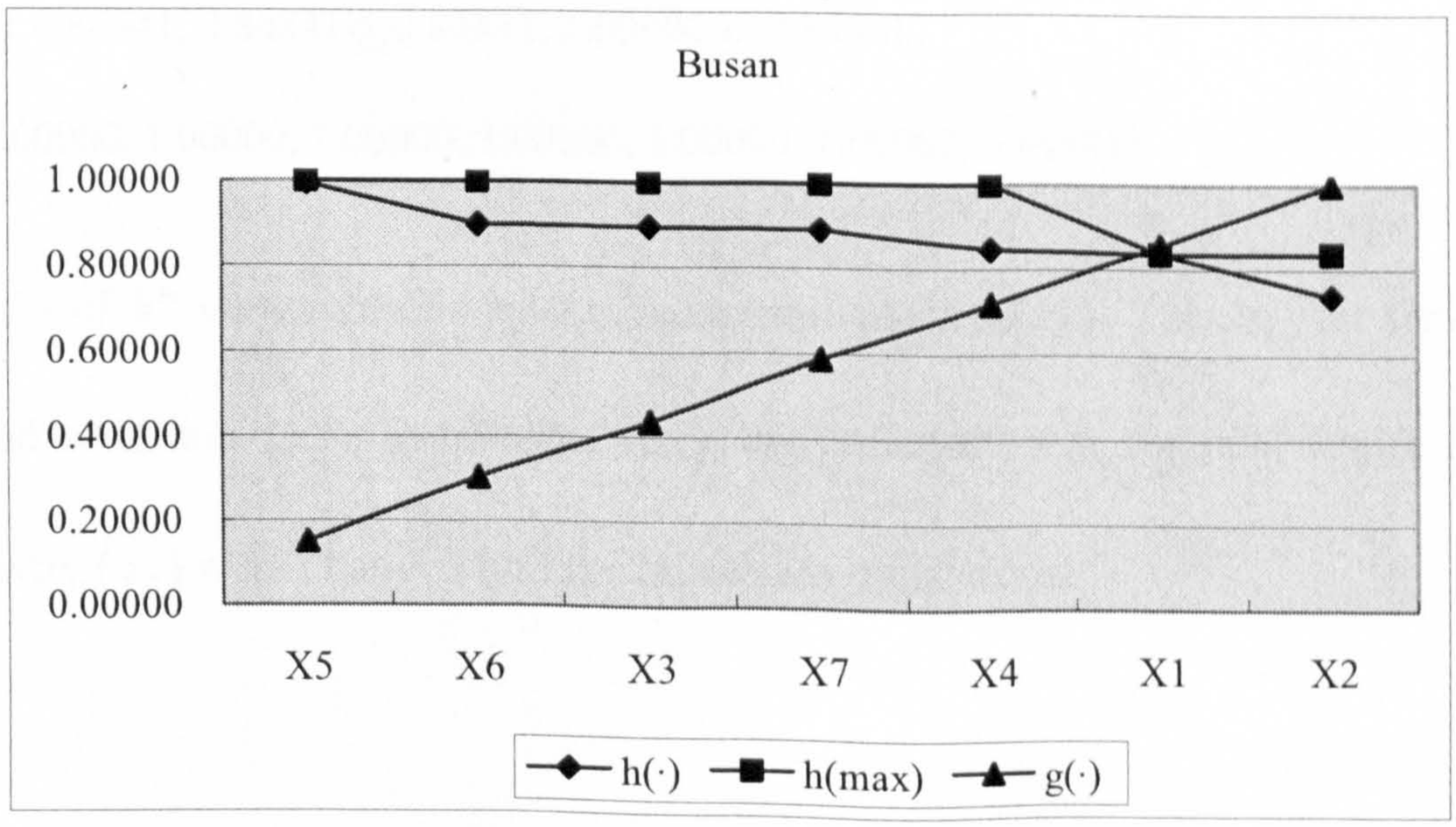
$$\int g(\cdot) \circ h(\cdot) \rightarrow \int g(\cdot) \circ h(\cdot)^m$$

The new fuzzy evaluation procedure is illustrated in Table7.2.

Table 7.2 Fuzzy evaluation process using h^m for Busan

Ports	Evaluation criteria	Fuzzy evaluation							Integral values
Busan	Factors	x_5	x_6	x_3	x_7	x_4	x_1	x_2	0.83680
	h^m values	1.00000	1.00000	1.00000	1.00000	1.00000	0.83680	0.83680	
	g(·) values	0.15159	0.30310	0.43699	0.58717	0.72027	0.85600	1.00000	

Figure 7.1 Diagram of new fuzzy evaluation for Busan



Very interestingly, the fuzzy integral value of $\int g(\cdot) \circ h(\cdot)$ and $\int g(\cdot) \circ h(\cdot)^m$ was exactly the same:

$$\int g(\cdot) \circ h(\cdot) = \int g(\cdot) \circ h(\cdot)^m = I(\cdot)$$

This means that the replaced maximum values of $h(\cdot)$ i.e. logistics cost (x_5), regional centre (x_6), availability (x_3), connectivity (x_7) and convenience (x_4) was not influential in improving the port's competitiveness.

As for Hong Kong, the fuzzy measure values were calculated in the previous Chapter as:

$$g(\cdot) = \{0.13572, 0.26961, 0.40272, 0.55423, 0.70441, 0.84841, 1.00000\}$$

In addition, the fuzzy integral value, $I(\cdot)$, was 0.84841. Using the values of these two variables, the super-solution for h^m could be formulated as:

$$h^m = g(\cdot) \underline{\alpha} I(\cdot)$$

$$= \{0.13572 \underline{\alpha} 0.84841,\ 0.26961 \underline{\alpha} 0.84841,\ 0.40272 \underline{\alpha} 0.84841,\ 0.55423 \underline{\alpha} 0.84841,\ 0.70441$$

$$\underline{\alpha} 0.84841, 0.84841 \underline{\alpha} 0.84841, 1.00000 \underline{\alpha} 0.84841\}$$

$$= \{1.00000, 1.00000, 1.00000, 1.00000, 1.00000, 1.00000, 0.84841\}$$

The results of h^m were replaced by the maximum values of $h(\cdot)$. That is, port service (x_1), hinterland condition (x_2), availability (x_3), convenience (x_4), regional centre (x_6) and connectivity (x_7) were changed into the maximum value of one.

Table 7.3 Maximum values of $h(\cdot)$ for Hong Kong

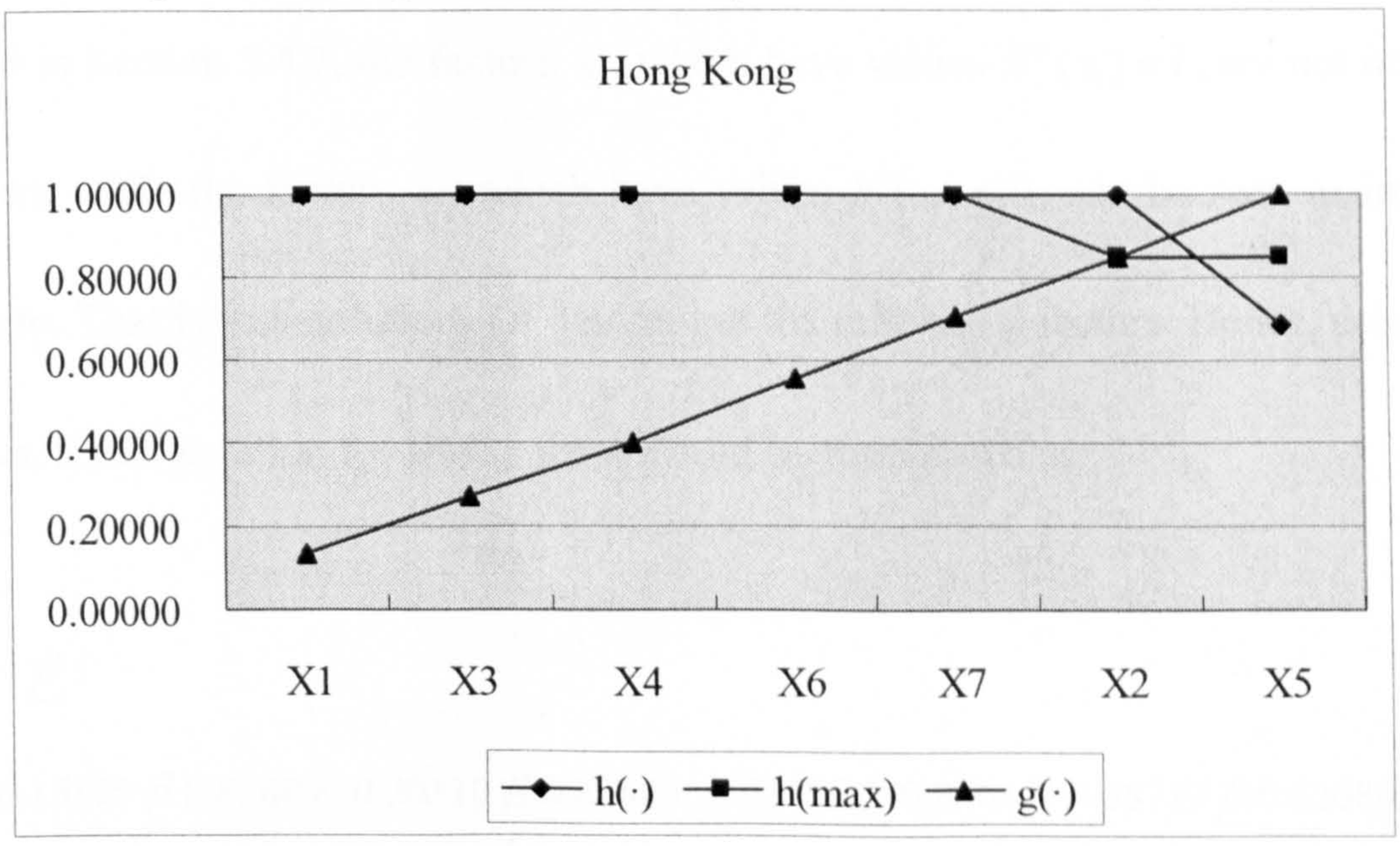
Factors	x_1	x_3	x_4	x_6	x_7	x_2	x_5
h values	1.00000	1.00000	1.00000	1.00000	1.00000	0.92737	0.68806
	↓	↓	↓	↓	↓	↓	↓
h^m values	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	0.84841

The new fuzzy evaluation procedures using the increased values are shown in Table 7.4.

Table 7.4 Fuzzy evaluation process using h^m for Hong Kong

Ports	Evaluation criteria	Fuzzy evaluation							Integral values
Hong Kong	Factors	x_1	x_3	x_4	x_6	x_7	x_2	x_5	
	h^m values	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	0.68806	0.84841
	g(·) values	0.13572	0.26961	0.40272	0.55423	0.70441	0.84841	1.00000	

Figure 7.2 Diagram of new fuzzy evaluation for Hong Kong



From the above results, it could be concluded that the non-influential factors for Hong Kong were port service (x_1), hinterland condition (x_2), availability (x_3), convenience (x_4), regional centre (x_6) and connectivity (x_7). Using the $\underline{\alpha}$ operation of IRFE for the rest of targeted ports, the following results could be obtained.

Table 7.5 The overall results from $\underline{\alpha}$ operation

Ports	Evaluation criteria	Fuzzy evaluation							Integral values
Busan	Factors	x_5	x_6	x_3	x_7	x_4	x_1	x_2	0.83680
	h^m values	**1.00000**	**1.00000**	**1.00000**	**1.00000**	**1.00000**	0.83680	0.83680	
Hong Kong	Factors	x_1	x_3	x_4	x_6	x_7	x_2	x_5	0.84841
	h^m values	**1.00000**	**1.00000**	**1.00000**	**1.00000**	**1.00000**	**1.00000**	0.84841	
Kaohsiung	Factors	x_5	x_4	x_3	x_2	x_6	x_1	x_7	0.74725
	h^m values	**1.00000**	**1.00000**	**1.00000**	**1.00000**	**1.00000**	0.74725	0.74725	
Qingdao	Factors	x_5	x_2	x_3	x_4	x_7	x_1	x_6	0.65891
	h^m values	**1.00000**	**1.00000**	**1.00000**	**1.00000**	0.65891	0.65891	0.65891	
Shanghai	Factors	x_2	x_5	x_6	x_7	x_3	x_4	x_1	0.81227
	h^m values	**1.00000**	**1.00000**	**1.00000**	**1.00000**	**1.00000**	0.81227	0.81227	
Shenzhen	Factors	x_5	x_2	x_3	x_6	x_4	x_7	x_1	0.80726
	h^m values	**1.00000**	**1.00000**	**1.00000**	**1.00000**	**1.00000**	0.80726	0.80726	
Tokyo	Factors	x_4	x_2	x_3	x_6	x_7	x_1	x_5	0.71372
	h^m values	**1.00000**	**1.00000**	**1.00000**	**1.00000**	**1.00000**	0.71372	0.71372	

Note: The values in the shadowed area indicate non-influential factors.

7.2 Selecting Influential Factors

As stated in Section 5.4.2, the factors x_i, which have values $h^m(x_i)=1$, are not improving the system while the factors x_i, which have values $h^l(x_i)=0$, can be seen as improving the system. That is, sub-solutions (h^l) point out the influential factors. Hence, using the $\underline{\beta}$ operation, a sub -solution for Busan for h^l could be formulated as:

$$h^l = g(\cdot)\ \underline{\beta}\ I$$

$$= \{0.15159\ \underline{\beta}\ 0.83680,\ 0.30310\ \underline{\beta}\ 0.83680,\ 0.43699\ \underline{\beta}\ 0.83680,\ 0.58717\ \underline{\beta}\ 0.83680,\ 0.72027$$

$$\underline{\beta}\ 0.83680,\ 0.85600\ \underline{\beta}\ 0.83680,\ 1.00000\ \underline{\beta}\ 0.83680\}$$

$$= \{0.83680,\ 0.83680,\ 0.83680,\ 0.83680,\ 0.83680,\ 0.83680,\ 0.00000\}$$

Thus, the results of h^l were replaced by minimum values of $h(\cdot)$. That is, the hinterland condition (x_2) was changed into the minimum value of zero. For Busan port, this factor could be seen as improving the port's competitiveness.

Table 7.6 Minimum values of $h(\cdot)$ for Busan

Factors	x_5	x_6	x_3	x_7	x_4	x_1	x_2
h values	0.99369	0.89706	0.89444	0.89065	0.84728	0.83680	0.73810
	↓	↓	↓	↓	↓	↓	↓
h^l values	0.83680	0.83680	0.83680	0.83680	0.83680	0.83680	0.00000

Using the $\underline{\beta}$ operation, a sub -solution for Hong Kong for h^l could be formulated as:

$$h^l = g(\cdot)\ \underline{\beta}\ I$$

$$= \{0.13572\ \underline{\beta}\ 0.84841,\ 0.26961\ \underline{\beta}\ 0.84841,\ 0.40272\ \underline{\beta}\ 0.84841,\ 0.55423\ \underline{\beta}\ 0.84841,\ 0.70441$$

$$\underline{\beta}\ 0.84841,\ 0.84841\ \underline{\beta}\ 0.84841,\ 1.00000\ \underline{\beta}\ 0.84841\}$$

$$= \{0.84841, 0.84841, 0.84841, 0.84841, 0.84841, 0.84841, 0.00000\}$$

From the results, it could be deduced that Hong Kong's logistics cost (x_5) could be seen as improving the port's competitiveness.

Table 7.7 Minimum values of $h(\cdot)$ for Hong Kong

Factors	x_1	x_3	x_4	x_6	x_7	x_2	x_5
h values	1.00000	1.00000	1.00000	1.00000	1.00000	0.92737	0.68806
	↓	↓	↓	↓	↓	↓	↓
h^m values	0.84841	0.84841	0.84841	0.84841	0.84841	0.84841	0.00000

By using the $\underline{\beta}$ operation of IRFE for the rest of the targeted ports, the following results could be obtained.

Table 7.8 The overall results from $\underline{\beta}$ operation

Ports	Evaluation criteria	Values of each factor							Integral values
Busan	Factors	x_5	x_6	x_3	x_7	x_4	x_1	x_2	0.83680
	h^l values	0.83680	0.83680	0.83680	0.83680	0.83680	0.83680	**0.00000**	
HongKong	Factors	x_1	x_3	x_4	x_6	x_7	x_2	x_5	0.84841
	h^l values	0.84841	0.84841	0.84841	0.84841	0.84841	0.84841	**0.00000**	
Kaohsiung	Factors	x_5	x_4	x_3	x_2	x_6	x_1	x_7	0.74725
	h^l values	0.74725	0.74725	0.74725	0.74725	0.74725	**0.00000**	**0.00000**	
Qingdao	Factors	x_5	x_2	x_3	x_4	x_7	x_1	x_6	0.65891
	h^l values	0.65891	0.65891	0.65891	0.65891	0.65891	**0.00000**	**0.00000**	
Shanghai	Factors	x_2	x_5	x_6	x_7	x_3	x_4	x_1	0.81227
	h^l values	0.81227	0.81227	0.81227	0.81227	0.81227	0.81227	**0.00000**	
Shenzhen	Factors	x_5	x_2	x_3	x_6	x_4	x_7	x_1	0.80726
	h^l values	0.80726	0.80726	0.80726	0.80726	0.80726	0.80726	**0.00000**	
Tokyo	Factors	x_4	x_2	x_3	x_6	x_7	x_1	x_5	0.71372
	h^l values	0.71372	0.71372	0.71372	0.71372	0.71372	**0.00000**	**0.00000**	

Note: The values in the shaded area indicate the influential factors.

7.3 Summary and Implications

To select non-influential and influential factors, $\underline{\alpha}$ operation and $\underline{\beta}$ operation of IRFE were adopted in this Chapter. As a result, values of super-solution (h^m) and sub-solution (h^l) were successfully drawn out as illustrated in Table 7.9.

Table 7.9 Overall results from $\underline{\alpha}$ and $\underline{\beta}$ operation

Ports	Evaluation criteria	Values of each factor						
Busan	Factors	5	6	3	7	4	1	2
	h(·) values	0.99369	0.89706	0.89444	0.89065	0.84728	0.83680	0.73810
	h^m values	1.00000	1.00000	1.00000	1.00000	1.00000	0.83680	0.83680
	h^l values	0.83680	0.83680	0.83680	0.83680	0.83680	0.83680	0.00000
Hong Kong	Factors	1	3	4	6	7	2	5
	h(·) values	1.00000	1.00000	1.00000	1.00000	1.00000	0.92737	0.68806
	h^m values	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	0.84841
	h^l values	0.84841	0.84841	0.84841	0.84841	0.84841	0.84841	0.00000
Kaohsiung	Factors	5	4	3	2	6	1	7
	h(·) values	0.85623	0.85426	0.84148	0.77504	0.75410	0.74725	0.73979
	h^m values	1.00000	1.00000	1.00000	1.00000	1.00000	0.74725	0.74725
	h^l values	0.74725	0.74725	0.74725	0.74725	0.74725	0.00000	0.00000
Qingdao	Factors	5	2	3	4	7	1	6
	h(·) values	1.00000	0.79993	0.77885	0.74820	0.65891	0.6478	0.64684
	h^m values	1.00000	1.00000	1.00000	1.00000	1.00000	0.65891	0.65891
	h^l values	0.65891	0.65891	0.65891	0.65891	0.65891	0.00000	0.00000
Shanghai	Factors	2	5	6	7	3	4	1
	h(·) values	1.00000	0.97579	0.91347	0.87478	0.84698	0.81227	0.75013
	h^m values	1.00000	1.00000	1.00000	1.00000	1.00000	0.81227	0.81227
	h^l values	0.81227	0.81227	0.81227	0.81227	0.81227	0.81227	0.00000
Shenzhen	Factors	5	2	3	6	4	7	1
	h(·) values	0.97837	0.91932	0.85416	0.85166	0.84222	0.80726	0.77953
	h^m values	1.00000	1.00000	1.00000	1.00000	1.00000	0.80726	0.80726
	h^l values	0.80726	0.80726	0.80726	0.80726	0.80726	0.80726	0.00000
Tokyo	Factors	4	2	3	6	7	1	5
	h(·) values	0.79086	0.77909	0.76963	0.7677	0.72282	0.71372	0.55621
	h^m values	1.00000	1.00000	1.00000	1.00000	1.00000	0.71372	0.71372
	h^l values	0.71372	0.71372	0.71372	0.71372	0.71372	0.71372	0.00000

In the case of Busan port, the most influential factor was hinterland condition while the non-influential factors were logistics cost (x_5), regional centre (x_6), availability (x_3), connectivity (x_7) and convenience (x_4). This means that when Busan attempts to improve the level of its hinterland condition, the possibility of overtaking its competitors can be increased compared to focusing on the non-influential factors.

As for Hong Kong, the most influential factor was logistics cost (x_5) while the non-influential factors were port service (x_1), hinterland condition (x_2), availability (x_3), convenience (x_4), regional centre (x_6) and connectivity (x_7). These results are in line

with findings by Seabrooke et al. (2003). As with Hong Kong, Tokyo's weakest point was logistics cost (x_5).

In addition, port service (x_1) was identified as the influential factor for Shanghai and Shenzhen. However, the Chinese government is attempting to increase the level of this factor, and thus these two ports' competitiveness can be expected to improve in the near future.

Finally, the port of Kaohsiung's key factor for increasing its competitiveness was port service (x_1) and connectivity (x_7). This result arises from a lack of network efficiency due to friction between mainland China and Taiwan. The newly emerging port, Qingdao, has two influential factors i.e. port service (x_1) and regional centre (x_6).

CHAPTER 8

Sensitivity Analysis using IRFE

To find out the changes in port competitiveness, the whole focus of this Chapter is on sensitivity analysis using the influential factors suggested in Chapter 7. As mentioned in the previous Chapter, the ranking of port competitiveness cannot yield other meaningful insights.apart from ranking order. Thus, using the results from Chapter 6 as a basic model and the influential factors as changeable input variables, all the relations and interactions among the targeted ports will be analysed. After this introduction, the construction method of scenarios will be suggested in the first section. The questions that arose in Chapter 6 will be clearly defined and answered by means of using the data from the results in Chapter 3 while also providing the definition of the scenarios. In the second section, using these scenarios constructed, a sensitivity analysis will be made. Finally, in the third section, overall implications and insights will be offered.

8.1 Construction of Scenarios

In general, regarding scenario analysis, Kippenberger (1999, p.8) clearly suggested the following definition:

> *"At one end of the spectrum, using scenarios can mean trying out 'what if' questions on an econometric model. At the other end, it can mean the development of full length, detailed 'stories' about possible alternative futures. The former tends to be an exercise in sensitivity analysis adjusting existing data within a model- as in 'what if interest rates went up by 2%?' The latter may involve several man-years of work and is a task that can only be undertaken with a good deal of commitment and at considerable cost".*

With respect to the scale or scope of a scenario exercise, he also proposed the following items (Kippenberger, 1999, p.9):

- *Increasing management sensitivity to potential future shocks and discontinuities*
- *Helping to identify and quantify the unknowns during a period of upheaval*
- *Explaining why there may be many possible answers to a single strategic question*
- *Looking for future threats and opportunities*
- *Generating future strategic options*
- *Creating a better and wider understanding of the real business drivers*
- *Gaining competitive advantage by recognising an emerging future early*
- *Helping to make implicit management mindsets explicit*
- *Building a common language across the organisation for people to talk about issues*
- *Developing a tool for organisational learning*
- *Crafting new strategies for different futures*

From the above items, in respect of port competitiveness, the following four items are closely related to the subject in question:

- *Looking for future threats and opportunities*
- *Generating future strategic options*
- *Gaining competitive advantage by recognising an emerging future early*
- *Crafting new strategies for different futures*

By synthesizing the above definition and items, the direction of scenario analysis can be made clearer. However, due to the limitation of PhD research work, '*a sensitivity analysis adjusting existing data within a model'* defined by Kippenberger (1999) is acceptable for further analysis.

On constructing the scenarios, Hoogeweegena *et al.*, (1998, p.124) stated that:

"The scenario could be implemented by using the model of the current situation as an alternative".

Among their arguments, '*model of the current situation'* can be replaced as the results of port competitiveness suggested in Chapter 6. For generation of the scenarios, the following data and issues need to be considered:

1) Issues emerged from the results of Chapter 6

- Issue 1; Can Busan take over Hong Kong's number one ranking?
- Issue 2; What if the influential factor values were increased in Busan, Shanghai and Shenzhen, ranked 2nd, 3rd and 4th respectively?
- Issue 3; Can Kaohsiung overtake Busan, Shanghai and Shenzhen?

2) Data used

- The average GDP estimated in each nation of the targeted ports, reviewed in Chapter 2 (see Table 8.1).
- The influential factors drawn out by $\underline{\beta}$ operation of IRFE, analyzed in Chapter 7 (see the Table 8.2).

Table 8.1 Average estimated rate of increase in GDP

	2006-2010		
	Case 1 (%)	Case 2 (%)	Average (%)
Korea	5.3	4.3	4.80
Japan	2.2	1.1	1.65
China	7.1	6.5	6.80
Hong Kong	3.5	2.0	2.75
Taiwan	4.5	3.5	4.00

Source: Ocean Shipping Consultants (2003), UNCTAD (2005)

Table 8.2 Influential factors from β operation

Ports	Influential factors						
Busan	x_5	x_6	x_3	x_7	x_4	x_1	x_2
HongKong	x_1	x_3	x_4	x_6	x_7	x_2	x_5
Kaohsiung	x_5	x_4	x_3	x_2	x_6	x_1	x_7
Qingdao	x_5	x_2	x_3	x_4	x_7	x_1	x_6
Shanghai	x_2	x_5	x_6	x_7	x_3	x_4	x_1
Shenzhen	x_5	x_2	x_3	x_6	x_4	x_7	x_1
Tokyo	x_4	x_2	x_3	x_6	x_7	x_1	x_5

Note: The values in the shaded area indicate influential factors.

Using the issues that had emerged and the data analysed, the scenarios could be generated. However, before evaluating the rate of increase, the level of interaction needed to be fixed (Kim et al., 2004). To deal with 'issue one', the influential factor for Busan will be increased to three and five times their GDP rate (Scenarios one and two). In addition, to analyse 'issue two', the influential factor for Shanghai and Shenzhen will be increased to one and two times their GDP rate (Scenarios from three to six). Next, to find the answer for 'issue three', the influential factors for Kaohsiung will be increased to three and five times its GDP rate (Scenarios seven and eight). Finally, to investigate port competitiveness broadly, the influential factors for all the targeted ports will be increased to estimated GDP rates (scenario nine). The nine different operative scenarios are displayed in Table 8.3.

Table 8.3 Scenarios constructed

Scenarios	Ports	Influential factors	Estimated average of GDP (%)	Multiple rates on GDP (times)	Input percentage calculated (%)
1	Busan	2	4.8	3	14.4
2	Busan	2	4.8	5	24
3	Shanghai	1	6.8	1	6.8
4	Shanghai	1	6.8	2	13.6
5	Shenzhen	1	6.8	1	6.8
6	Shenzhen	1	6.8	2	13.6
7	Kaohsiung	1,7	4.0	3	12
8	Kaohsiung	1,7	4.0	5	20
9	All ports	Every influential factors	Followed by each nations' GDP rates	1	Followed by each nations' GDP rates

8.2 Sensitivity Analysis on Each Port through the use of Scenarios

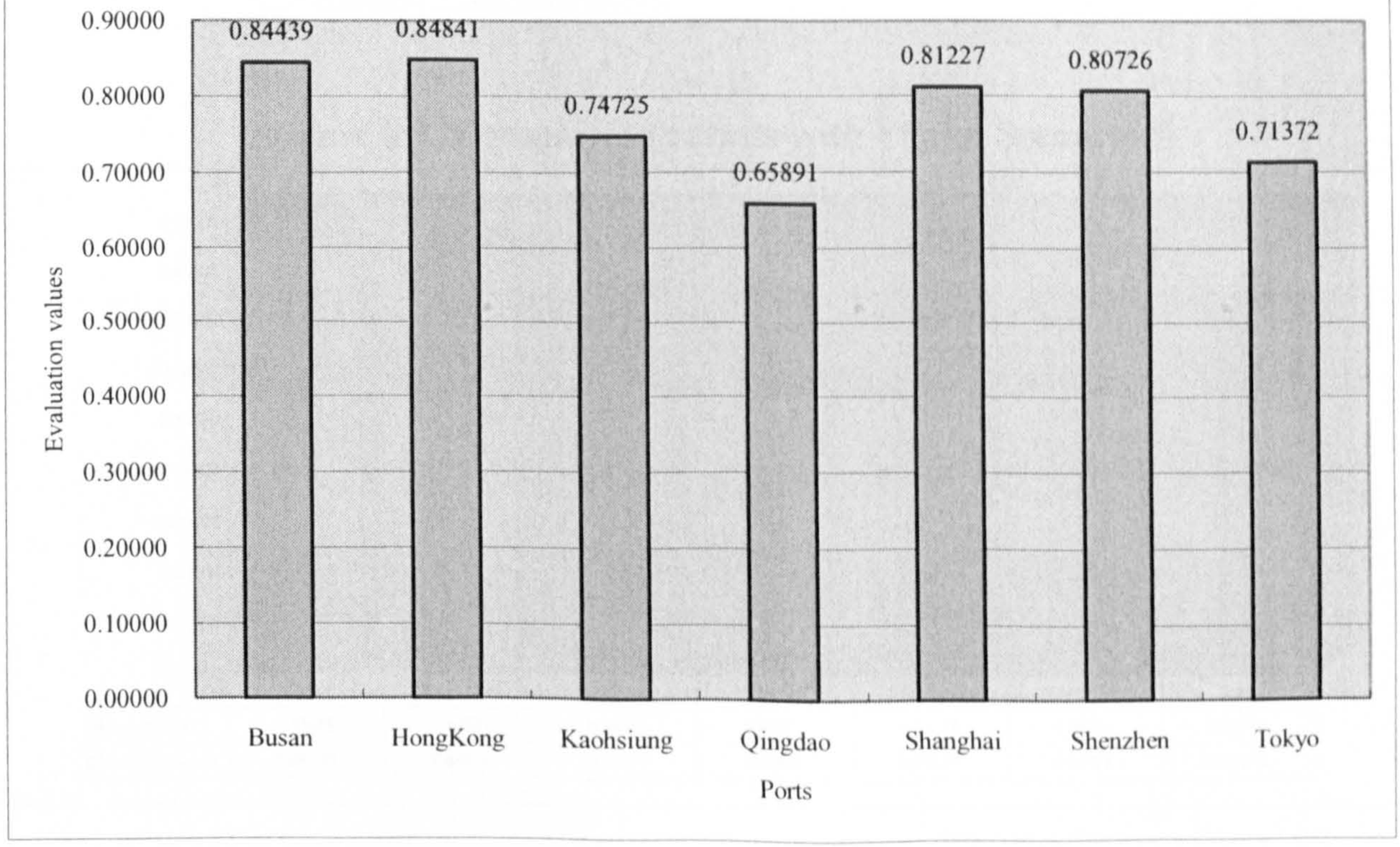
8.2.1 Scenario 1

In Scenario 1, Busan's influential factor will be increased to three times the estimated GDP rates (14.4%). As suggested in Chapter 7, the influential and/or weakest factor for Busan is its hinterland condition. This factor includes the three attributes i.e. "professionals and skilled labour in port operations", "size and activity of Free Trade Zone (FTZ) in port hinterland" and "volume of total container cargos". Using the increased score in the hinterland condition factor, the IRFE procedures were adopted and the results obtained are illustrated in Table 8.4, and Figure 8.1.

Table 8.4 Calculation procedures from Scenario 1

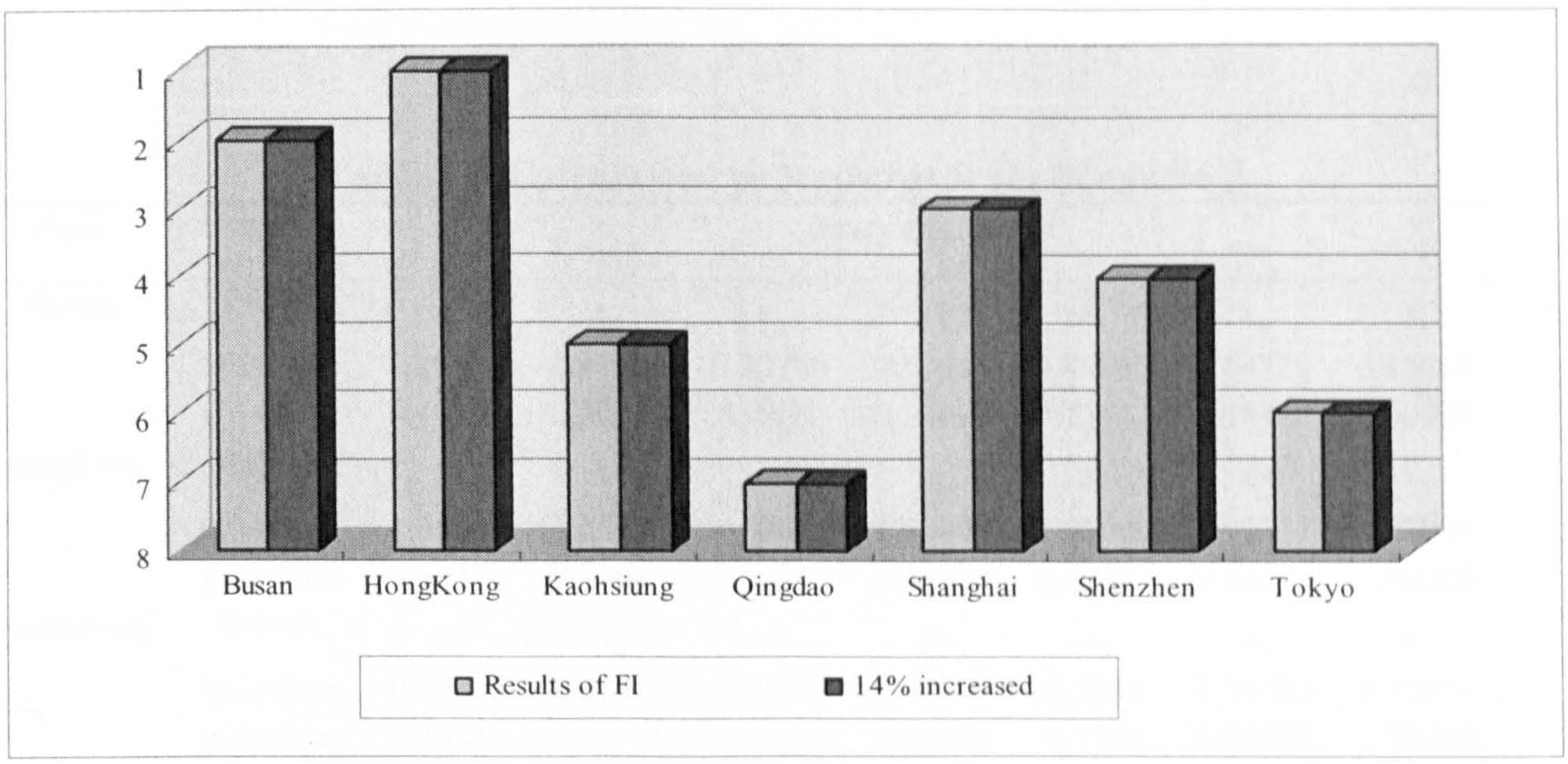
Ports	Evaluation criteria	Fuzzy evaluation						
Busan	Factors	x_5	x_6	x_3	x_7	x_4	x_2	x_1
	h(·) values	0.99369	0.89706	0.89444	0.89065	0.84728	0.84439	0.83680
	g(·) values	0.15159	0.30310	0.43699	0.58717	0.72027	0.85600	1.00000
HongKong	Factors	x_1	x_3	x_4	x_6	x_7	x_2	x_5
	h(·) values	1.00000	1.00000	1.00000	1.00000	1.00000	0.92737	0.68806
	g(·) values	0.13572	0.26961	0.40272	0.55423	0.70441	0.84841	1.00000
Kaohsiung	Factors	x_5	x_4	x_3	x_2	x_6	x_1	x_7
	h(·) values	0.85623	0.85426	0.84148	0.77504	0.7541	0.74725	0.73979
	g(·) values	0.15159	0.28470	0.41858	0.56259	0.71410	0.84982	1.00000
Qingdao	Factors	x_5	x_2	x_3	x_4	x_7	x_1	x_6
	h(·) values	1.00000	0.79993	0.77885	0.74820	0.65891	0.64780	0.64684
	g(·) values	0.15159	0.29559	0.42948	0.56259	0.71277	0.84849	1.00000
Shanghai	Factors	x_2	x_5	x_6	x_7	x_3	x_4	x_1
	h(·) values	1.00000	0.97579	0.91347	0.87478	0.84698	0.81227	0.75013
	g(·) values	0.14400	0.29559	0.44710	0.59728	0.73117	0.86428	1.00000
Shenzhen	Factors	x_5	x_2	x_3	x_6	x_4	x_7	x_1
	h(·) values	0.97837	0.91932	0.85416	0.85166	0.84222	0.80726	0.77953
	g(·) values	0.15159	0.29559	0.42948	0.58099	0.71410	0.86428	1.00000
Tokyo	Factors	x_4	x_2	x_3	x_6	x_7	x_1	x_5
	h(·) values	0.79086	0.77909	0.76963	0.76770	0.72282	0.71372	0.55621
	g(·) values	0.13311	0.27711	0.41099	0.56251	0.71269	0.84841	1.00000

Figure 8.1 Fuzzy integral values from Scenario 1



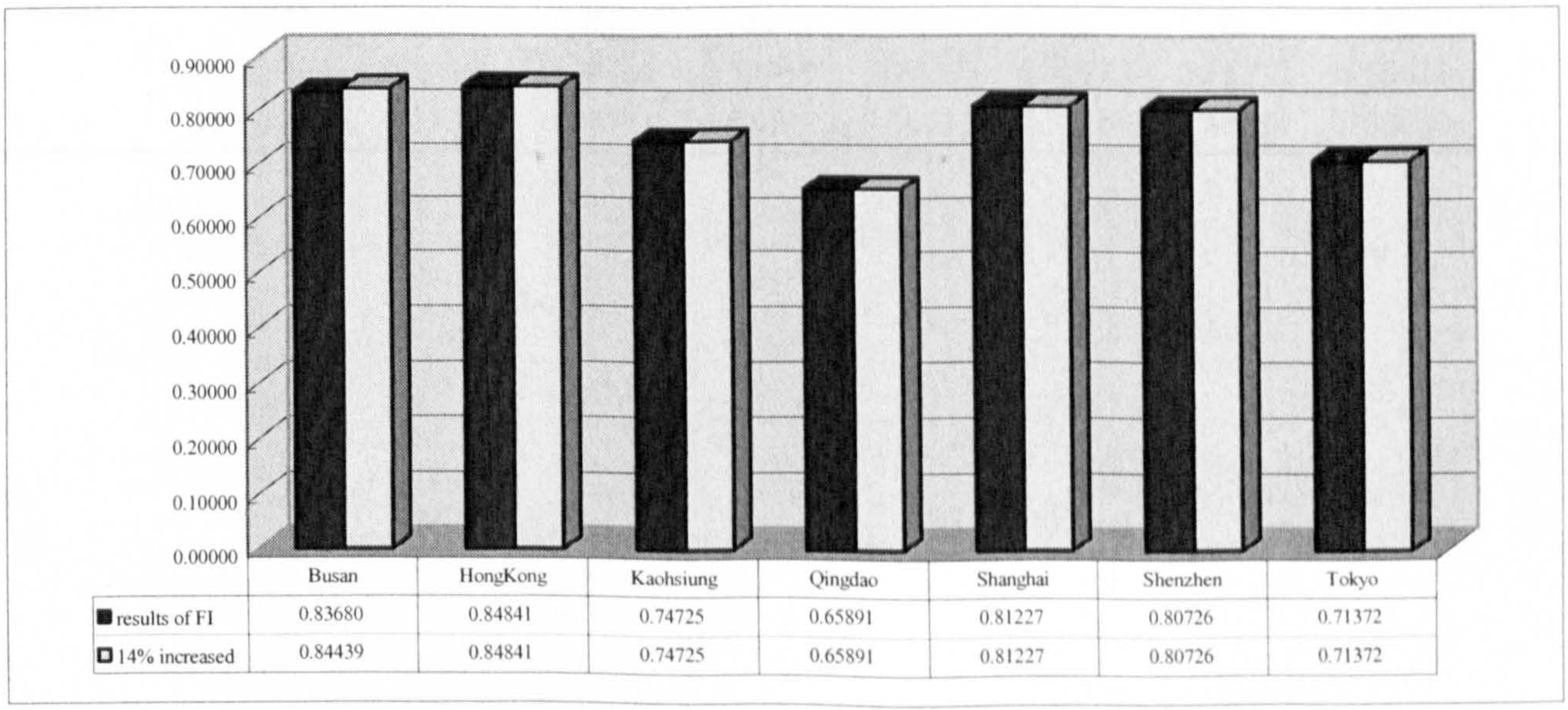
According to the above results, the following rankings of port competitiveness were obtained: Hong Kong (1^{st}), Busan (2^{nd}), Shanghai (3^{rd}), Shenzhen (4^{th}), Kaohsiung (5^{th}), Tokyo (6^{th}) and Qingdao (7^{th}), which are exactly the same as suggested in Chapter 6.

Figure 8.2 Changes in port competitiveness ranking through Scenario 1



In spite of the slight increase in the integral value for Busan port from 0.83680 to 0.84439, Busan cannot overtake Hong Kong.

Figure 8.3 Comparison results with FI and Scenario 1



	Busan	HongKong	Kaohsiung	Qingdao	Shanghai	Shenzhen	Tokyo
results of FI	0.83680	0.84841	0.74725	0.65891	0.81227	0.80726	0.71372
14% increased	0.84439	0.84841	0.74725	0.65891	0.81227	0.80726	0.71372

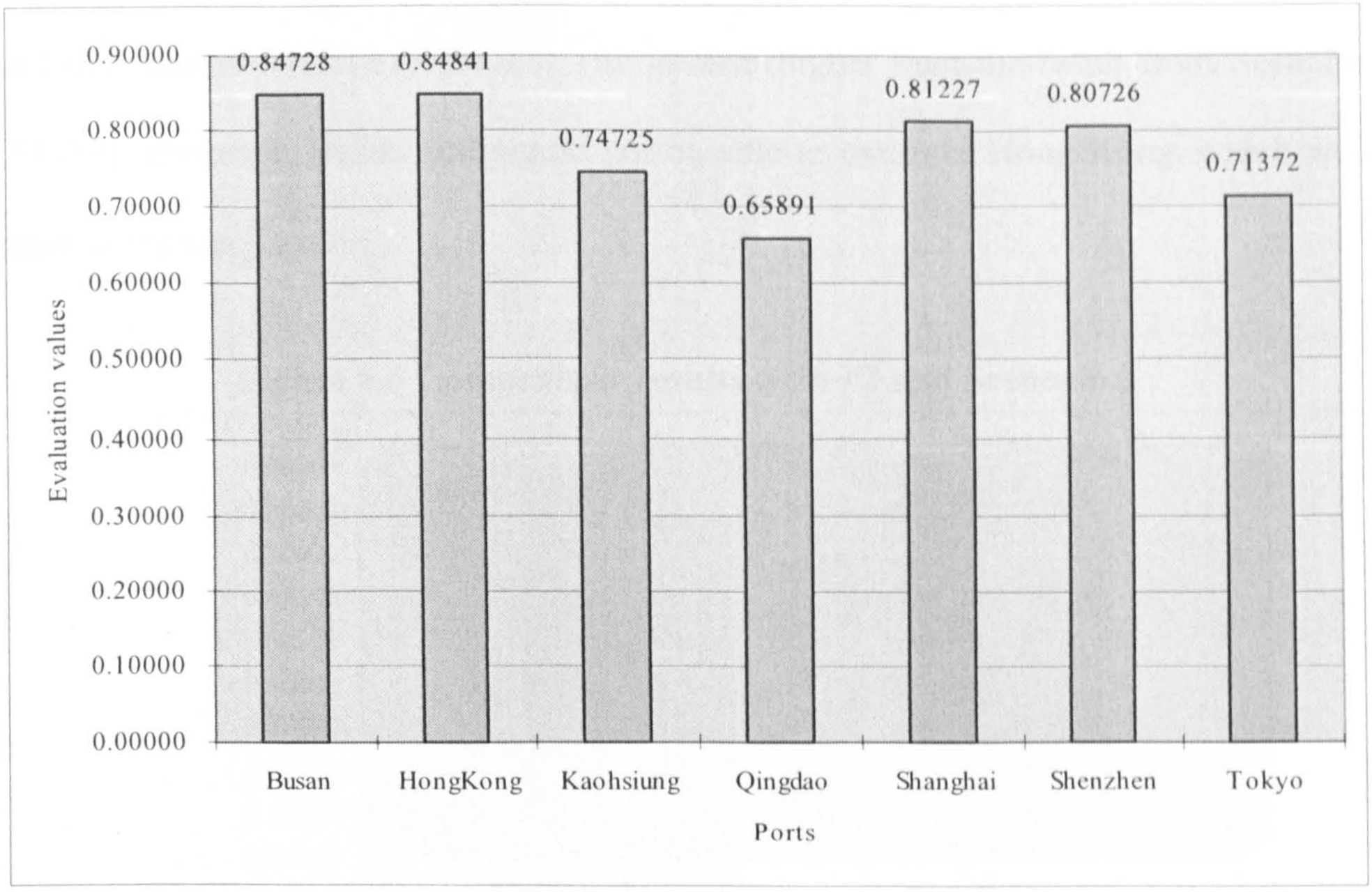
8.2.2 Scenario 2

Scenario 2 indicates higher increase rates than Scenario 1. In this case, Busan's influential factor was increased to five times the estimated GDP rate (24%). Using the increased score on the hinterland condition factor, the IRFE procedures were adopted and the results obtained are shown in Table 8.5, and Figure 8.4.

Table 8.5 Calculation procedures from Scenario 2

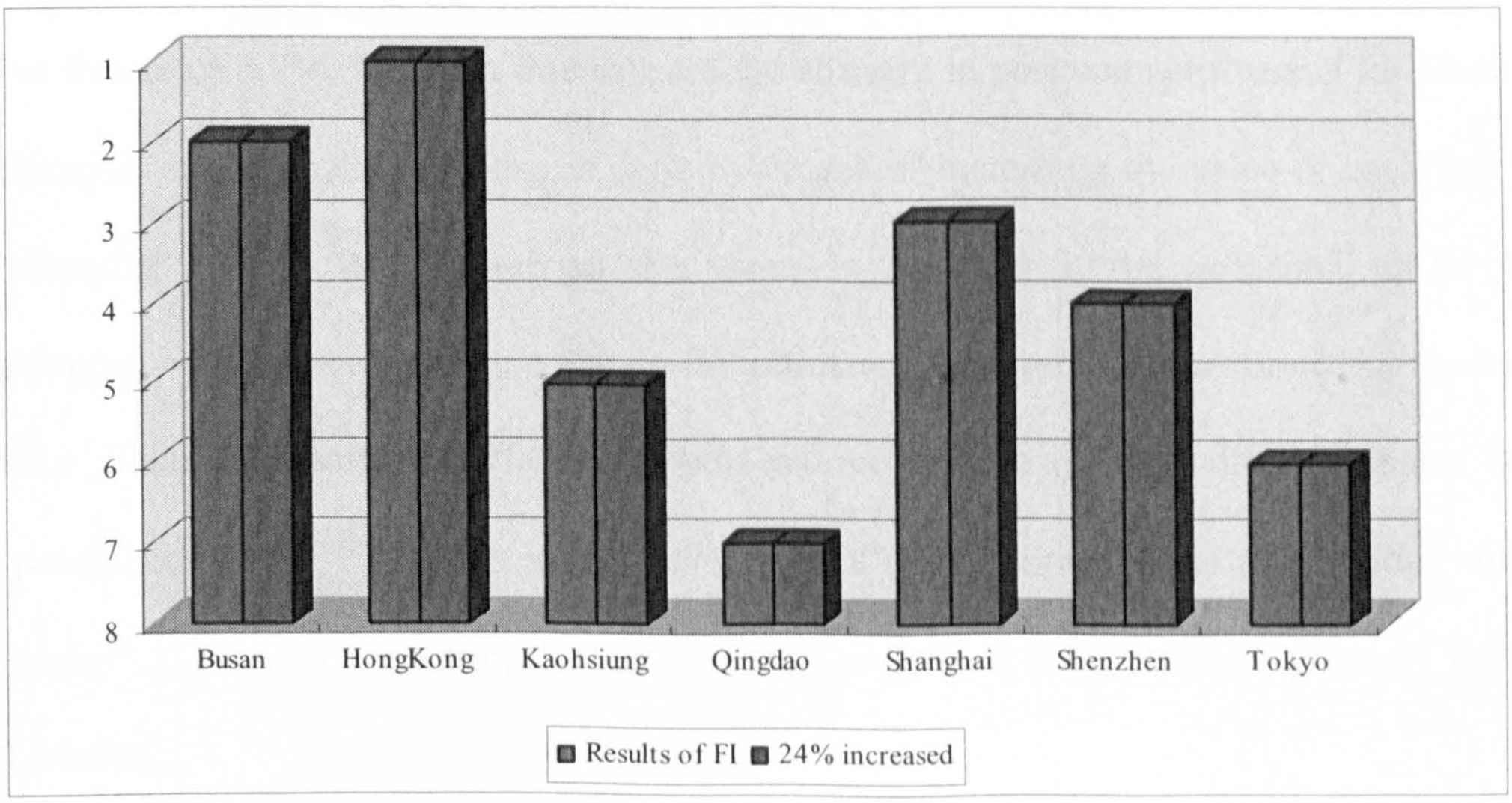
Ports	Evaluation criteria	Fuzzy evaluation						
Busan	Factors	x_5	x_2	x_6	x_3	x_7	x_4	x_1
	h(·) values	0.99369	0.91525	0.89706	0.89444	0.89065	0.84728	0.83680
	g(·) values	0.15159	0.29559	0.4471	0.58099	0.73117	0.86428	1.00000
HongKong	Factors	x_1	x_3	x_4	x_6	x_7	x_2	x_5
	h(·) values	1.00000	1.00000	1.00000	1.00000	1.00000	0.92737	0.68806
	g(·) values	0.13572	0.26961	0.40272	0.55423	0.70441	0.84841	1.00000
Kaohsiung	Factors	x_5	x_4	x_3	x_2	x_6	x_1	x_7
	h(·) values	0.85623	0.85426	0.84148	0.77504	0.7541	0.74725	0.73979
	g(·) values	0.15159	0.2847	0.41858	0.56259	0.7141	0.84982	1.00000
Qingdao	Factors	x_5	x_2	x_3	x_4	x_7	x_1	x_6
	h(·) values	1.00000	0.79993	0.77885	0.7482	0.65891	0.64780	0.64684
	g(·) values	0.15159	0.29559	0.42948	0.56259	0.71277	0.84849	1.00000
Shanghai	Factors	x_2	x_5	x_6	x_7	x_3	x_4	x_1
	h(·) values	1.00000	0.97579	0.91347	0.87478	0.84698	0.81227	0.75013
	g(·) values	0.14400	0.29559	0.44710	0.59728	0.73117	0.86428	1.00000
Shenzhen	Factors	x_5	x_2	x_3	x_6	x_4	x_7	x_1
	h(·) values	0.97837	0.91932	0.85416	0.85166	0.84222	0.80726	0.77953
	g(·) values	0.15159	0.29559	0.42948	0.58099	0.71410	0.86428	1.00000
Tokyo	Factors	x_4	x_2	x_3	x_6	x_7	x_1	x_5
	h(·) values	0.79086	0.77909	0.76963	0.7677	0.72282	0.71372	0.55621
	g(·) values	0.13311	0.27711	0.41099	0.56251	0.71269	0.84841	1.00000

Figure 8.4 Fuzzy integral values from Scenario 2



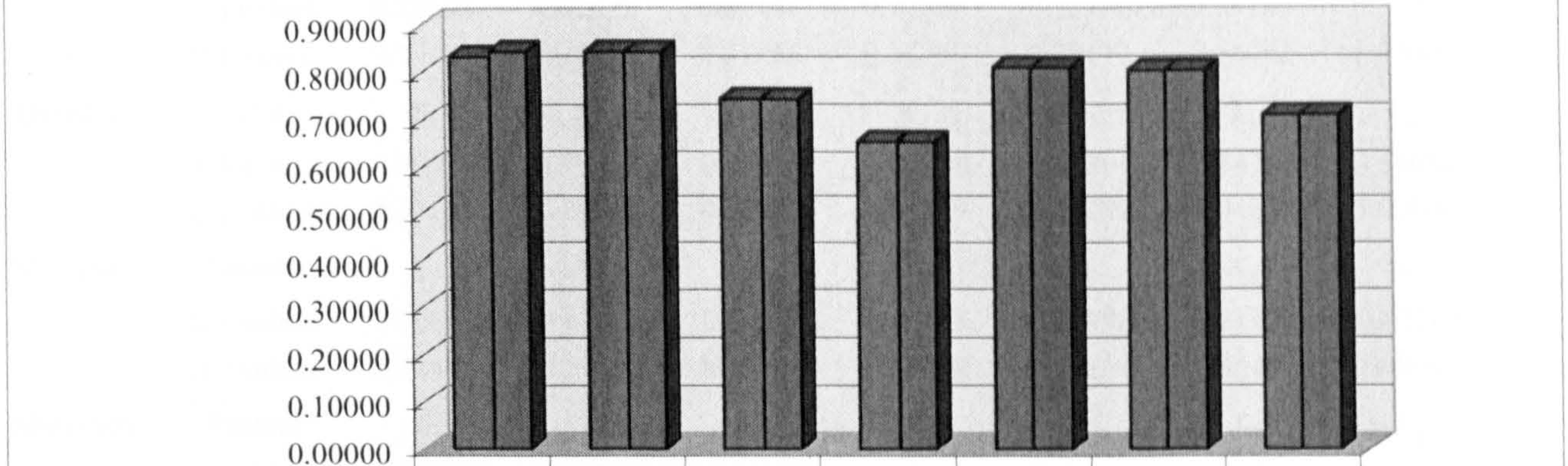
Even though the weakest point was increased by 24%, the rankings for port competitiveness did not change compared to the previous scenario.

Figure 8.5 Changes in port competitiveness ranking by Scenario 2



Due to the large increase rate in the influential factor, the integral value for Busan port was lifted from 0.83680 to 0.84728. This is also higher than the result from Scenario 1 (0.84439). However, Busan still would not be able to overtake Hong Kong, which would remain in the top position.

Figure 8.6 Comparison results with FI and Scenario 2



	Busan	HongKong	Kaohsiung	Qingdao	Shanghai	Shenzhen	Tokyo
Results of FI	0.83680	0.84841	0.74725	0.65891	0.81227	0.80726	0.71372
24% increased	0.84728	0.84841	0.74725	0.65891	0.81227	0.80726	0.71372

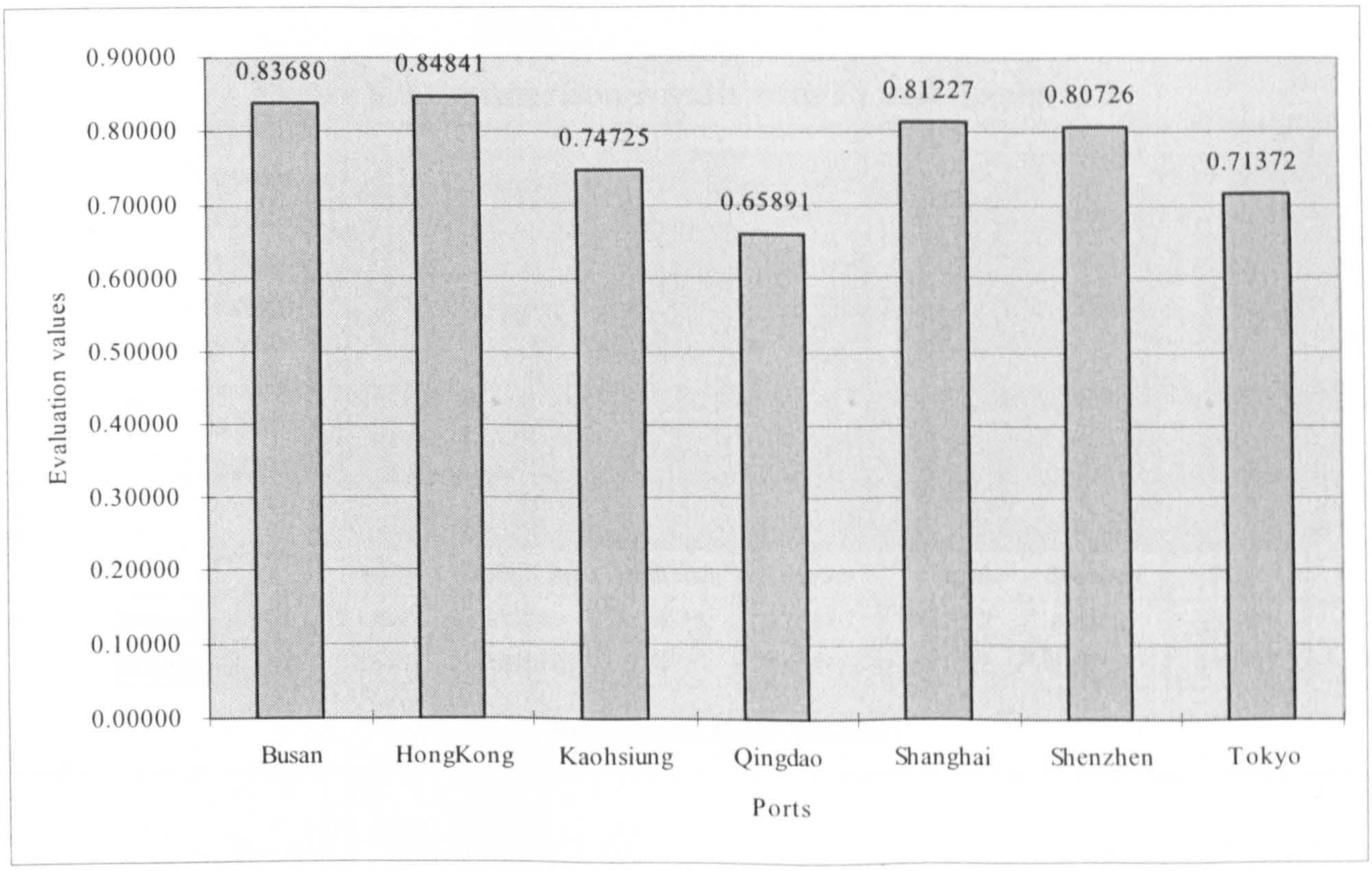
8.2.3 Scenario 3

For Scenarios 3 ~ 6, the main interests are the changes in port competitiveness for Busan, Shanghai and Shenzhen and this is done by means of increasing the value of each port's influential factors. With regard to this issue, in Scenario 3, the influential factor of Shanghai will be increased by 6.8% on the estimated GDP rate. As mentioned in Section 6.2.1, Shanghai's influential factor is 'port service', which includes three attributes i.e. "prompt response", "24 hours a day, seven days a week service" and "zero waiting time service". Using this scenario, the results of the evaluation with IRFE are given in Table 8.6 below.

Table 8.6 Calculation procedures from Scenario 3

Ports	Evaluation criteria	Fuzzy evaluation						
Busan	Factors	x_5	x_6	x_3	x_7	x_4	x_1	x_2
	h(·) values	0.99369	0.89706	0.89444	0.89065	0.84728	0.83680	0.73810
	g(·) values	0.15159	0.30310	0.43699	0.58717	0.72027	0.85600	1.00000
HongKong	Factors	x_1	x_3	x_4	x_6	x_7	x_2	x_5
	h(·) values	1.00000	1.00000	1.00000	1.00000	1.00000	0.92737	0.68806
	g(·) values	0.13572	0.26961	0.40272	0.55423	0.70441	0.84841	1.00000
Kaohsiung	Factors	x_5	x_4	x_3	x_2	x_6	x_1	x_7
	h(·) values	0.85623	0.85426	0.84148	0.77504	0.75410	0.74725	0.73979
	g(·) values	0.15159	0.28470	0.41858	0.56259	0.71410	0.84982	1.00000
Qingdao	Factors	x_5	x_2	x_3	x_4	x_7	x_1	x_6
	h(·) values	1.00000	0.79993	0.77885	0.74820	0.65891	0.64780	0.64684
	g(·) values	0.15159	0.29559	0.42948	0.56259	0.71277	0.84849	1.00000
Shanghai	Factors	x_2	x_5	x_6	x_7	x_3	x_4	x_1
	h(·) values	1.00000	0.97579	0.91347	0.87478	0.84698	0.81227	0.80114
	g(·) values	0.14400	0.29559	0.44710	0.59728	0.73117	0.86428	1.00000
Shenzhen	Factors	x_5	x_2	x_3	x_6	x_4	x_7	x_1
	h(·) values	0.97837	0.91932	0.85416	0.85166	0.84222	0.80726	0.77953
	g(·) values	0.15159	0.29559	0.42948	0.58099	0.71410	0.86428	1.00000
Tokyo	Factors	x_4	x_2	x_3	x_6	x_7	x_1	x_5
	h(·) values	0.79086	0.77909	0.76963	0.7677	0.72282	0.71372	0.55621
	g(·) values	0.13311	0.27711	0.41099	0.56251	0.71269	0.84841	1.00000

Figure 8.7 Fuzzy integral values from Scenario 3



Although the influential factor of Shanghai was increased, there were no changes in the integrated values and ranking on each port. In the case of Scenario 1 and Scenario 2, slight increases could be seen in the integrated values, although, no changes were identified in the ranking order. This means that, if Shanghai wants to overtake its competitors i.e. Busan and Shenzhen, comparing to GDP rates (6.8%), more investment will be needed.

Figure 8.8 Changes of port competitiveness ranking by Scenario 3

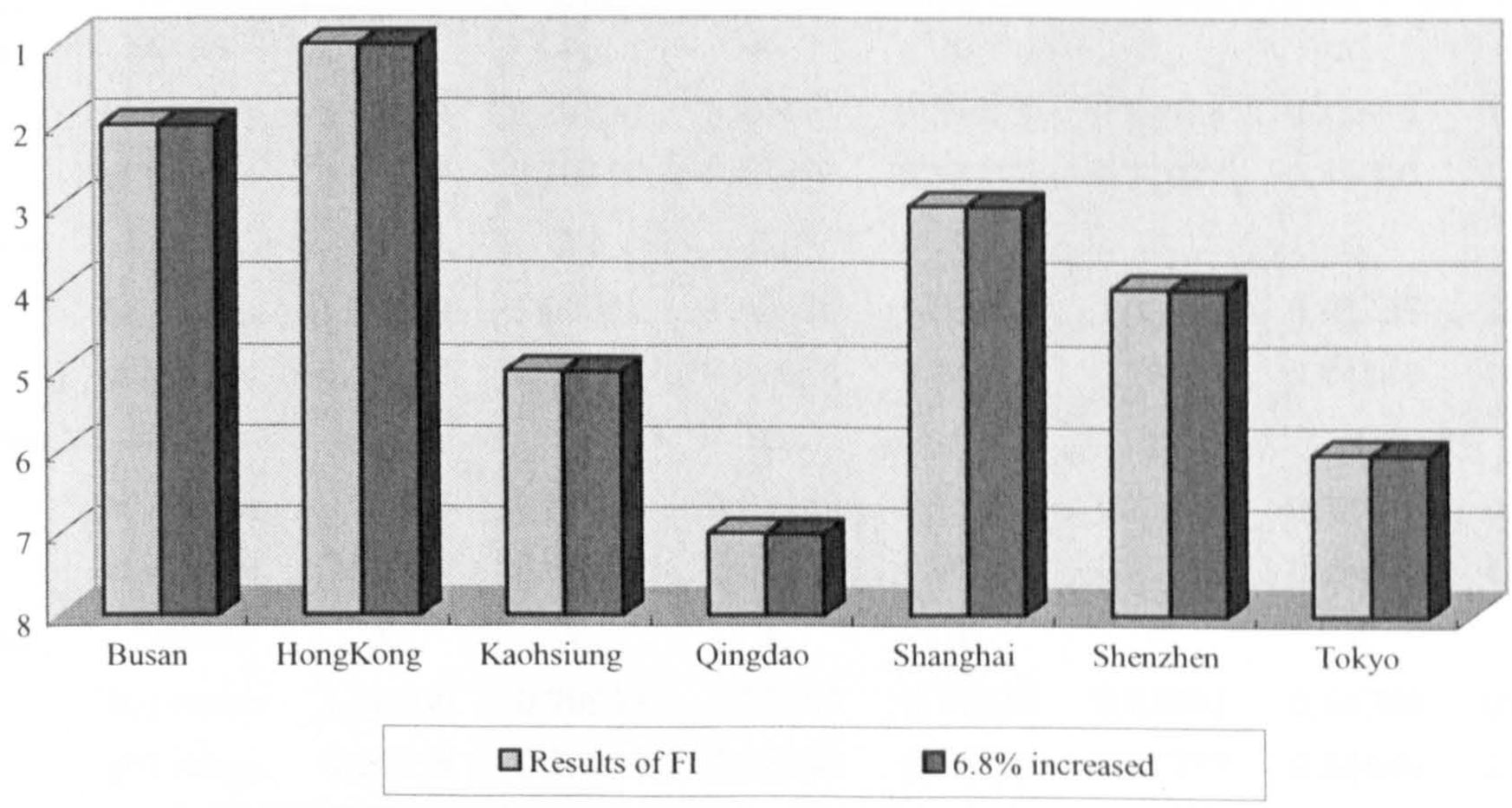
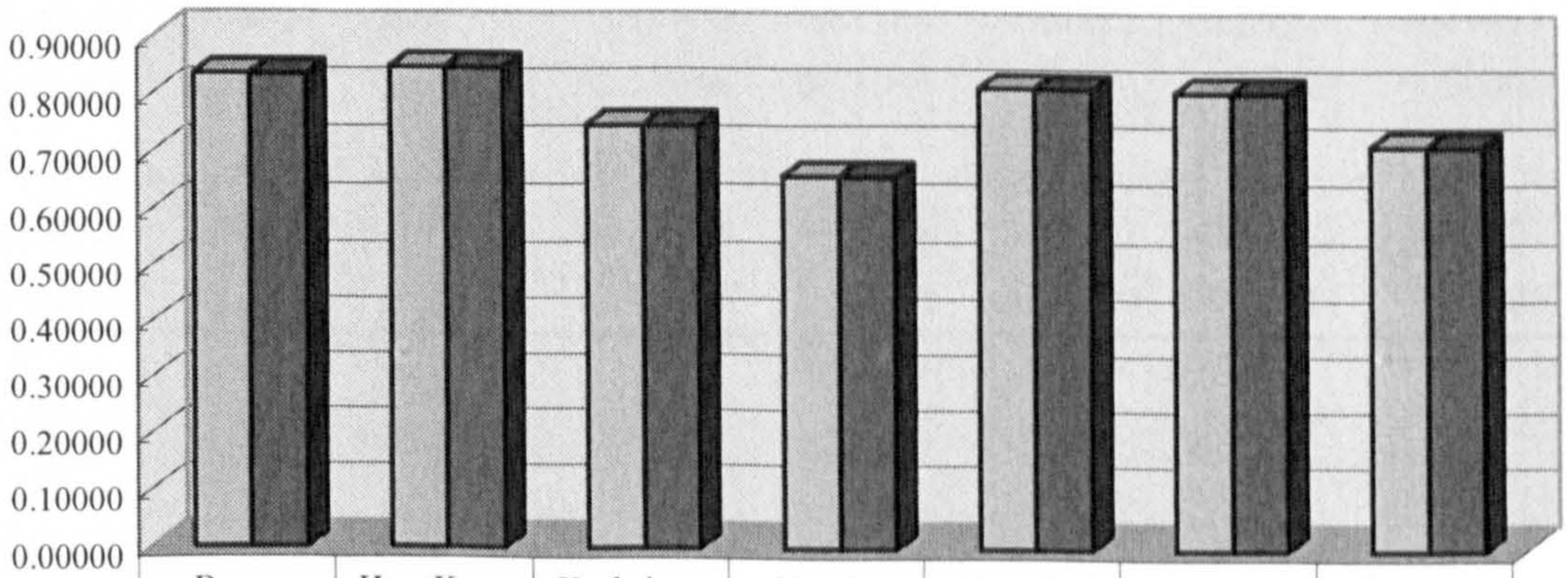


Figure 8.9 Comparison results with FI and Scenario 3



	Busan	HongKong	Kaohsiung	Qingdao	Shanghai	Shenzhen	Tokyo
Results of FI	0.83680	0.84841	0.74725	0.65891	0.81227	0.80726	0.71372
6.8% increased	0.83680	0.84841	0.74725	0.65891	0.81227	0.80726	0.71372

Results of FI 6.8% increased

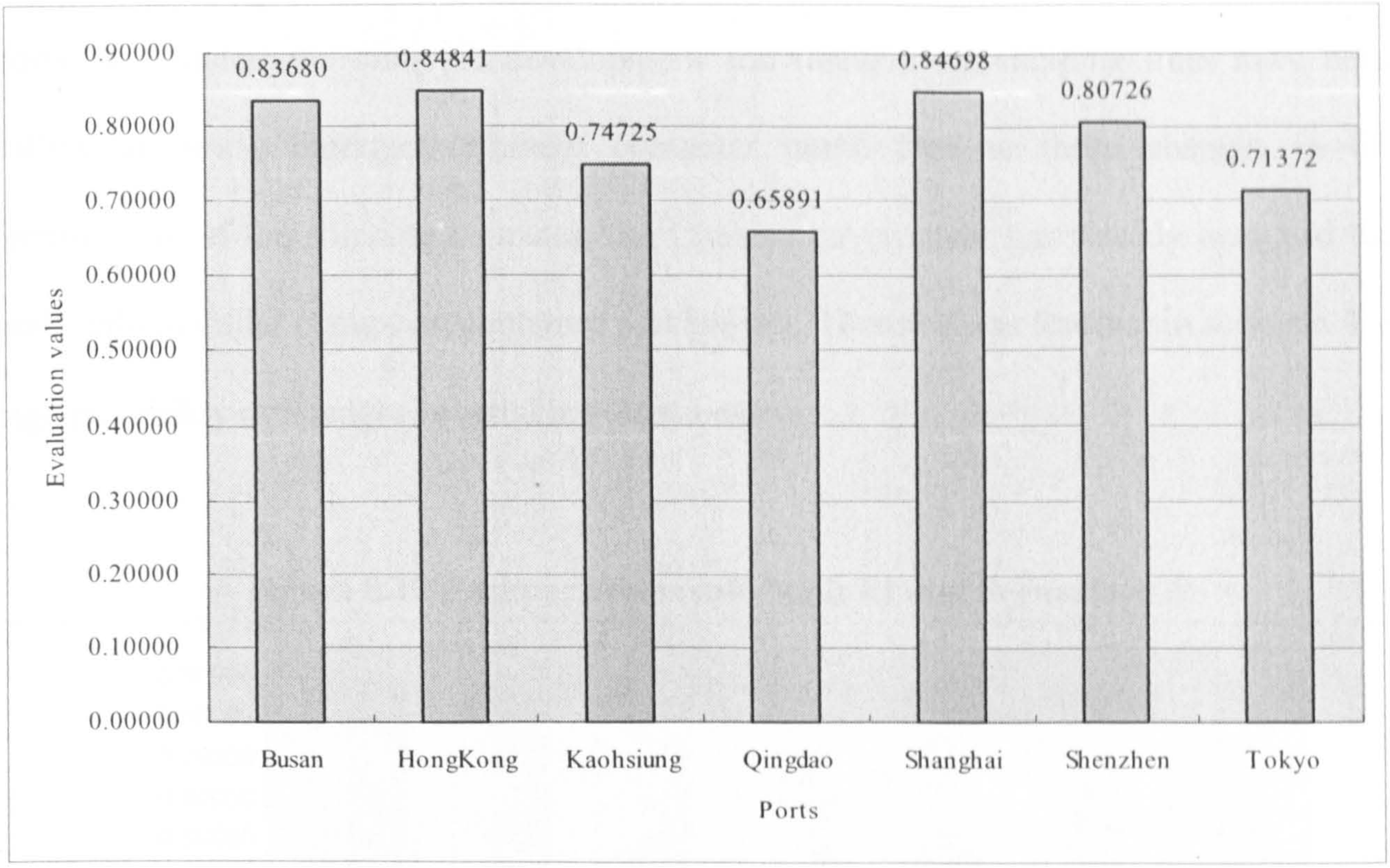
8.2.4 Scenario 4

To test the improvement of Shanghai's competitiveness, in Scenario 4, the level of its influential factor was increased to 13.6% higher than that at present. The Table 8.7 and Figure 8.10 illustrate the results of IRFE.

Table 8.7 Calculation procedures from Scenario 4

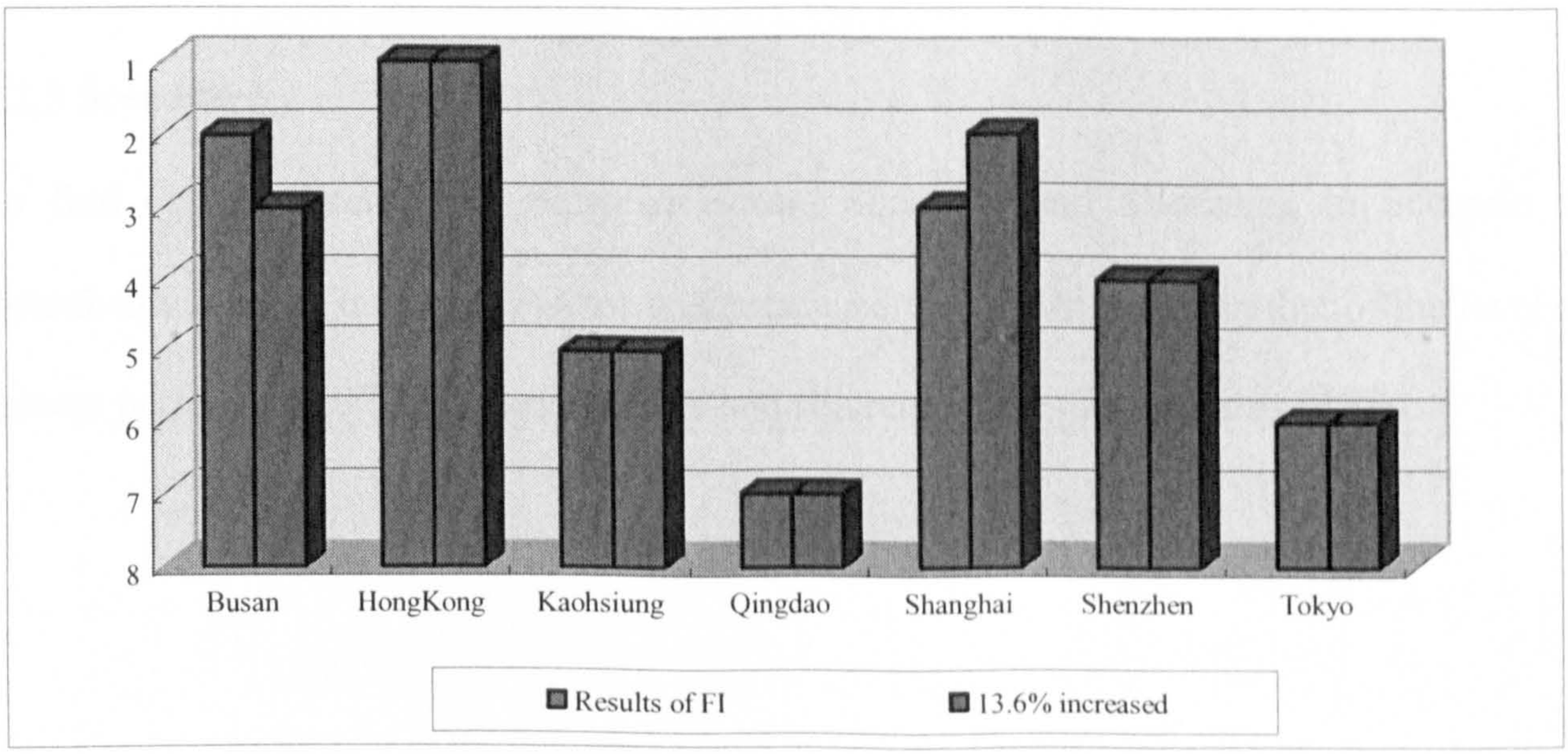
Ports	Evaluation criteria	Fuzzy evaluation						
Busan	Factors	x_5	x_6	x_3	x_7	x_4	x_1	x_2
	h(·) values	0.99369	0.89706	0.89444	0.89065	0.84728	0.83680	0.73810
	g(·) values	0.15159	0.30310	0.43699	0.58717	0.72027	0.85600	1.00000
HongKong	Factors	x_1	x_3	x_4	x_6	x_7	x_2	x_5
	h(·) values	1.00000	1.00000	1.00000	1.00000	1.00000	0.92737	0.68806
	g(·) values	0.13572	0.26961	0.40272	0.55423	0.70441	0.84841	1.00000
Kaohsiung	Factors	x_5	x_4	x_3	x_2	x_6	x_1	x_7
	h(·) values	0.85623	0.85426	0.84148	0.77504	0.75410	0.74725	0.73979
	g(·) values	0.15159	0.28470	0.41858	0.56259	0.71410	0.84982	1.00000
Qingdao	Factors	x_5	x_2	x_3	x_4	x_7	x_1	x_6
	h(·) values	1.00000	0.79993	0.77885	0.74820	0.65891	0.64780	0.64684
	g(·) values	0.15159	0.29559	0.42948	0.56259	0.71277	0.84849	1.00000
Shanghai	Factors	x_2	x_5	x_6	x_7	x_1	x_3	x_4
	h(·) values	1.00000	0.97579	0.91347	0.87478	0.85215	0.84698	0.81227
	g(·) values	0.14400	0.29559	0.44710	0.59728	0.73301	0.86689	1.00000
Shenzhen	Factors	x_5	x_2	x_3	x_6	x_4	x_7	x_1
	h(·) values	0.97837	0.91932	0.85416	0.85166	0.84222	0.80726	0.77953
	g(·) values	0.15159	0.29559	0.42948	0.58099	0.71410	0.86428	1.00000
Tokyo	Factors	x_4	x_2	x_3	x_6	x_7	x_1	x_5
	h(·) values	0.79086	0.77909	0.76963	0.76770	0.72282	0.71372	0.55621
	g(·) values	0.13311	0.27711	0.41099	0.56251	0.71269	0.84841	1.00000

Figure 8.10 Fuzzy integral values from Scenario 4



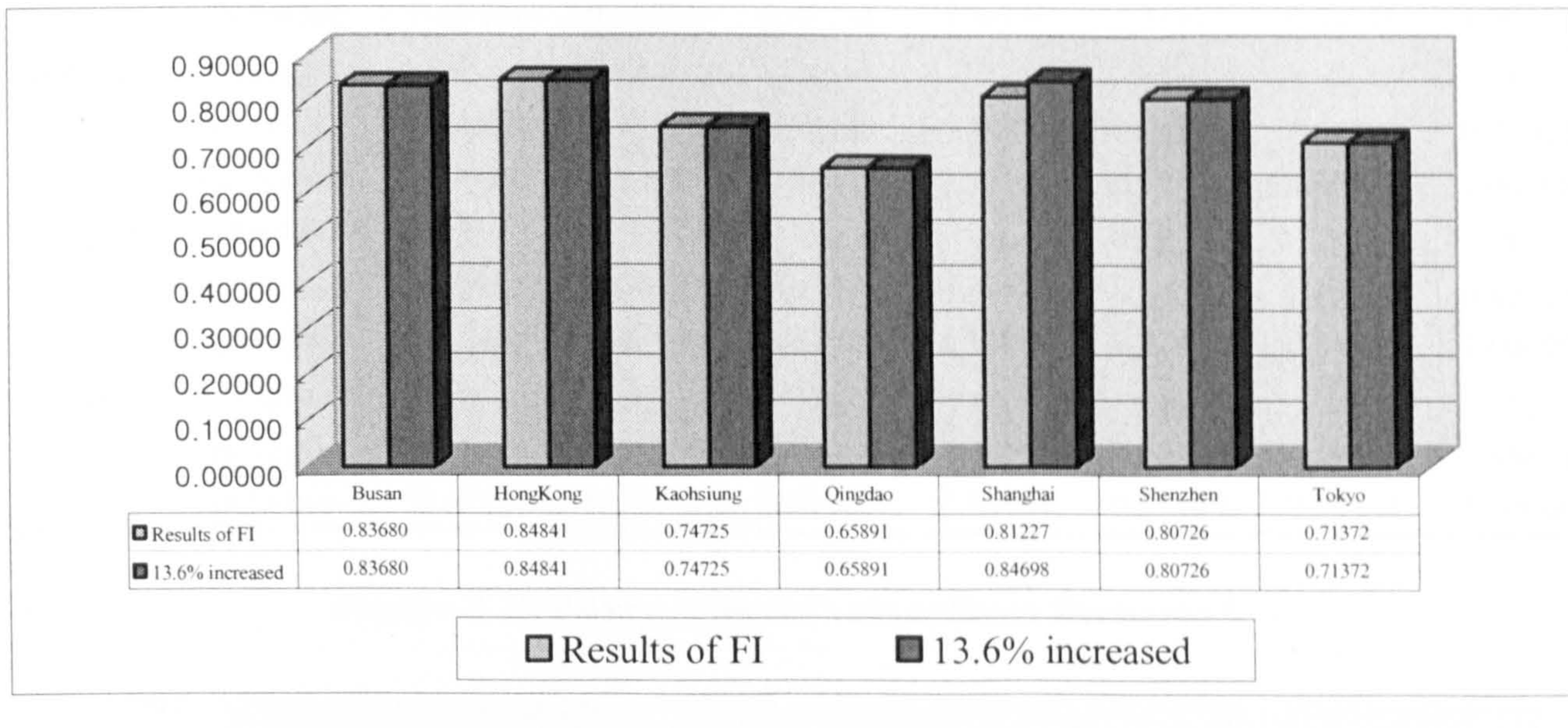
According to the results, Shanghai overtakes Busan, and ranks 2nd, Busan stepping down to 3rd position.

Figure 8.11 Changes in port competitiveness ranking by Scenario 4



This scenario has a high possibility to become reality. As stated in Section 2.3.2, Chinese ports have undergone dramatic development and many mega-shipping lines have been calling at newly emerging Chinese container ports. Due to these changes in the environment of the shipping business, the Chinese government has already launched the multi-billion dollar Yangshan container port project. Therefore, as forecast in scenario 4, a high possibility of Shanghai overtaking Busan exists.

Figure 8.12 Comparison results with FI and Scenario 4



	Busan	HongKong	Kaohsiung	Qingdao	Shanghai	Shenzhen	Tokyo
Results of FI	0.83680	0.84841	0.74725	0.65891	0.81227	0.80726	0.71372
13.6% increased	0.83680	0.84841	0.74725	0.65891	0.84698	0.80726	0.71372

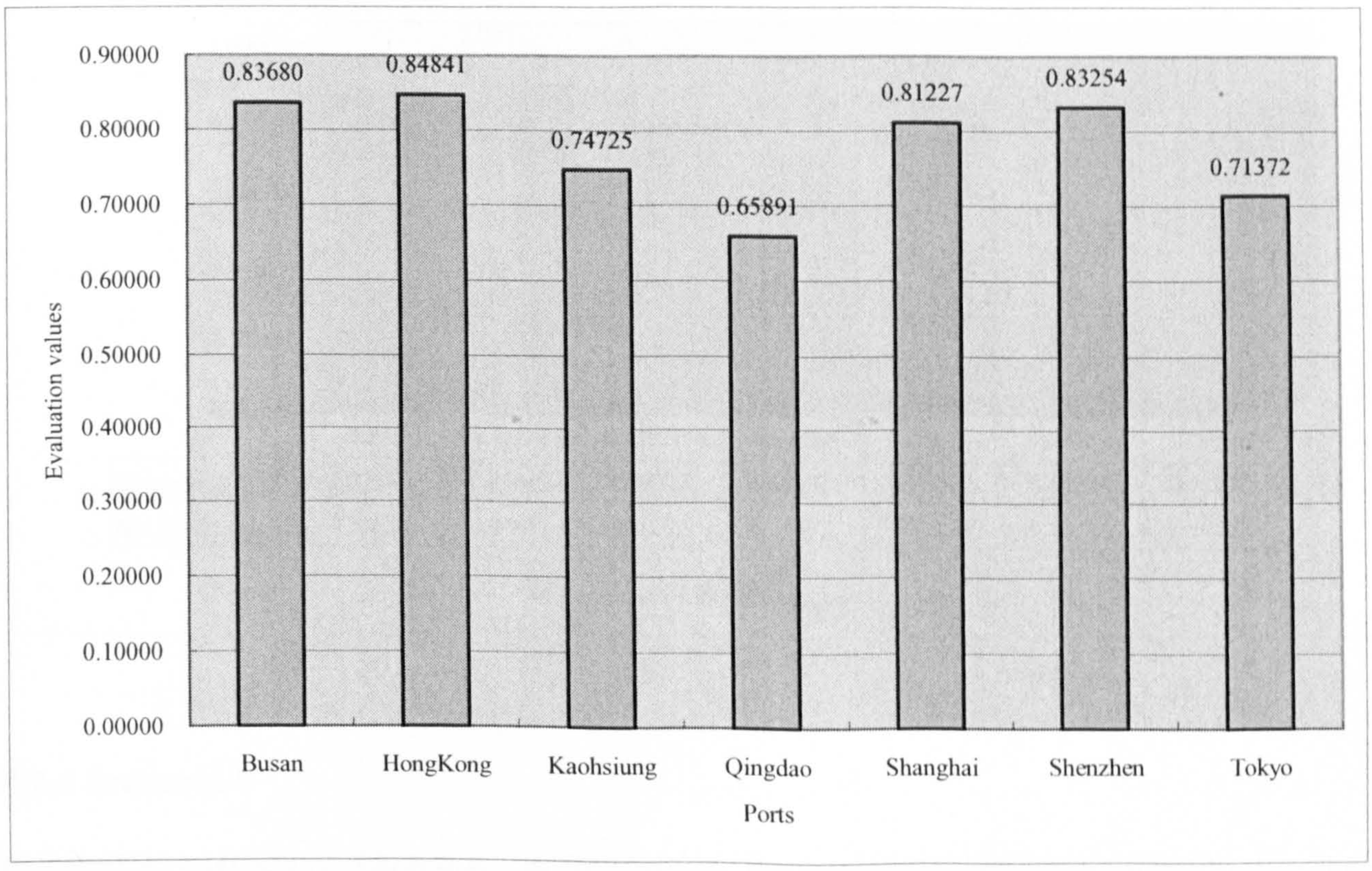
8.2.5 Scenario 5

To find out the interactions between Busan, Shanghai and Shenzhen, in Scenario 5, Shenzhen's level of influential factor was increased to 6.8% higher than that of the level of present performance. The following table and figure provide the results of IRFE.

Table 8.8 Calculation procedures from Scenario 5

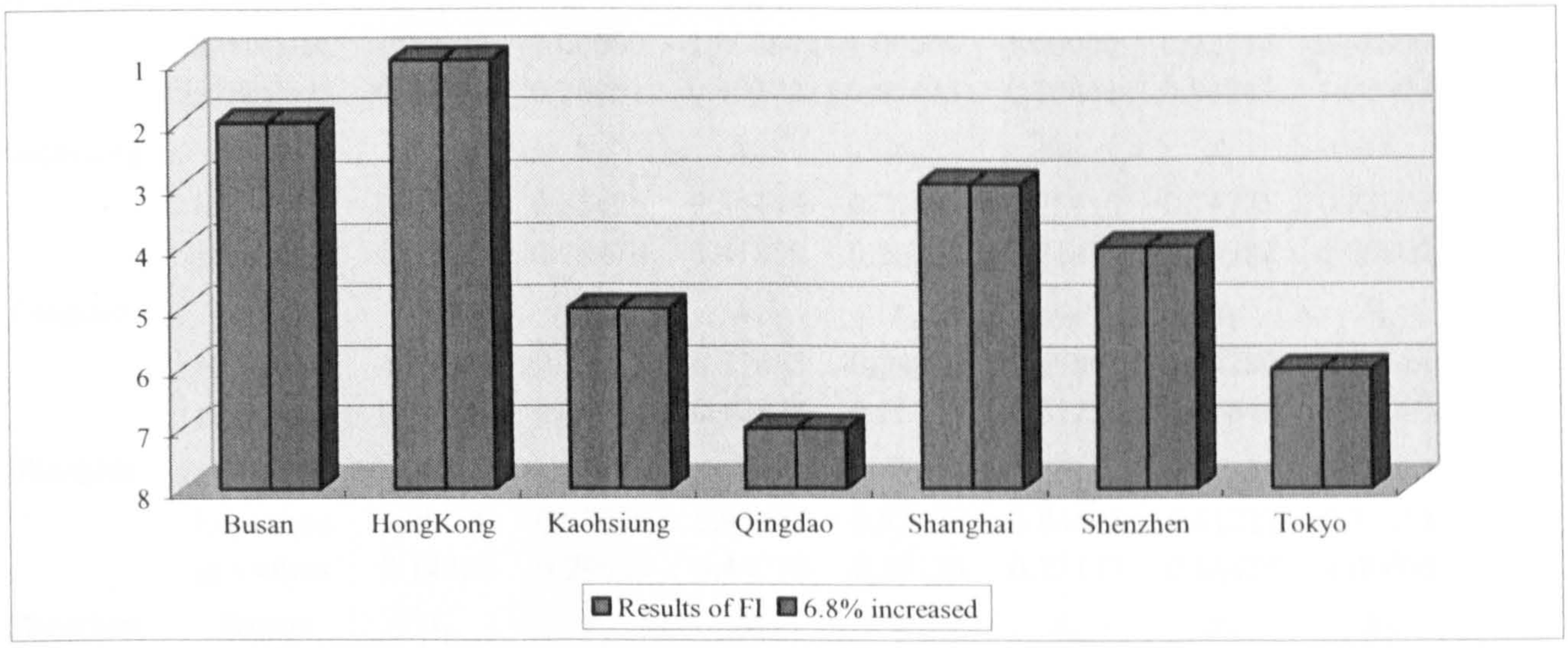
Ports	Evaluation criteria	Fuzzy evaluation						
Busan	Factors	x_5	x_6	x_3	x_7	x_4	x_1	x_2
	h(·) values	0.99369	0.89706	0.89444	0.89065	0.84728	0.83680	0.73810
	g(·) values	0.15159	0.30310	0.43699	0.58717	0.72027	0.85600	1.00000
HongKong	Factors	x_1	x_3	x_4	x_6	x_7	x_2	x_5
	h(·) values	1.00000	1.00000	1.00000	1.00000	1.00000	0.92737	0.68806
	g(·) values	0.13572	0.26961	0.40272	0.55423	0.70441	0.84841	1.00000
Kaohsiung	Factors	x_5	x_4	x_3	x_2	x_6	x_1	x_7
	h(·) values	0.85623	0.85426	0.84148	0.77504	0.75410	0.74725	0.73979
	g(·) values	0.15159	0.28470	0.41858	0.56259	0.71410	0.84982	1.00000
Qingdao	Factors	x_5	x_2	x_3	x_4	x_7	x_1	x_6
	h(·) values	1.00000	0.79993	0.77885	0.74820	0.65891	0.64780	0.64684
	g(·) values	0.15159	0.29559	0.42948	0.56259	0.71277	0.84849	1.00000
Shanghai	Factors	x_2	x_5	x_6	x_7	x_3	x_4	x_1
	h(·) values	1.00000	0.97579	0.91347	0.87478	0.84698	0.81227	0.75013
	g(·) values	0.14400	0.29559	0.44710	0.59728	0.73117	0.86428	1.00000
Shenzhen	Factors	x_5	x_2	x_3	x_6	x_4	x_1	x_7
	h(·) values	0.97837	0.91932	0.85416	0.85166	0.84222	0.83254	0.80726
	g(·) values	0.15159	0.29559	0.42948	0.58099	0.71410	0.84982	1.00000
Tokyo	Factors	x_4	x_2	x_3	x_6	x_7	x_1	x_5
	h(·) values	0.79086	0.77909	0.76963	0.76770	0.72282	0.71372	0.55621
	g(·) values	0.13311	0.27711	0.41099	0.56251	0.71269	0.84841	1.00000

Figure 8.13 Fuzzy integral values from Scenario 5



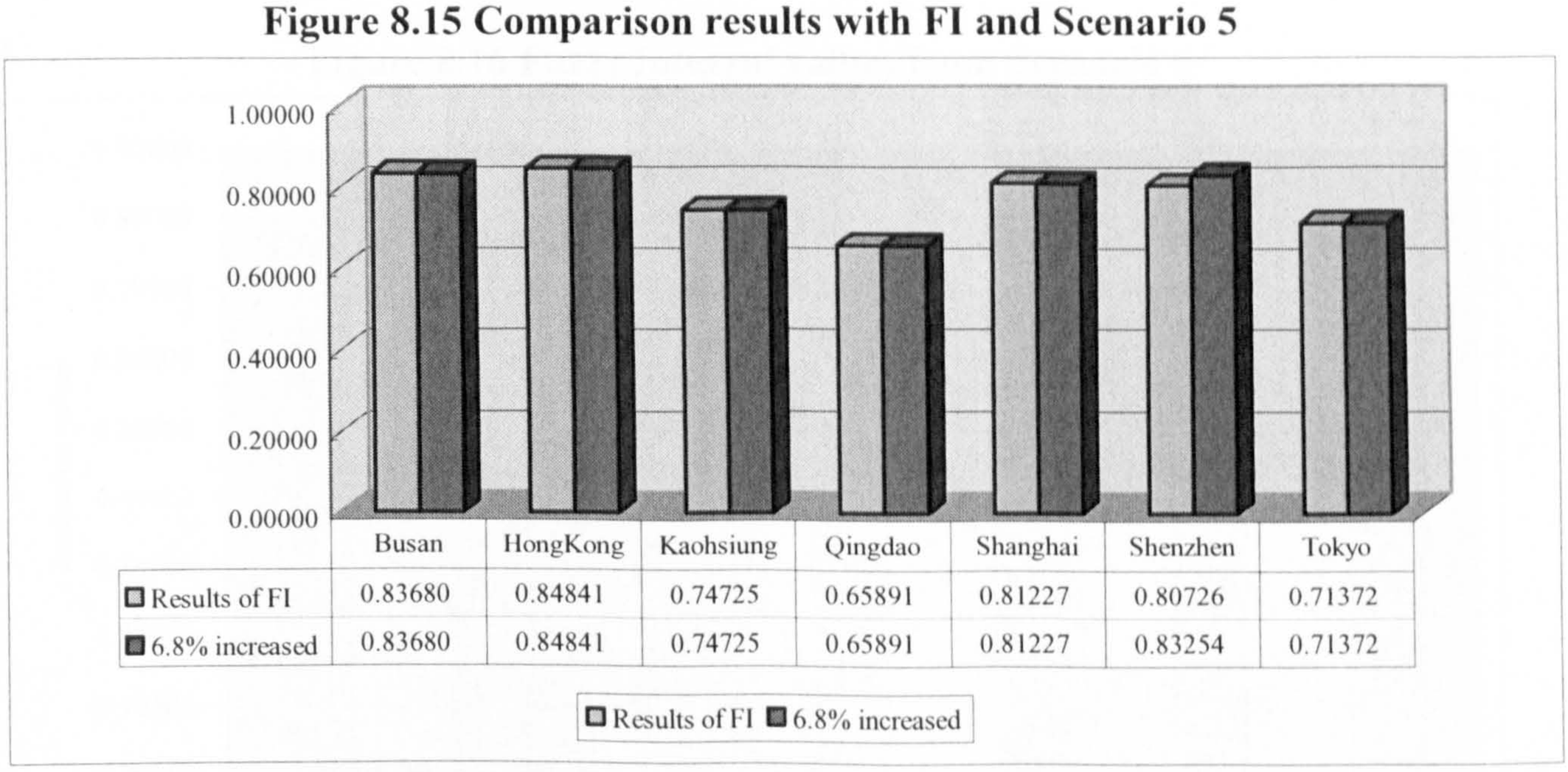
Even though the weakest point of Shenzhen port was increased by 6.8%, the ranking of its competitiveness did not change compared to the results of the fuzzy integral.

Figure 8.14 Changes in port competitiveness ranking by Scenario 5



As can be seen from this figure, should the rate of increase in Shenzhen's influential factor follow that of the GDP, it would not make any difference to the port's ranking.

Figure 8.15 Comparison results with FI and Scenario 5



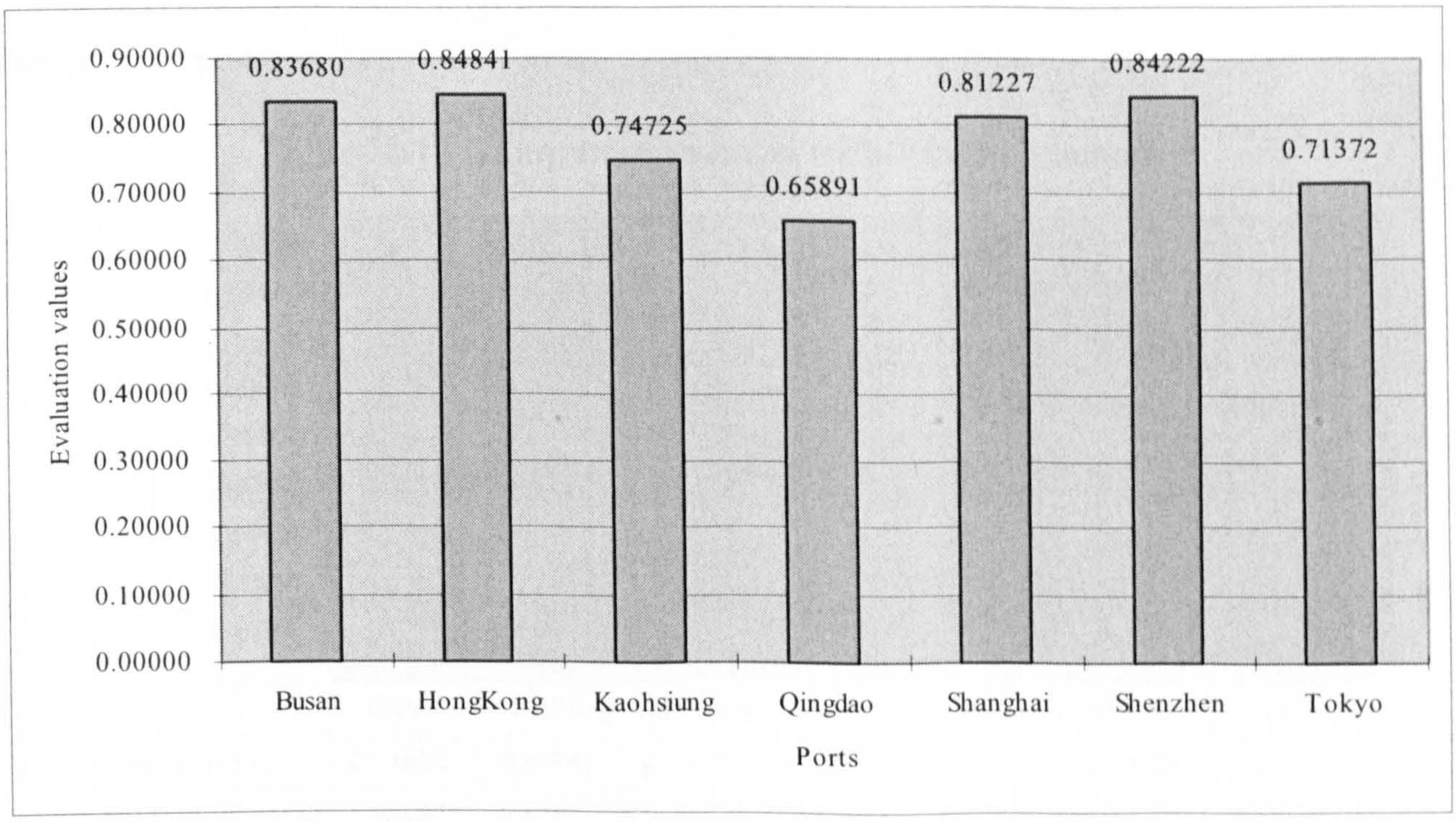
8.2.6 Scenario 6

For further analysis of Shenzhen, in Scenario 6, the increasing rate was raised higher than in Scenario 5, i.e. up to 13.6% compared to the present level of performance. The followings results were obtained using IRFE procedures.

Table 8.9 Calculation procedures from scenario 6

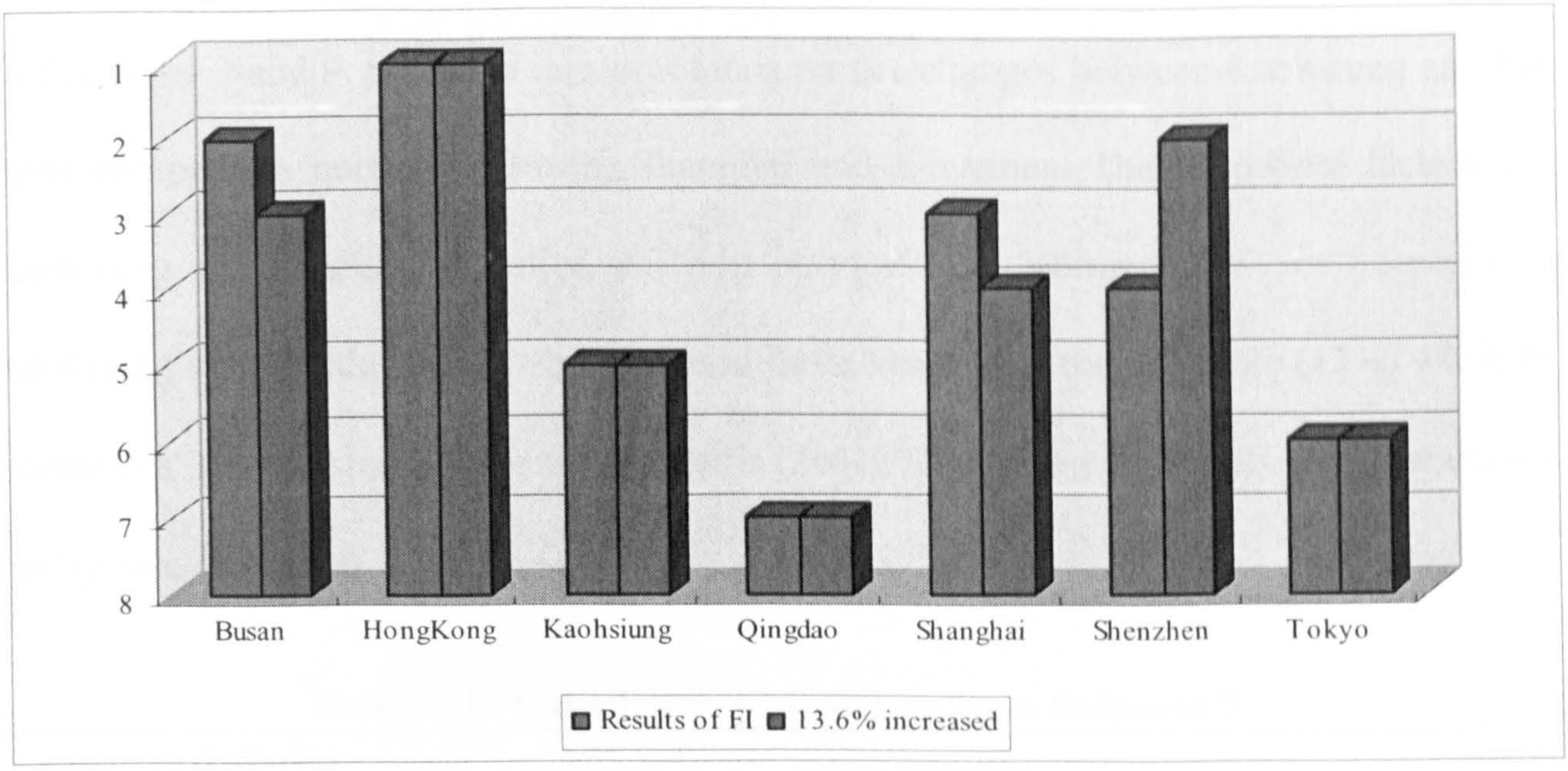
Ports	Evaluation criteria	Fuzzy evaluation						
Busan	Factors	x_5	x_6	x_3	x_7	x_4	x_1	x_2
	h(·) values	0.99369	0.89706	0.89444	0.89065	0.84728	0.83680	0.73810
	g(·) values	0.15159	0.30310	0.43699	0.58717	0.72027	0.85600	1.00000
HongKong	Factors	x_1	x_3	x_4	x_6	x_7	x_2	x_5
	h(·) values	1.00000	1.00000	1.00000	1.00000	1.00000	0.92737	0.68806
	g(·) values	0.13572	0.26961	0.40272	0.55423	0.70441	0.84841	1.00000
Kaohsiung	Factors	x_5	x_4	x_3	x_2	x_6	x_1	x_7
	h(·) values	0.85623	0.85426	0.84148	0.77504	0.75410	0.74725	0.73979
	g(·) values	0.15159	0.28470	0.41858	0.56259	0.71410	0.84982	1.00000
Qingdao	Factors	x_5	x_2	x_3	x_4	x_7	x_1	x_6
	h(·) values	1.00000	0.79993	0.77885	0.74820	0.65891	0.64780	0.64684
	g(·) values	0.15159	0.29559	0.42948	0.56259	0.71277	0.84849	1.00000
Shanghai	Factors	x_2	x_5	x_6	x_7	x_3	x_4	x_1
	h(·) values	1.00000	0.97579	0.91347	0.87478	0.84698	0.81227	0.75013
	g(·) values	0.14400	0.29559	0.44710	0.59728	0.73117	0.86428	1.00000
Shenzhen	Factors	x_5	x_2	x_1	x_3	x_6	x_4	x_7
	h(·) values	0.97837	0.91932	0.88555	0.85416	0.85166	0.84222	0.80726
	g(·) values	0.15159	0.29559	0.43132	0.56520	0.71671	0.84982	1.00000
Tokyo	Factors	x_4	x_2	x_3	x_6	x_7	x_1	x_5
	h(·) values	0.79086	0.77909	0.76963	0.7677	0.72282	0.71372	0.55621
	g(·) values	0.13311	0.27711	0.41099	0.56251	0.71269	0.84841	1.00000

Figure 8.16 Fuzzy integral values from Scenario 6



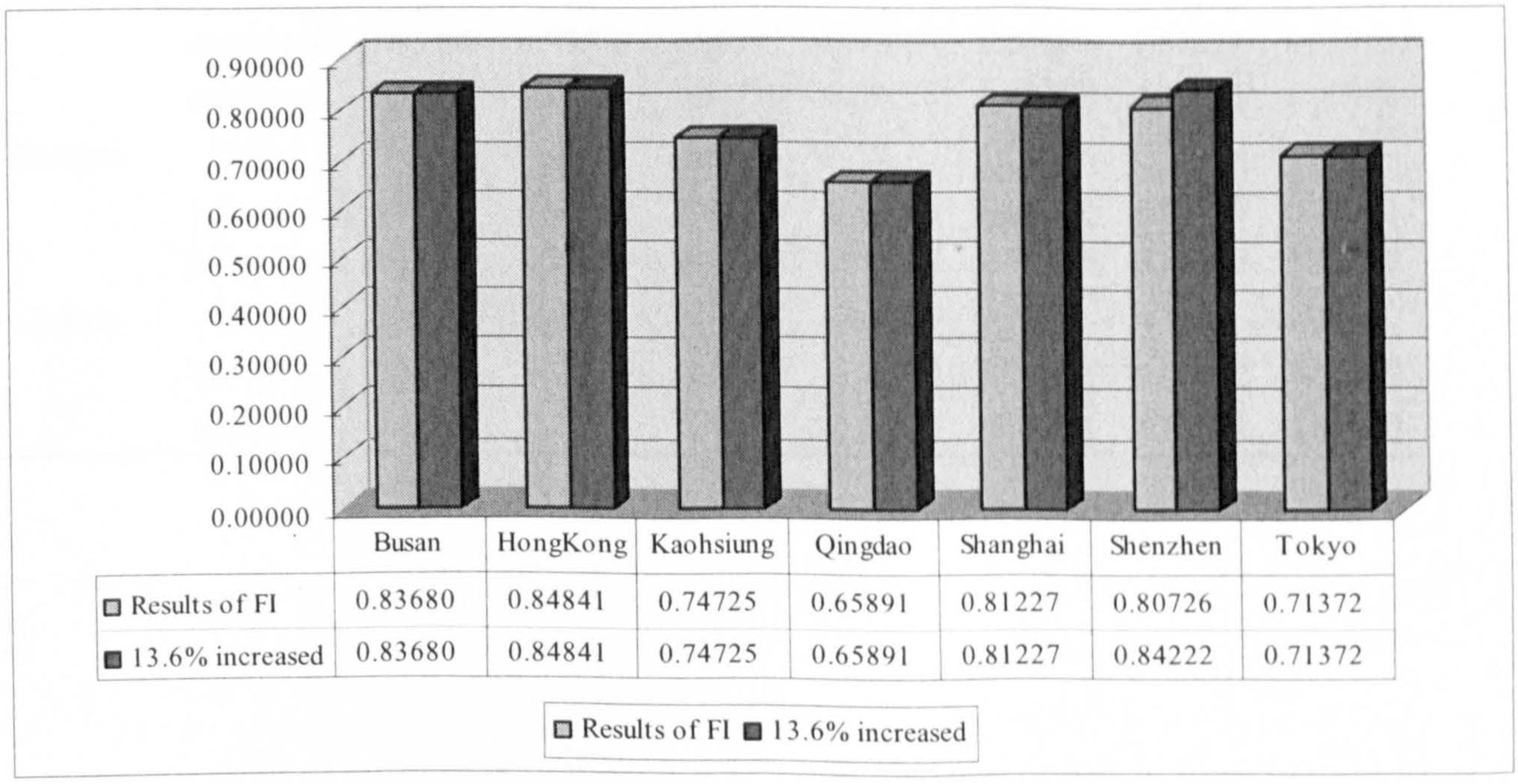
Very interestingly, several changes in port competitiveness could be identified. That is, Shenzhen become the 2nd in the ranking, and Busan and Shanghai fell back one step each, becoming the 3rd and the 4th respectively.

Figure 8.17 Changes of port competitiveness ranking by Scenario 6



Together with Scenario 4, this projection also has a high possibility of becoming a reality. Considering the rapid development in mainland Chinese container ports, the degree of likelihood for this assumption is quite high. Furthermore, Shenzhen is closely located in the vicinity of Hong Kong and has low rates of logistics cost compared to Hong Kong. If Shenzhen successfully overcomes its weakest point, i.e. port service, it will obtain more competitive power.

Figure 8.18 Comparison results with FI and Scenario 6



8.2.7 Scenarios 7 and 8

In Scenarios 7 and 8, the main interests focus on the changes between Kaohsiung and the more competitive ports, i.e. Busan, Shanghai and Shenzhen. The influential factors for Kaohsiung were earlier identified as 'port service' and 'connectivity'. In Scenario 7, Kaohsiung's influential factor was increased three times over the GDP rate (12%) while in Scenario 8 it has increased five times over it (20%). The following results could be drawn out by using Scenario 7.

Table 8.10 Calculation procedures from Scenario 7

Ports	Evaluation criteria	Fuzzy evaluation						
Busan	Factors	x_5	x_6	x_3	x_7	x_4	x_1	x_2
	h(·) values	0.99369	0.89706	0.89444	0.89065	0.84728	0.83680	0.73810
	g(·) values	0.15159	0.30310	0.43699	0.58717	0.72027	0.85600	1.00000
HongKong	Factors	x_1	x_3	x_4	x_6	x_7	x_2	x_5
	h(·) values	1.00000	1.00000	1.00000	1.00000	1.00000	0.92737	0.68806
	g(·) values	0.13572	0.26961	0.40272	0.55423	0.70441	0.84841	1.00000
Kaohsiung	Factors	x_5	x_4	x_3	x_1	x_7	x_2	x_6
	h(·) values	0.85623	0.85426	0.84148	0.83692	0.82857	0.77504	0.75410
	g(·) values	0.15159	0.28470	0.41858	0.55431	0.70449	0.84849	1.00000
Qingdao	Factors	x_5	x_2	x_3	x_4	x_7	x_1	x_6
	h(·) values	1.00000	0.79993	0.77885	0.74820	0.65891	0.64780	0.64684
	g(·) values	0.15159	0.29559	0.42948	0.56259	0.71277	0.84849	1.00000
Shanghai	Factors	x_2	x_5	x_6	x_7	x_3	x_4	x_1
	h(·) values	1.00000	0.97579	0.91347	0.87478	0.84698	0.81227	0.75013
	g(·) values	0.14400	0.29559	0.44710	0.59728	0.73117	0.86428	1.00000
Shnzhen	Factors	x_5	x_2	x_3	x_6	x_4	x_7	x_1
	h(·) values	0.97837	0.91932	0.85416	0.85166	0.84222	0.80726	0.77953
	g(·) values	0.15159	0.29559	0.42948	0.58099	0.71410	0.86428	1.00000
Tokyo	Factors	x_4	x_2	x_3	x_6	x_7	x_1	x_5
	h(·) values	0.79086	0.77909	0.76963	0.76770	0.72282	0.71372	0.55621
	g(·) values	0.13311	0.27711	0.41099	0.56251	0.71269	0.84841	1.00000

Figure 8.19 Changes in port competitiveness ranking by Scenario 7

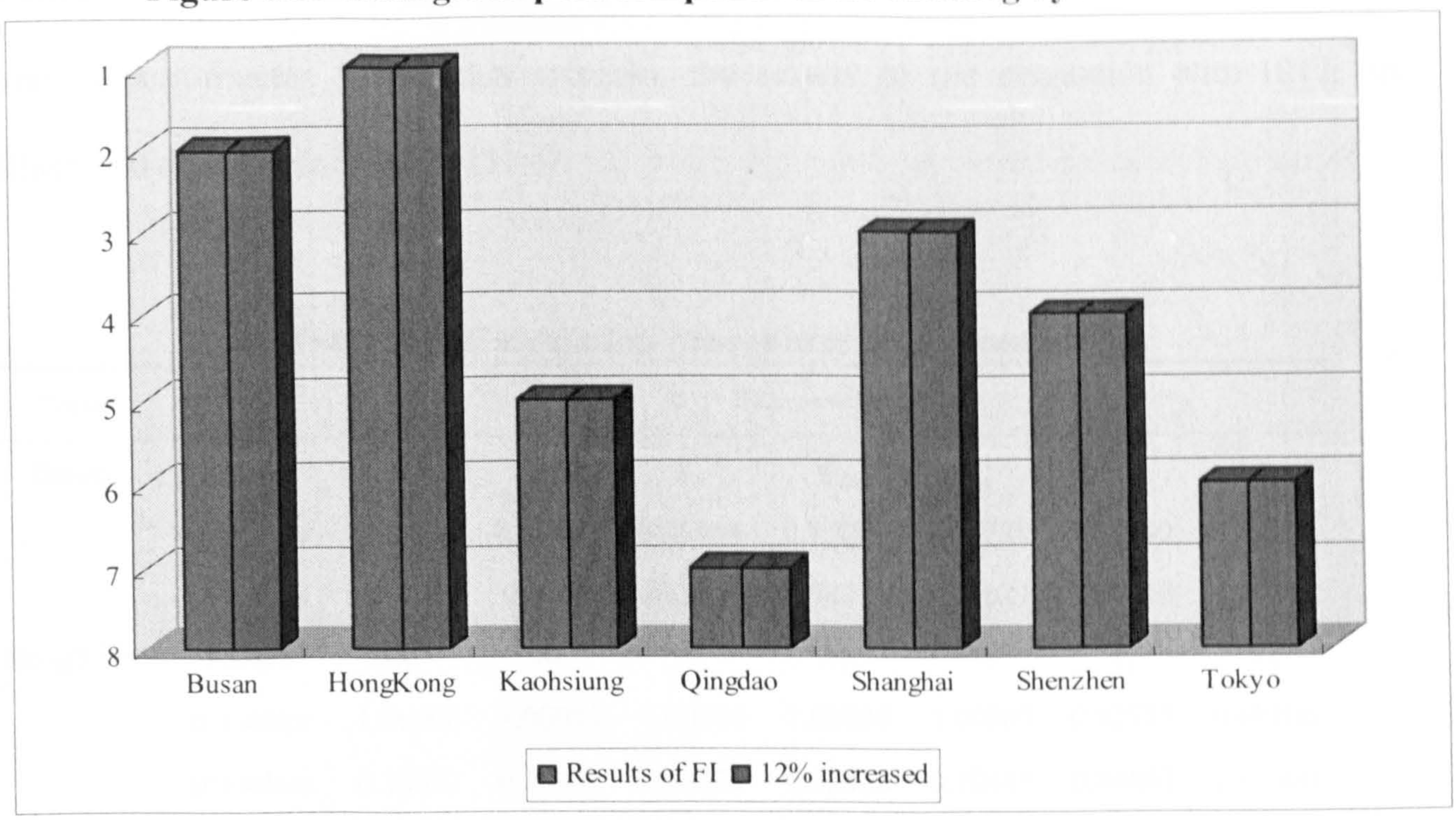
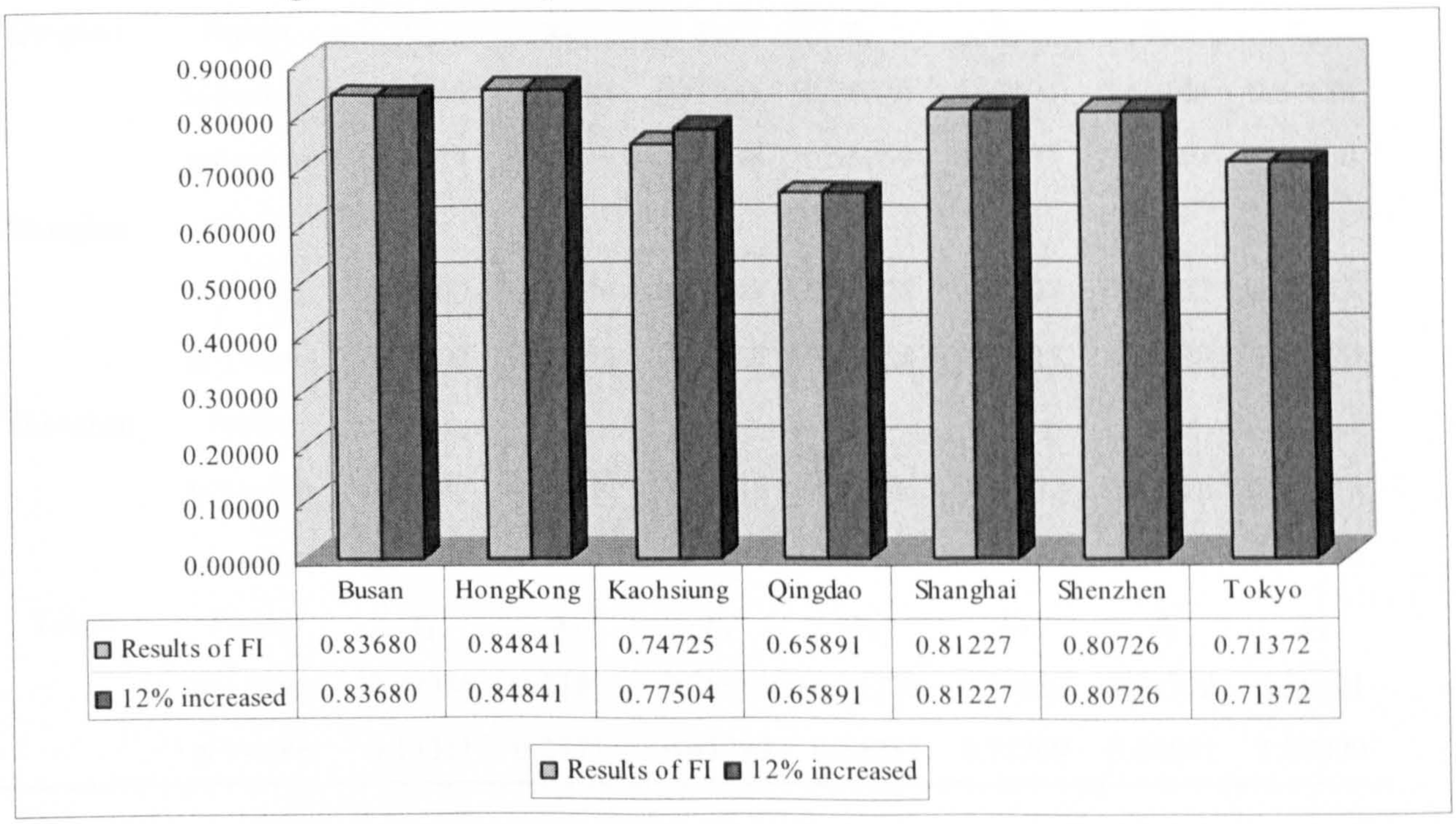


Figure 8.20 Comparison results with FI and Scenario 7



	Busan	HongKong	Kaohsiung	Qingdao	Shanghai	Shenzhen	Tokyo
Results of FI	0.83680	0.84841	0.74725	0.65891	0.81227	0.80726	0.71372
12% increased	0.83680	0.84841	0.77504	0.65891	0.81227	0.80726	0.71372

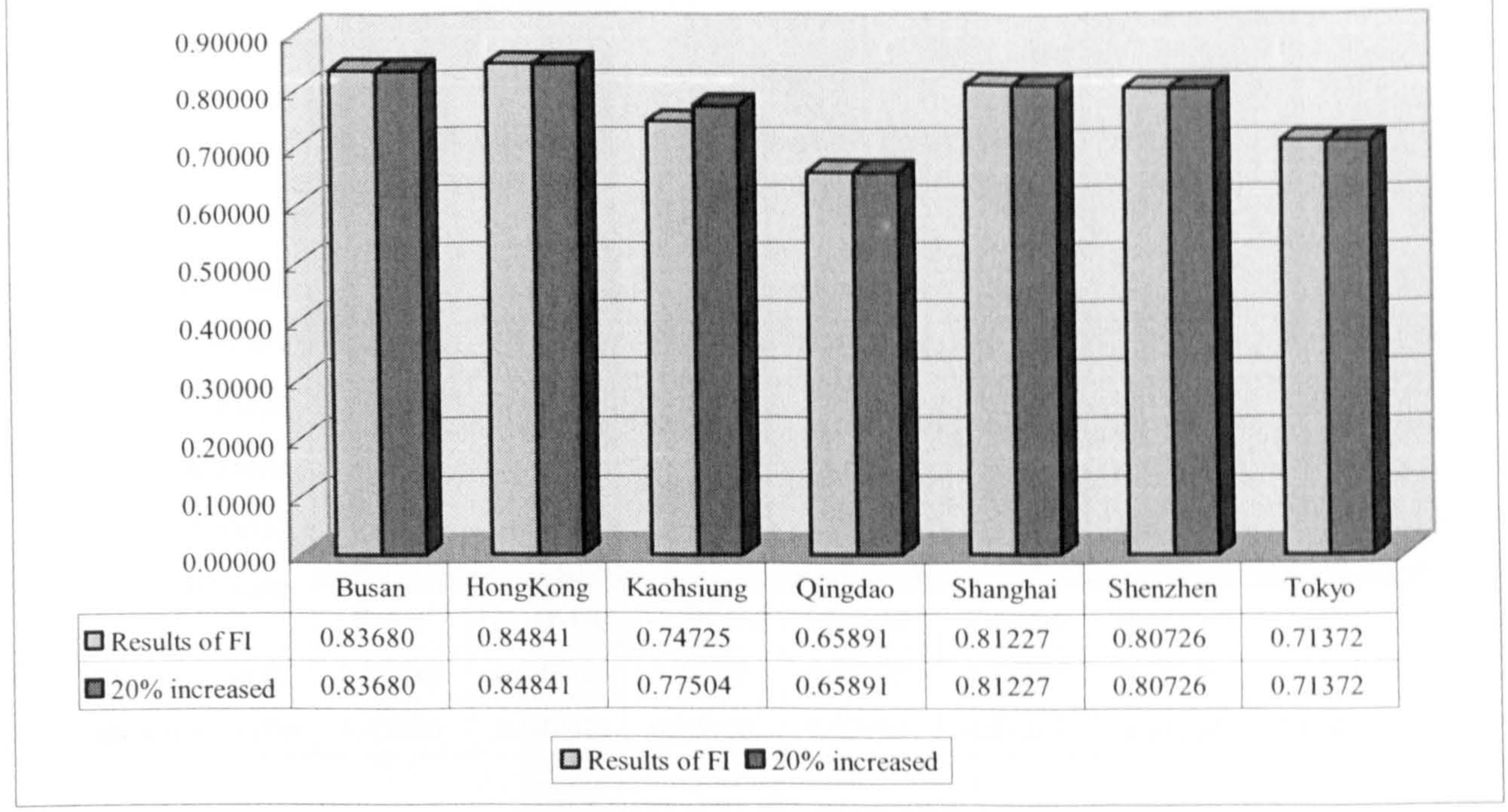
Despite the large increase rates on the influential factors, no difference could be observed with the use of fuzzy integral.

Furthermore, in Scenario 8, Kaohsiung's influential factor was increased to 20% over its current performance. Using this scenario, the results of the evaluation with IRFE are illustrated depicted in Table 8.11.

Table 8.11 Calculation procedures from Scenario 8

Ports	Evaluation criteria	Fuzzy evaluation						
Busan	Factors	x_5	x_6	x_3	x_7	x_4	x_1	x_2
	h(·) values	0.99369	0.89706	0.89444	0.89065	0.84728	0.83680	0.73810
	g(·) values	0.15159	0.3031	0.43699	0.58717	0.72027	0.85600	1.00000
HongKong	Factors	x_1	x_3	x_4	x_6	x_7	x_2	x_5
	h(·) values	1.00000	1.00000	1.00000	1.00000	1.00000	0.92737	0.68806
	g(·) values	0.13572	0.26961	0.40272	0.55423	0.70441	0.84841	1.00000
Kaohsiung	Factors	x_5	x_4	x_3	x_1	x_7	x_2	x_6
	h(·) values	0.85623	0.85426	0.84148	0.83692	0.82857	0.77504	0.75410
	g(·) values	0.15159	0.28470	0.41858	0.55431	0.70449	0.84849	1.00000
Qingdao	Factors	x_5	x_2	x_3	x_4	x_7	x_1	x_6
	h(·) values	1.00000	0.79993	0.77885	0.74820	0.65891	0.64780	0.64684
	g(·) values	0.15159	0.29559	0.42948	0.56259	0.71277	0.84849	1.00000
Shanghai	Factors	x_2	x_5	x_6	x_7	x_3	x_4	x_1
	h(·) values	1.00000	0.97579	0.91347	0.87478	0.84698	0.81227	0.75013
	g(·) values	0.14400	0.29559	0.44710	0.59728	0.73117	0.86428	1.00000
Shenzhen	Factors	x_5	x_2	x_3	x_6	x_4	x_7	x_1
	h(·) values	0.97837	0.91932	0.85416	0.85166	0.84222	0.80726	0.77953
	g(·) values	0.15159	0.29559	0.42948	0.58099	0.71410	0.86428	1.00000
Tokyo	Factors	x_4	x_2	x_3	x_6	x_7	x_1	x_5
	h(·) values	0.79086	0.77909	0.76963	0.76770	0.72282	0.71372	0.55621
	g(·) values	0.13311	0.27711	0.41099	0.56251	0.71269	0.84841	1.00000

Figure 8.21 Comparison results with FI and Scenario 8



Despite the large increase rates on the influential factors, no difference could be seen in results with the fuzzy integral. This means that, if Kaohsiung wants to overtake its nearest competitors i.e. Shanghai, Busan and Shenzhen, an increase of more than 20% compared to its current performance on two factors, 'port service' and 'connectivity', will be needed.

8.2.8 Scenario 9

Finally, in Scenario 9, the influential factors of all the targeted ports were increased according to the estimated GDP rates. In this scenario, the assumption was that every country had successfully improved the level of their ports' influential factors according to the GDP rates suggested in Table 8.3. Using this scenario, the following results could be obtained.

Figure 8.22 Comparison results with FI and Scenario 9

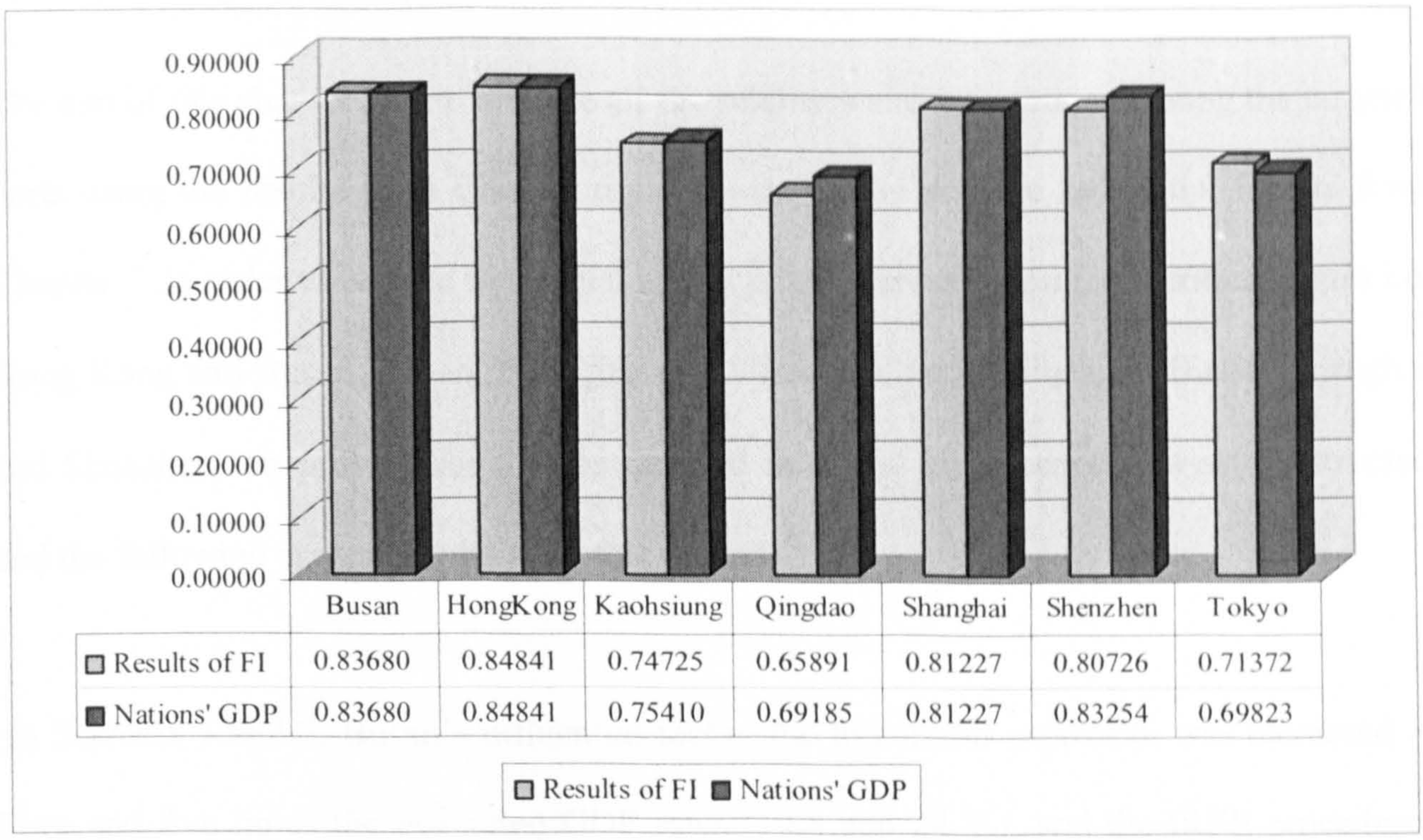
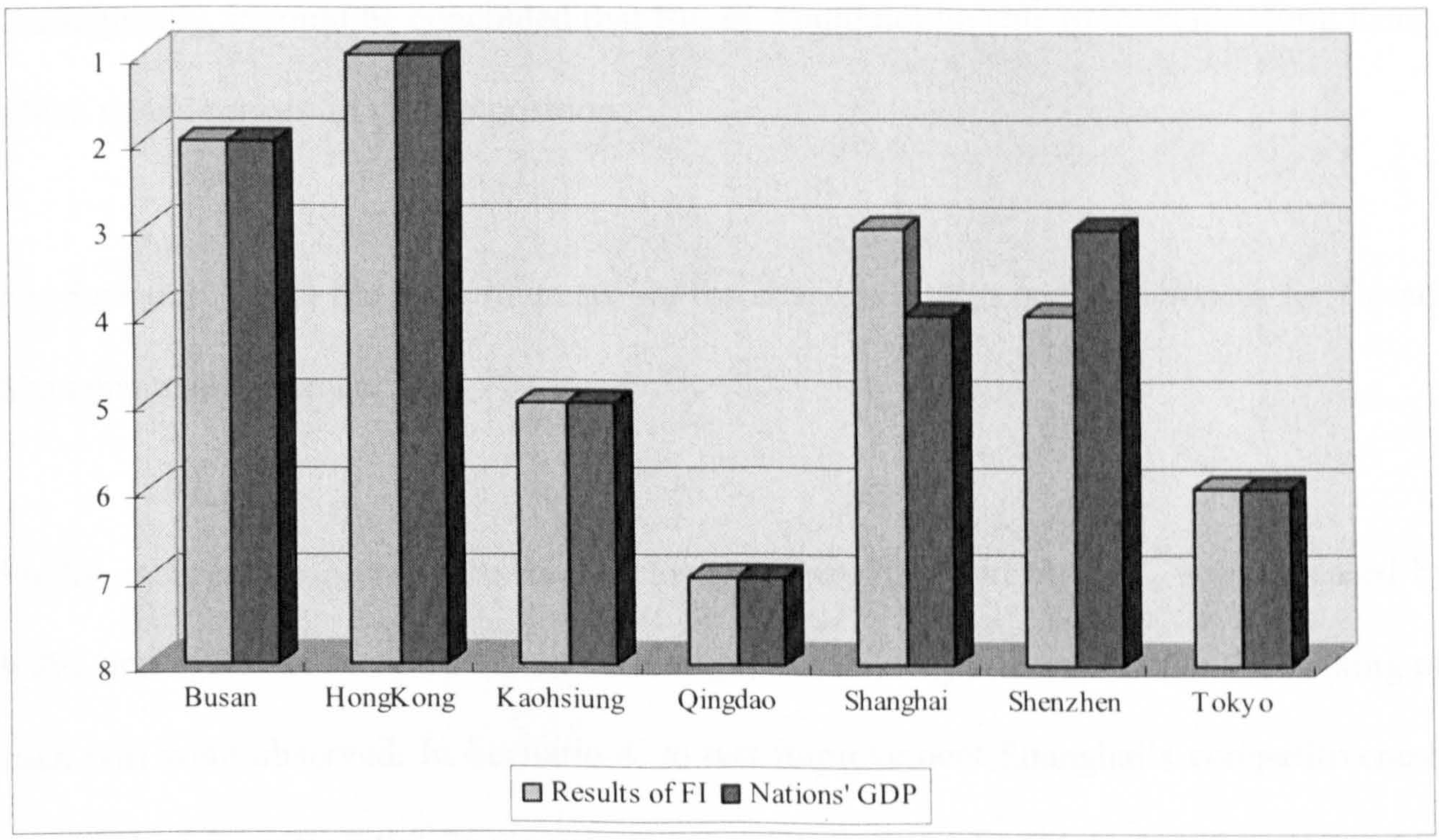


Figure 8.23 Changes in port competitiveness ranking by Scenario 9



With regard to this scenario, there were no sizeable changes in port competitiveness except for Shanghai and Shenzhen. Shanghai's ranking fell by one position while Shenzhen went up one position.

8.3 Summary and Implications

The aim of this chapter was to analyse all the relations and interactions among the targeted ports using the results from Chapter 6 as a basic model and the influential factors from Chapter 7. In order to be able to do this, the focus of interest lay on three critical issues i.e. Hong Kong and Busan; Busan, Shanghai and Shenzhen; and Kaohsiung, Busan, Shanghai and Shenzhen. To provide for a more detailed analysis, nine scenarios were constructed and the following are the results from this process.

In Scenario 1 and 2, Busan's influential factor, the hinterland condition, was increased to three and five times the estimated GDP rates (14.4 and 24 %), and the IRFE procedures were adopted. However, only a slight increase in the integral value could be detected. Consequently, it could be concluded that Busan would not be able to overtake Hong Kong, which would remain in the top position.

For Scenario 3 to 6, the main interests are the changes in port competitiveness for Busan, Shanghai and Shenzhen.

Firstly, in Scenario 3, the influential factor for Shanghai, 'port service', was increased by 6.8%, and evaluated with IRFE, but no changes in the integrated values and the ranking on each port were observed. In Scenario 4, to test improvement Shanghai's competitiveness, the level of its influential factor was increased to a level 13.6% higher than that of its present performance. According to the results, Shanghai is to overtake Busan, and rank 2nd, Busan stepping down to 3rd. This scenario has a high possibility of becoming reality due to the Chinese government having launched a large container port development project. In Scenario 5, Shenzhen's level of influential factor was increased to a level 6.8% higher than that of the level of present performance. However, the ranking of its competitiveness did

not change compared to the results of the fuzzy integral. In Scenario 6, for further analysis of Shenzhen, the increasing rate was raised higher than in Scenario 5, i.e. up to 13.6%. In this case, Shenzhen became 2nd in the ranking, and Busan and Shanghai fell back one step each, becoming 3rd and the 4th respectively. As with Scenario 4, this projection also has a high possibility of becoming reality.

In Scenarios 7 and 8, the main focus of interest lay on the changes between Kaohsiung and the more competitive ports, i.e. Busan, Shanghai and Shenzhen. In Scenario 7, Kaohsiung's influential factors, 'port service' and 'connectivity' were increased three times over the GDP rate (12%) while in Scenario 8, it has increased five times over that (20%). Despite the large increase rates on the influential factors, no difference could be observed with the use of the fuzzy integral.

Finally, in Scenario 9, the influential factors of all the targeted ports were increased according to the estimated GDP rates. Nevertheless, there were no large changes in port competitiveness.

From the above results, the Chinese ports i.e. Shanghai and Shenzhen can be estimated to overtake Busan easily. However, Busan's overtaking Hong Kong, or Kaohisung its closest competitors i.e. Busan, Shanghai and Shenzhen, is estimated to be far more difficult.

CHAPTER 9

Discussion and Conclusions

9.1 Introduction

In order to achieve the research objective and obtain a clearer understanding of container port competitiveness in NEA, the integrated fuzzy approach methodology was used. Consequently, notable results for the container port industry were obtained. In this chapter, the findings are discussed in detail and their implications suggested. Following the introduction in Section 2, thorough reviews of research findings are provided. This section consists of five aspects. The first section points out the problematic issues in assessing the competitiveness of container ports in NEA. In the second, implications regarding conceptualisation of port competitiveness are dealt with. Following this, the significance of the integrated fuzzy approach as the methodology adopted is discussed in the third part. Then, the fourth discusses the results of the port competitiveness work for the targeted container ports. Finally, in the fifth part, results from analysis of the interactions among the competing ports are provided. In Section 3, the limitation of this research and suggestions for future research will be given.

9.2 Findings arising from adoption of the methodology

This section reviews the overall findings from applying the methodology selected and is divided into five sub-sections ranging from meaningful insights gained from the literature reviews to significant results from adoption of the integrated fuzzy approach.

9.2.1 Findings on issues regarding the competitiveness of container ports in NEA

The review of the container ports in Northeast Asia (NEA) fully dealt with issues related to factors from the general business environment to more specific competitiveness. As a result of the review, the following notable facts about NEA were found:

- It was identified that among the NEA nations, China, Japan, Mongolia, North Korea, the Russian Federation, and South Korea, the representatives of major growth markets are China and South Korea. Recently, thanks to their geographical advantage of being close to the main sea trunk routes, they have shown aspirations of becoming global or regional transport and logistics hubs, which have resulted in severe port competition.
- It was noted that, as a consequence of China's booming economy and the increased import and export container cargo volumes in the area, four of the top five and 20 of the top 30 container ports were located in NEA and Asia in 2003 respectively (Hoffmann, 2004; UNCTAD, 2004). This means that the NEA region has a central position in liner shipping and the handling of container cargo volumes.
- More interestingly, it was noted that among the most important 35 maritime countries ranked according to deadweight tonnage, the NEA countries' total share of world ship deadweight total is presently 33.51% (UNCTAD, 2005). With respect to the nations' total share of world trade, the NEA countries occupied 20.6% and by means of rankings according to major trading nations and the world leading container terminal operators, NEA can be seen as being in the leading position in world production and shipping.
- Due to these astonishing figures, port competition and competitiveness in NEA have become hot issues.

However, it was found that only a few limited studies have been carried out on this theme in this region while abundant studies have been conducted in the regions of Europe and USA. Moreover, no exact definition of port competition and competitiveness for ports located in NEA could be found. In particular, the evaluation of port competitiveness for this region has not been addressed much, due to the operational secrets of competing ports. For all these reasons, the evaluation of port competitiveness in NEA has been regarded as a problematic and urgent issue to be tackled.

9.2.2 Suggested conceptualisation of port competitiveness

From the results of the review of port competitiveness, it was concluded that it consisted of six categories i.e. port competition, port efficiency, port performance, port selection, port service and other related issues. After thorough reviews for these categories carried out according to the research objective, 38 factors were found.

However, with regard to the choice of key factors from those suggested, it was considered that the factors still overlapped slightly and unimportant factors for the research region remained. After the employment of scientific methods i.e. factor analysis (FA), seven principal factors emerged: port service, hinterland condition, availability, convenience, logistics cost, regional centre and connectivity, and a taxonomy for evaluating the structure of port competition in this region.

To solve the problems connected with port competitiveness, it was found that there are two phases of problem sets. Firstly, the evaluation of port competitiveness can give meaningful information to every stakeholder. However, when the evaluation is dependent on confidentiality and corporate business secrets, obtaining secondary data becomes impossible.

In addition to the above mentioned obstacles, further difficulties were found to exist in measuring uncertainty and ambiguity in evaluation and knowledge quantification of experts' opinions, which consist of subjective and qualitative dimensions (Chen *et al.*, in press). To deal with such problems, natural language, which can express the experts' thinking and preference, and/or semantic words, should be employed within the fuzzy evaluation methodologies (Lirn *et al.*, 2003; Chiou *et al.*, 2005).

To summarize the above issues, it can be concluded that quantitative methodologies have certain limitations in solving dynamic and complicated problems such as the evaluation of port competitiveness. The fuzzy evaluation method is regarded as a particularly suitable methodology for dealing with data which has characteristics of uncertainty, ambiguity, non-observability and scarcity. The other difficulties observed in the research, i.e. extracting influential factors and formulating meaningful strategies, can also be solved within the boundaries of fuzzy evaluation. After the inclusion of all the above issues, a conceptual model, which clearly defines the problem and suggests the solution procedures, was developed.

9.2.3 An integrated fuzzy approach as a methodology

The evaluation of port competitiveness was identified as a complicated problem, where a number of alternatives and actions or stakeholders need to be chosen based on a given set of criteria and hierarchies (Aouam T. et al., 2003), and, therefore, it becomes a problem of complex multiple-attributes and multiple-hierarchies (CMAMH).

In addition, it was also found that the evaluation of port competitiveness had difficulties concerning certain characteristics of evaluation such as complexity, uncertainty and ambiguity. After a review of the fuzzy evaluation, it was concluded that it could be an optimal method to solve such problems as CMAMH with ill-defined, ambiguous, vague or

uncertain characteristics. Consequently, in this research, it has been decided to employ integrated fuzzy evaluation (IFE) as an all-encompassing methodology.

The adoption of IFE was divided into three parts: data input, calculation and results output. As for the first, the following detailed data collection method was chosen:

- Importance weights of port competitiveness factors, $w(\cdot)$, $w(\cdot)$ indicating the relative importance of each of the principal factors. However, to obtain the weight values of port competitiveness factors involved multiple decision makers, including shipping companies, freight forwarders, logistics companies, academics and researchers. This typical multiple decision making group (MDMG) problem is known to cause bias in evaluation (Lim, 2000). To compensate for this, the evaluation required that judgment values are weighted to unify rationally the heterogeneous preferences of each group. To solve such complicated problems, the procedures of introducing uncertainty, Dempster-Shafer (DS) theory and the levelling process were used.

- Degree of overlap among port competitiveness factors, λ . The evaluation factors always included a certain amount of overlap (λ). This becomes a non-additive problem and is different from traditional additive problems (Chiou, 2005). This phenomenon needed to be adjusted to avoid bias. Thus, this research introduced the concept of 'overlapping degrees' between factors.

- Scoring rating for factors for each targeted port, $h(\cdot)$. Due to difficulties experienced with quantifying and measuring factors, the existing studies had used proxies or representative attributes that were easy to use to collect quantitative data. However, there has been increasing debate on the definition of input factors and

finding quantitative proxies. To solve this problem, the fuzzy number concept was introduced.

The second part, calculation, describes the adaptation procedure of the fuzzy integral process with direct relation (MDMG-HFP) and inverse relation of the existing fuzzy integral, IRFE. The final part, output, had the function of showing rankings for port competitiveness and suggested strategies for improvement of port competitiveness.

In conclusion, the IFE was suggested as a methodology to overcome the limitations of the existing methods and as able to expand the body of knowledge regarding the evaluation procedure.

9.2.4 Evaluating port competitiveness in NEA

Due to the difficulties in solving the problems with the evaluation of container port competitiveness, a very limited amount of research has been conducted in NEA, as mentioned in Section 9.2.1. To overcome the obstacles to this research, a new conceptual model and research methodology were suggested. Using these, rankings for the targeted ports were obtained. In this section, a brief review of the procedures of the adaptation and the results obtained is given.

To obtain port rankings, the process of fuzzy integration was needed. As mentioned in Section 9.2.3, fuzzy integration uses the fuzzy evaluation value $h(\cdot)$ and the fuzzy measure value $g(\cdot)$. Furthermore, the calculation of fuzzy measure $g(\cdot)$ uses the overlap degree λ, as suggested in Section 6.2.2, and weight value $w(\cdot)$, introduced in Section 5.3.2. To draw out the above input data, a total of 300 questionnaires, translated into English, Korean and Chinese, were posted to each expert between October 2005 and January 2006, using an on-

line questionnaire format on the Internet, and the valid response rates stood at 14.3%. The targeted ports for the evaluation were Hong Kong (1st), Busan (3rd), Shanghai (4th), Kaohsuing (5 th), Shenzhen (6 th), Qindao (16th) and Tokyo (20th), which are located in NEA and ranked within the top 20 in terms of their container handling throughputs.

Regarding the outputs of the questionnaire, firstly, $h(\cdot)$, which indicates the scoring for each port on each factor, was successfully analyzed as follows:

- The port service score obtained for Hong Kong was the highest of all (1.00000), followed by Busan (0.83680) and Shenzhen (0.77953).

- Regarding the hinterland condition, very interestingly, Busan (0.73810) had the lowest score while Shanghai (1.00000) had the highest.

- In terms of the availability factor, Hong Kong occupied the top position. In addition, with regard to the convenience factor, Hong Kong had the highest value followed by Kaohsiung, Busan and Shenzhen, which had similar scores to each other.

- In the light of the logistics cost, except for Hong Kong, the Chinese ports (Qingdao, Shanghai and Shenzhen) and Busan had a high ranking.

Regarding the overlap degree λ, the final mean was computed at -0.08715, which means that the evaluation factors were overlapping by 8.715%.

With the use of the above data for the input variables and the calculation process suggested in Chapter 5, the integral values and port rankings were identified. The following are the summary of the results:

- Hong Kong (0.84841), which had the top position for five other factors i.e. port service, availability, convenience, regional centre and connectivity, could be regarded as the most competitive port. However, the logistics cost for Hong Kong showed the lowest score when compared with the other ports.
- The port of Busan (0.83680) emerged as the second most competitive port. In contrast to Hong Kong, Busan has attained attractive port tariffs while having good conditions for the other factors. However, the hinterland condition for Busan lags behind compared to its competitors in Northeast Asia.
- The next most competitive ports were the newly emerged Chinese ports Shanghai (0.81227), and Shenzhen (0.80726). They showed good performance in terms of hinterland condition, logistics cost and availability while their weak point was port service. However, recently, they have been focusing on enhancing their service and convenience, and their potential to overtake Busan is regarded as a high possibility.
- The ports located in the group with lower competitive power are Tokyo (0.71372) and Qingdao (0.65891). However, of the two, Qingdao has more potential to proceed into the higher group due to the development strategies adopted by the Chinese government to cover the port's weaknesses i.e. port service, connectivity and regional centre.

9.2.5 Analysing the interactions among the targeted ports

The rankings on competitiveness for container ports were obtained by means of the factors selected. However, the evaluation algorithm, the fuzzy evaluation, is a methodology that

only calculates ranking of ports by their level of competitiveness and, therefore, critical weak points and/or influential factors affecting current port competitiveness cannot be extracted fully.

With this in mind, IRFE was adopted to identify the influential factors, which were then used for the scenario analysis. In order to find critical weak points, $\underline{\alpha}$ and $\underline{\beta}$ operations were used. As a result, in the case of Busan, the most influential factor was hinterland condition while for Hong Kong and Tokyo it was logistics cost (x_5). For Shanghai and Shenzhen, port service (x_1) was identified as the influential factor while Kaohsiung's was connectivity (x_7). Finally, the newly emerging port, Qingdao, had two influential factors i.e. port service (x_1) and regional centre(x_6).

Using these influential factors for each port and the three critical issues which emerged in Chapter 6, nine scenarios were constructed, run and analysed in the Chapter 8, and the following were the results from this process.

- First, regarding Issue 1 (Can Busan take over Hong Kong's number one ranking?), Scenarios 1 and 2 were analyzed. In these, Busan's influential factor, the hinterland condition, was increased first to three and then five times the estimated GDP rates (14.4 and 24 %), and the IRFE procedures were adopted. However, it could be concluded that Busan would not be able to overtake Hong Kong.
- Second, with respect to Issue 2 (What if the influential factor values were increased in Busan, Shanghai and Shenzhen, ranked 2nd, 3rd and 4th respectively?), Scenarios 3 to 6 were suggested. In Scenario 3, Shanghai's influential factor, 'port service', was increased by 6.8%, and evaluated with IRFE, but no changes in the integrated values and the ranking on each port were observed. In Scenario 4, to

test the improvement of Shanghai's competitiveness, the level of its influential factor was increased to a level of 13.6% higher than that of its present performance. According to the results, Shanghai is to overtake Busan, and rank 2nd, Busan stepping down to 3rd. In Scenario 5, the level of Shenzhen's influential factor was increased to a level 6.8% higher than that of its present performance. However, the ranking of its competitiveness did not change compared to the results from the fuzzy integral. In Scenario 6, for further analysis of Shenzhen, the increasing rate was raised higher than in Scenario 5, i.e. up to 13.6%. In this case, Shenzhen became 2nd in the ranking, and Busan and Shanghai fell back one step each, becoming 3rd and the 4th respectively.

- Third, about Issue 3 (Can Kaohsiung overtake Busan, Shanghai and Shenzhen?), Scenarios 7 and 8 were used. In Scenario 7, Kaohsiung's influential factors, 'port service' and 'connectivity' were increased three times over the GDP rate (to 12%) while in Scenario 8, it was increased five times over that (20%). Despite the large increase rates on the influential factors, no difference could be observed with the use of the fuzzy integral.
- Fourth, in Scenario 9, the influential factors of all the targeted ports were increased according to the estimated GDP rates. Nevertheless, there were no large changes in port competitiveness.
- Finally, to summarize the above results, it was found that the Chinese ports i.e. Shanghai and Shenzhen can be expected to overtake Busan easily. However, Busan overtaking Hong Kong, or Kaohisung its closest competitors i.e. Busan, Shanghai and Shenzhen, is estimated to be far more difficult.

9.3 Implications of This Research for Theory and Practice

Certain contributions of this research to the theory and practice for container ports have emerged and are clearly identifiable. With regard to theory, this research has contributed to theoretical development significantly in the following areas:

- The factors and taxonomy of port competitiveness for container ports in NEA have been provided for the first time.
- This is the first integrated approach for container ports in NEA, which is the most competitive area in the world. To solve the problems connected with the ranking of port competitiveness, the extracted evaluation structure, the complex multiple-attributes and multiple-hierarchies (CMAMH) concept and fuzzy evaluation method were introduced. Therefore, it can be suggested that, by using this approach, port ranking in terms of competitiveness can be conducted successfully.
- In the procedure utilized in the above approach, to solve the problem with importance weights of port competitiveness factors, the technique for multiple decision making group (MDMG) problems was introduced for the first time in this area of evaluation. Furthermore, this research was the first to introduce the fuzzy number concept for the scoring of ratings for the factors on each targeted port.
- In addition, this research was also the first to attempt extracting the critical weak points and/or influential factors affecting current port competitiveness. As a result, the influential factors for the each targeted port were clearly identified.
- Finally, by using the influential factors and critical issues extracted from the targeted ports, nine scenarios were constructed. With the adoption of IRFE, the interactive relationship between the competing container ports was found for the first time in the area of evaluation of container port competitiveness.

In terms of practice, this research has provided the following important contributions.

- The ports with the most severe competition and within the world's top 20 container port in terms of container throughputs in NEA, Hong Kong (1^{st}), Busan (3^{rd}), Shanghai (4^{th}), Kaohsuing (5^{th}), Shenzhen (6^{th}), Qindao (16^{th}) and Tokyo (20^{th}), were selected and analyzed. The results of this analysis can provide useful information for stakeholders who have keen interest in the targeted ports.
- This research has suggested the detailed factors and structure of container port competitiveness for NEA, which can be utilised by every stakeholder and can also give them useful insights to establish their strategies.
- The most recent port ranking in respect of port competitiveness has been suggested, which can provide guidelines to stakeholders choosing the container port.
- The influential factors that is the critical weak points for each targeted ports were clearly identified. These results can be used as policy pointer to each nations' government in the targeted area.
- Moreover, the changes in competitiveness power, which is dynamically and interactively affected by the relationship between the ports, has been successfully estimated and suggested. Thus, changes in competitiveness in NEA can be easily forecasted by port actors.

9.4 Limitations and Suggestions for Future Research

- The evaluation of port competitiveness in this research focused on the functions of container terminals of each targeted port. However, the targeted major ports have also strong points in terms of facilities for break-bulk, which have not been considered. Therefore, in future research, more synthesized evaluation combining the functions for container and bulk terminals should perhaps be considered.

- Regarding the research scope, this research only dealt with container ports located in NEA. However, container ports in Southeast Asia, especially Singapore and some other major ports, compete with those in NEA directly and/or indirectly. Therefore, more broadly, an expanded research design will be needed.
- On the other hand, more detailed evaluation will be needed regarding the competition between container terminals located within the same port. Recently, several global terminal operators (GTO) have been competing with each other within the same port. Thus, an analysis of this phenomenon could be recommended for future research.
- The integrated fuzzy approach suggested in this research can also be adapted to logistics related industries, e.g., the evaluation of competition between air ports, and that of transport mode and distribution centre selection and competition. In this respect, further studies will be needed.

APPENDICES

APPENDIX A

Questionnaire for Weighting the Degree of overlap (for English Respondents)

Gi-Tae Yeo

Researcher
International Shipping and Logistics Group
University of Plymouth
Drake Circus, Plymouth PL4 8AA
E-mail : gi-tae.yeo@plymouth.ac.uk
Tel : ++ 44 (0)1752 232412
Fax : ++ 44 (0) 1752 232249

Dear.....

We are researching port competition in Northeast Asia. Please, could you spare a few moments to complete and return the enclosed questionnaire.

You have been selected as an expert whose opinions would be very valuable in this research. Your responses are strictly confidential.

If you require any further information, please, contact us at the above address. May we thank you in advance for returning your response promptly.

Yours sincerely,

Questionnaire for scoring the degree of overlap

Introduction for Section I

The evaluation consisted of port competition, its structure, the criteria for it and the evaluators. When we think about the 'evaluation of port competition', it also implies several criteria within the evaluation structure. In order to understand port competition in Northern Asia, the following factors and structure have already been extracted recently, as explained in section I.

Introduction for Section II

When a large system or objects are evaluated, the evaluation structure uses several hierarchies, and each hierarchy has several criteria. Moreover, there is overlap between the criteria. To evaluate precisely requires a coefficient, the so-called, degree of overlap. Please read these two sections carefully so as to be able to provide a score for the degree of overlap between factors.

Section I The Explanation of Port Competitiveness Factors and the Structure.

Based on literature related to port selection and competition, a regional survey employing factor analysis revealed that *port service, hinterland condition, availability, convenience, logistics cost, regional centre and connectivity* are the determining factors in the Northeast Asia region.

A more detailed definition for each factor is given in the following.

Port Service As the overall quality of service provided to users in a port area increases, so does the port's competitiveness. Port service includes "prompt response", "24 hours a day, seven days a week service" and "zero waiting time service". The port service factor accounts for 13.6% of total variance and confirms that "24 hours a day, seven days a week service" is the most important dimension of service attribute perceived by respondents.

Hinterland Condition As the condition of the hinterland increases, so does a port's competitiveness. Hinterland condition includes "professionals and skilled labour in port operations", "size and activity of Free Trade Zone (FTZ) in port hinterland" and "volume of total container cargos". The latter is the most important attribute. This implies that Busan and Shanghai have huge hinterlands encompassing the Korean peninsula and Chinese mainland respectively. For more efficient treatment of increased cargoes, port operators concentrate on port productivity and investments. This phenomenon acts to increase port competitiveness.

Availability This includes "availability of a vessel berth on arrival in port" and "port congestion". The former element is most highly correlated with this factor. Korean and Chinese ports experience heavy port traffic, and for just in time delivery, availability of berths is a vital attribute for port users.

Convenience This component includes "water depth in approach channels and at berth", "sophistication of port information and its application" and "the stability of port labour".

Logistics Cost The lower the cost, the greater the competitiveness. Logistics costs include "inland transportation cost", "costs related to vessels and cargoes entering port" and "free dwell time on the terminal".

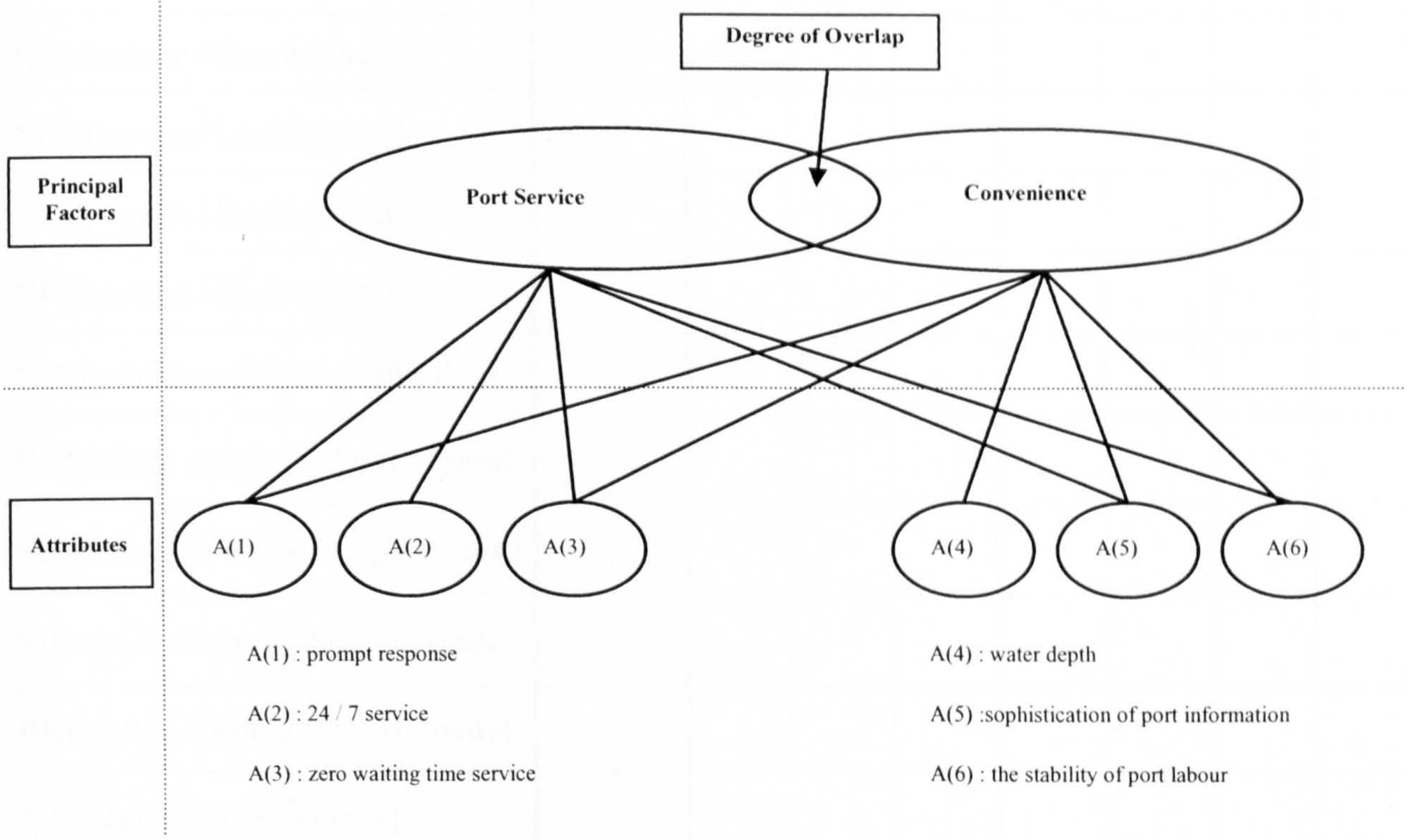
Regional Centre Having a good location is deemed to render a port more competitive. The concept of a regional centre includes geographical aspects such as "deviation from main trunk routes" and "port accessibility".

Connectivity The greater the connectivity, the higher the competitiveness. Connectivity includes both "land distance and connectivity to major shippers" and "an efficient inland transport network".

Section II Explanation of the degree of overlap.

When we look at the above section, the factors are ideally divided into seven principal factor groups. This means that all the factors are independent of each other. However, in reality, this assumption is impossible. Many factors and criteria overlaps. For example, 'port service' and 'convenience' overlap to a certain extent. This phenomenon needs to be adjusted.

[Overlapping concept between factors]



In the following, there is a sample of how to provide your answer. If you think that overlap exists between 'port service' and 'convenience' and its degree is considered as 'medium low', you should tick as shown in the first answer low. And if you think that overlap doesn't exist between 'port service' and 'availability', you should tick only 'yes/no overlap column' in the second answer low.

Example (Between 'Port service' and 'Convenience')

Questions : pair-wise comparison	Overlap exist /not exist		The extent of overlaps:						
Is there overlap between *[/]?	No	Yes	very low	low	medium low	medium	medium high	high	very high
*[Port service / Convenience]		V			V				
*[Port service / Availability]	V								

Section III Scoring the degree of overlap

Please consider each of the following questions and tick the appropriate box.

Questions : pair-wise comparison	Overlap exist /not exist		The extent of overlaps:						
Is there overlap between *[/] ?	No	Yes	very low	low	medium low	medium	medium high	high	very high
*[Port service / Hinterland condition]									
*[Port service / Availability]									
*[Port service / Convenience]									
*[Port service / Logistics cost]									
*[Port service / Regional centre]									
*[Port service / Connectivity]									
*[Hinterland condition / Availability]									
*[Hinterland condition / Convenience]									
*[Hinterland condition / Logistics cost]									
*[Hinterland condition / Regional centre]									
*[Hinterland condition / Connectivity]									
*[Availability / Convenience]									
*[Availability / Logistics cost]									
*[Availability / Regional centre]									
*[Availability / Connectivity]									
*[Convenience / Logistics cost]									
*[Convenience / Regional centre]									
*[Convenience / Connectivity]									
*[Logistics cost / Regional centre]									
*[Logistics cost / Connectivity]									
*[Regional centre / Connectivity]									

APPENDIX B

Questionnaire for Scoring Port Performance
(for English Respondents)

Section I Details of Respondents

Some information about you and your organisation.

1. What is the name of your organisation?
( )

2. Which category does your organisation fall in?
Shipping company( ) Forwarder ( ) Terminal operator ( )
Port authority( ) Researcher/Academic( ) Shipper( )

3. How many years have you been in business?
more than 20 ( )
between 16 and 20 years ( )
between 11 and 15 years ( )
between 5 and 10 years ( )
less than 5 years ( )

4. What is your occupational status?
Senior level ( )
Middle level ( )
Junior level ( )

5. Please, answer the following questions if they are related to your organisation's business area?

5-1. What is average ship size usually used by your company?
over than 5000 TEU ( )
between 3000 and 5000 TEU ( )
between 1000 and 3000 TEU ( )
between 500 and 1000 TEU ( )
under 500 TEU ( )

5-2. Please indicate the total volume of traffic created by your company annually in terms of TEU.
Export products : (TEU)
Import products : (TEU)

5-3. Please describe which types of product your company is exporting or importing.
Export products ( )
Import products ( )

5-4. Which sea routes does your company usually use(tick more than one if so required)
Europe ( )
America ( )
Korea/China ( )
South east Asia ( )
Other ( )

5-5. How many employees are there in?

Over 1000 ( )
between 501 and 1000 ( )
between 100 and 500 ( )
under 100 ( )

5-6. What is your company' annual sales(US$/ billion)?

Over 5.0 ( )
between 1.0 and 5.0 ( )
between 0.1 and 1.0 ( )
under 0.1 billion ( )

Section II The Explanation of Port Competitiveness Factors and the Structure.

Based on literature related to port selection and competition, a regional survey employing factor analysis revealed that *port service, hinterland condition, availability, convenience, logistics cost, regional centre and connectivity* are the determining factors in the Northeast Asia region.

A more detailed definition for each factor is given in the following.

Port Service As the overall quality of service provided to users in a port area increases, so does the port's competitiveness. Port service includes "prompt response", "24 hours a day, seven days a week service" and "zero waiting time service". The port service factor accounts for 13.6% of total variance and confirms that "24 hours a day, seven days a week service" is the most important dimension of service attribute perceived by respondents.

Hinterland Condition As the condition of the hinterland increases, so does a port's competitiveness. Hinterland condition includes "professionals and skilled labour in port operations", "size and activity of Free Trade Zone (FTZ) in port hinterland" and "volume of total container cargos". The latter is the most important attribute. This implies that Busan and Shanghai have huge hinterlands encompassing the Korean peninsula and Chinese mainland respectively. For more efficient treatment of increased cargoes, port operators concentrate on port productivity and investments. This phenomenon acts to increase port competitiveness.

Availability This includes "availability of a vessel berth on arrival in port" and "port congestion". The former element is most highly correlated with this factor. Korean and Chinese ports experience heavy port traffic, and for just in time delivery, availability of berths is a vital attribute for port users.

Convenience This component includes "water depth in approach channels and at berth", "sophistication of port information and its application" and "the stability of port labour".

Logistics Cost The lower the cost, the greater the competitiveness. Logistics costs include "inland transportation cost", "costs related to vessels and cargoes entering port" and "free dwell time on the terminal".

Regional Centre Having a good location is deemed to render a port more competitive. The concept of a regional centre includes geographical aspects such as "deviation from main trunk routes" and "port accessibility".

Connectivity The greater the connectivity, the higher the competitiveness. Connectivity includes both "land distance and connectivity to major shippers" and "an efficient inland transport network".

Instructions for Section II

After careful reading about above explanations, please provide your opinion about the following questions. For your information, in each answer, linguistic expressions were introduced. This can help you can easily check answers. Your linguistic data will be converted to natural numbers using fuzzy technique. Please go to the section II, and tick one box on each row.

Section II Scoring for Port Performance

Background and Instruction

This section aims to find out your thoughts on the performance of each port. Expert opinions are needed for the seven principal factors: *availability, connectivity, convenience, hinterland condition, logistics cost, port service and regional centre.*

Please express your opinions using the scale: very poor, poor, medium poor, fair, medium good, good and very good, and tick the corresponding boxes.

1. Asking for opinions about 'availability' factor.

Container ports in Northeast Asia	What are your thoughts regarding the performance of each port with respect to **availability**? (tick one box on each row)						
	very poor	poor	medium poor	fair	medium good	good	very good
Busan							
Hong Kong							
Kaohsiung							
Qingdao							
Shanghai							
Shenzen							
Tokyo							

2. Asking for opinions about 'connectivity' factor.

Container ports in Northeast Asia	What are your thoughts regarding the performance of each port with respect to **connectivity**? (tick one box on each row)						
	very poor	poor	medium poor	fair	medium good	good	very good
Busan							
Hong Kong							
Kaohsiung							
Qingdao							
Shanghai							
Shenzhen							
Tokyo							

3. Asking for opinions about 'convenience' factor.

Container ports in Northeast Asia	What are your thoughts regarding the performance of each port with respect to **convenience**? (tick one box on each row)						
	very poor	poor	medium poor	fair	medium good	good	very good
Busan							
Hong Kong							
Kaohsiung							
Qingdao							
Shanghai							
Shenzhen							
Tokyo							

4. Asking for opinions about 'hinterland condition' factor.

Container ports in Northeast Asia	What are your thoughts regarding the performance of each port with respect to **hinterland condition**? (tick one box on each row)						
	very poor	poor	medium poor	fair	medium good	good	very good
Busan							
Hong Kong							
Kaohsiung							
Qingdao							
Shanghai							
Shenzhen							
Tokyo							

5. Asking for opinions about 'logistics cost' factor.

Container ports in Northeast Asia	What are your thoughts regarding the performance of each port with respect to **logistics cost**? (tick one box on each row)						
	very poor	poor	medium poor	fair	medium good	good	very good
Busan							
Hong Kong							
Kaohsiung							
Qingdao							
Shanghai							
Shenzhen							
Tokyo							

6. Asking for opinions about 'port service' factor.

Container ports in Northeast Asia	What are your thoughts regarding the performance of each port with respect to **port service**? (tick one box on each row)						
	very poor	poor	medium poor	fair	medium good	good	very good
Busan							
Hong Kong							
Kaohsiung							
Qingdao							
Shanghai							
Shenzhen							
Tokyo							

7. Asking for opinions about 'regional centre' factor.

Container ports in Northeast Asia	What are your thoughts regarding the performance of each port with respect to **regional centre**? (tick one box on each row)						
	very poor	poor	medium poor	fair	medium good	good	very good
Busan							
Hong Kong							
Kaohsiung							
Qingdao							
Shanghai							
Shenzhen							
Tokyo							

Thank you for your kind co-operation. Should you wish to make any additional comments on this questionnaire, please, write them in the box below.

If you would like to receive a summary of the survey results, please, provide your details below.

Name .....
Position in company .....
E-mail .....
Address .....
.....
.....
.....

Thank you very much again for your kind co-operation.

APPENDIX C

Questionnaire for Weighting the Degree of Overlap (for Korean Respondents)

International Shipping and Logistics Group
University of Plymouth
Drake Circus, Plymouth PL4 8AA
United Kingdom

설 문 서

안녕하십니까?

· 귀 기관의 무궁한 발전을 기원합니다.

바쁘신 가운데 질문을 드리게 되어 대단히 죄송합니다.

본 설문서는 동북아시아 항만의 경쟁력을 평가하기 위하여 작성되었습니다. 설문의 내용은 <경쟁력요소>간 상호중복도(Degree of Overlap)를 여쭙는 형태로 구성되어 있습니다.

본 연구를 통하여 동북아시아 항만간의 경쟁에 관하여 의미 있는 결과를 제시할 수 있을 것으로 판단되며, 이를 위하여 귀하의 전문가적 판단이 절실함을 말씀드립니다.

본 설문의 응답은 연구 목적으로만 사용할 것이며, 외부에 절대 제공하지 않을 것입니다.
또한 자료처리 과정에서 귀 기관의 명칭은 익명으로 사용됨으로 추후 이에 따른 불이익은 절대 없을 것임을 밝혀둡니다.

감사합니다.

2005. 10.
여 기 태 드림.

Gi-Tae Yeo
International Shipping and Logistics Group
University of Plymouth
Drake Circus, Plymouth PL4 8AA
E-mail : gi-tae.yeo@plymouth.ac.uk
Tel : ++ 44 (0)1752 232412
Fax : ++ 44 (0) 1752 232249

1. 본 연구에서 정의한 항만경쟁력 평가모델의 구성요인 및 구조에 관한 설명입니다.

(본 연구팀이 정의한 항만간 경쟁력평가 모델의 속성에 대한 해설입니다.
아래 나열한 속성들을 충분히 숙지하신 후, 다음 설문에 답해주시면 감사하겠습니다.)

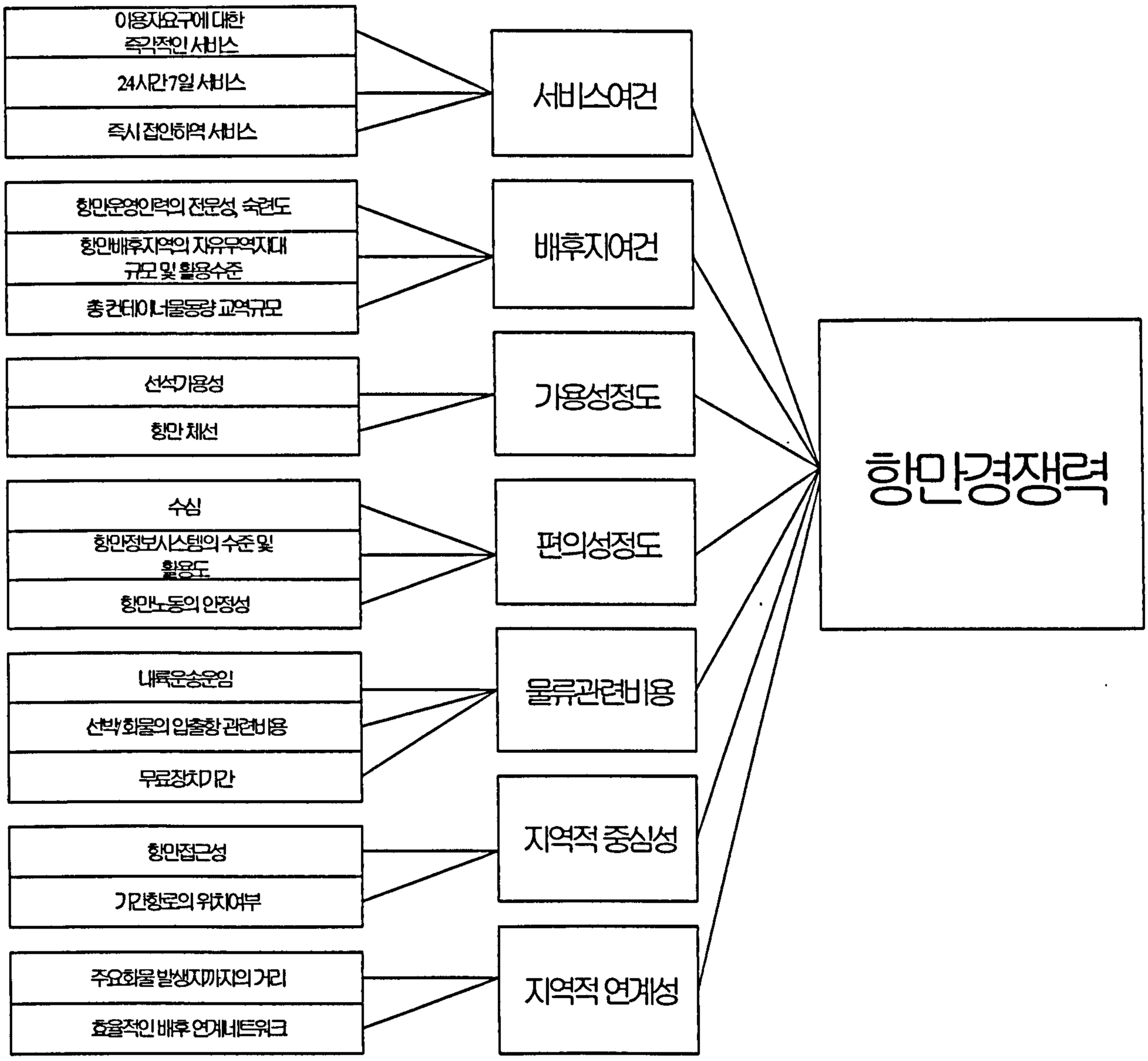
■ 항만경쟁력평가 모델의 개요

○ 동북아시아에서 항만의 경쟁력은 아래표와 같이 7 개의 대표속성과 그 하부에 18 개의 세부속성으로 구성됨이 확인 되었습니다.

<표> 항만경쟁력 구성요인

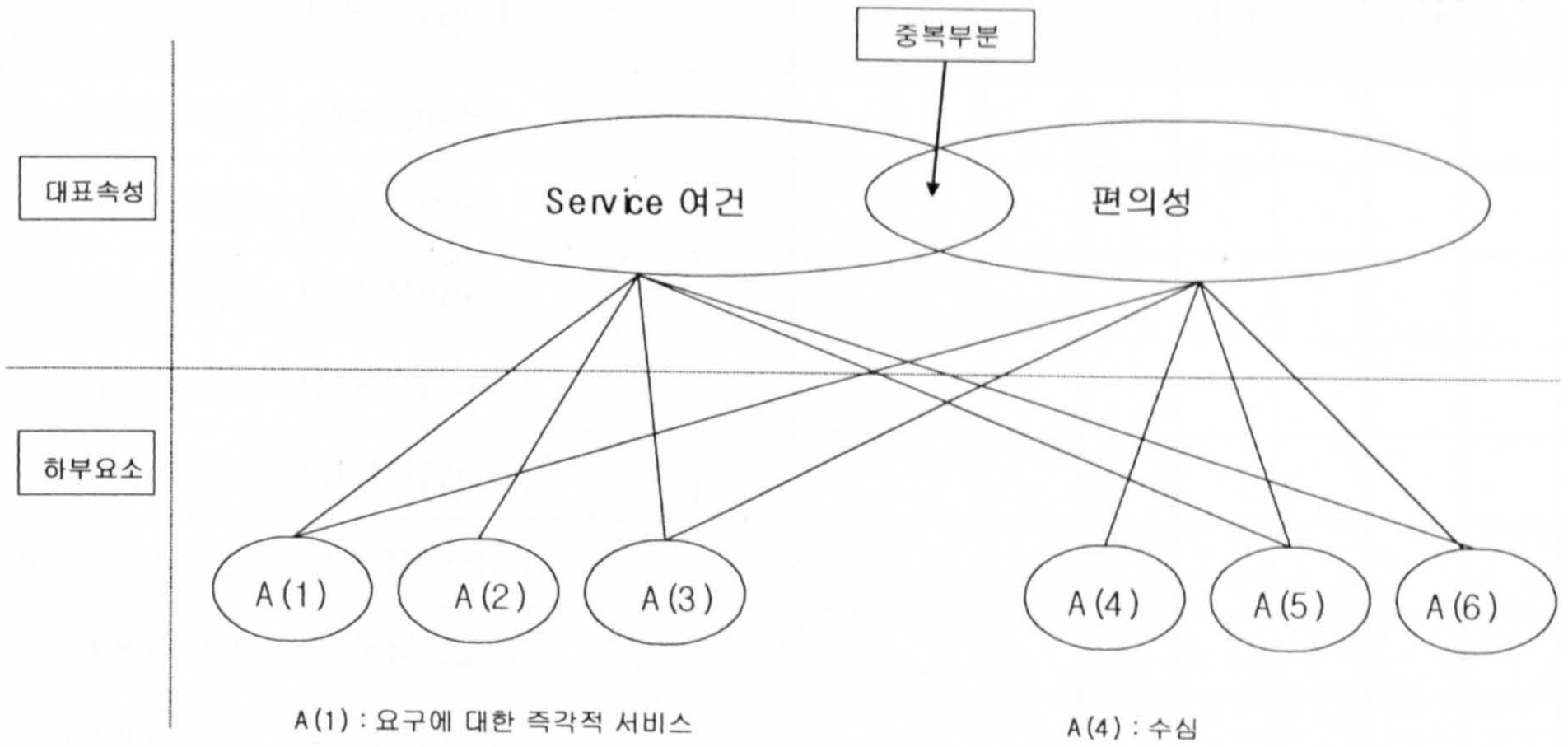
요인 1 **서비스여건**	- 이용자요구에 대한 즉각적인 서비스 - 24 시간 7 일서비스 - 즉시 접안하역 서비스
요인 2 **배후지여건**	- 항만운영인력의 전문성과 숙련도 - 항만배후지역의 자유무역지대의 규모 활용수준 - 총 컨테이너물동량 교역규모
요인 3 **가용성정도**	- 선석가용성 - 항만체선
요인 4 **편의성정도**	- 수심 - 항만정보시스템의 수준 및 활용도 - 항만노동의 안정성
요인 5 **물류관련비용**	- 내륙운송운임 - 선박/화물 입출항관련 비용 - 무료장치기간
요인 6 **지역적 중심성**	- 항만 접근성 - 기간항로의 위치여부
요인 7 **지역적 연계성**	- 주요화물 발생지까지의 거리 - 효율적인 배후 연계네트워크

○ 이를 도식화 하여 보면 항만경쟁력은 아래의 구조에 의하여 평가됨을 알 수 있습니다.



2. 항만의 경쟁력을 구성하는 속성 사이의 <중복현상>에 관한 설명입니다.

설명) 위의 결과를 보면 항만경쟁력은 7 개의 대표속성으로 이상적으로 분리되어 있습니다. 하지만, 대부분 현실문제의 경우, 어느 정도 속성간의 <중복현상>은 존재합니다. 즉 아래의 그림에서와 같이 '서비스 여건'과 '편의성정도'는 개념상 중복이 있다고 판단됩니다. 지금부터의 질문은 선택된 2 개 속성간에 존재하는 <중복현상의 유무> 및 <중복현상의 크기>를 귀하의 판단으로 답해 주시는 것입니다.



A(1) : 요구에 대한 즉각적 서비스

A(2) : 24시간 7일 서비스

A(3) : 즉시 접안 하역 서비스

A(4) : 수심

A(5) : 항만정보시스템 수준 및 활용도

A(6) : 노동의 안정성

■ 예제 : (*서비스여건*)과 (*편의성정도*)의 두 항목만 비교할 때, (항목간 중복유무는?), (중복의 정도는?)에 체크하여 주십시오.

→ (항목간 중복유무는? **있다**), (중복의 정도는 : **약간낮다**)라고 판단하실 경우 아래 표의 **(1)**과 같이 답변하시면 됩니다.

→ (항목간 중복유무는? **없음**)이라고 판단하실 경우 아래 표의 **(2)**와 같이 답변하시면 됩니다.(이 경우, 중복의 정도는 표시하지 않으셔도 됩니다.)

두 항목간의 비교	중복현상 유 무		중복현상의 정도						
아래 두 항목간에 <중복현상>을 비교해 주십시요.	없다	있다	아주 낮다	낮다	약간 낮다	중간	약간 높다	높다	아주 높다
(1) [서비스여건] / [편의성정도]		√			√				
(2) [서비스여건] / [가용성정도]	√								

3. 항목간 <중복현상>에 대한 본 질문입니다.

두 항목간의 비교	중복현상 유 무		중복현상의 정도						
아래 두 항목간에 <중복현상>을 비교해 주십시요.	없다	있다	아주 낮다	낮다	약간 낮다	중간	약간 높다	높다	아주 높다
1) [서비스여건] / [배후지여건]									
2) [서비스여건] / [가용성정도]									
3) [서비스여건] / [편의성정도]									
4) [서비스여건] / [물류관련비용]									
5) [서비스여건] / [지역적중심성]									
6) [서비스여건] / [지역적연계성]									
7) [배후지여건] / [가용성정도]									
8) [배후지여건] / [편의성정도]									
9) [배후지여건] / [물류관련비용]									
10) [배후지여건] / [지역적중심성]									
11) [배후지여건] / [지역적연계성]									
12) [가용성정도] / [편의성정도]									
13) [가용성정도] / [물류관련비용]									
14) [가용성정도] / [지역적중심성]									
15) [가용성정도] / [지역적연계성]									
16) [편의성정도] / [물류관련비용]									
17) [편의성정도] / [지역적중심성]									
18) [편의성정도] / [지역적연계성]									
19) [물류관련비용] / [지역적중심성]									
20) [물류관련비용] / [지역적연계성]									
21) [지역적중심성] / [지역적연계성]									

대단히 감사합니다.

APPENDIX D

Questionnaire for Scoring Port Performance (for Korean Respondents)

1. 응답자의 일반사항에 관련된 질문입니다. 다음 각 질문 중에서 해당 되는 ( )에 √ 또는 직접 기입해 주십시오.

1. 귀하께서 몸담고 계신 기관명은 무엇입니까?

( )

2. 귀하께서 담당하고 계신 업무는 주로 어떤 분야입니까?

선사( ) 포워더( ) 터미널운영( )

PA 혹은 정부( ) 연구분야( ) 화 주( )

3. 귀하께서 이 분야에 종사하신 지는 얼마나 됩니까?

5 년 미만( ) 5 - 10 년( ) 11 - 15 년( ) 16 - 20 년( ) 20 년 이상( )

4. 귀하의 직책은? (아래의 항목에 V 표 해주시기 바랍니다)

고위간부( ) 중간간부( ) 사원급( )

5. 응답자의 업무와 관련 있는 항목만 답변하여 주시면 됩니다.

5-1. 귀사가 이용하는 선박의 평균선형은 어느 정도입니까?

500 TEU 미만( ) 500 - 1000 TEU 미만( )

1000 - 3000TEU 미만( ) 3000TEU - 5000TEU 미만( ) 5000TEU 이상( )

5-2. 귀사에서 발생되는 연간 화물량을 기입해 주십시요.(TEU 기준)

수출화물량(TEU)

수입화물량(TEU)

5-3. 귀사의 주요 수출입화물을 기입해 주십시요.

수출화물( )

수입화물( )

5-4. 귀사에서 주로 취항하고 있는 항로는 다음 중 어디입니까?(복수응답가능)

유럽항로( ) 미주항로( ) 한국/중국/일본 항로( )

동남아 항로( ) 기타( )

5-5. 귀사의 전체 종업원 수는 대략 몇 명입니까? ( )명

5-6. 귀사의 연간 매출액은 어느 정도 입니까? (원)

2. 본 연구에서 정의한 항만경쟁력 평가모델의 구성요인 및 구조에 관한 설명입니다.

(본 연구팀이 정의한 항만간 경쟁력평가 모델의 속성에 대한 해설입니다. 아래 나열한 속성들을 충분히 숙지하신 후, 다음 설문에 답해주시면 감사하겠습니다.)

■ 항만경쟁력평가 모델의 개요

○ 동북아시아에서 항만의 경쟁력은 아래표와 같이 7 개의 대표속성과 그 하부에 18 개의 세부속성으로 구성됨이 확인 되었습니다.

<표> 항만경쟁력 구성요인

요인 1 **서비스여건**	- 이용자요구에 대한 즉각적인 서비스 - 24 시간 7 일서비스 - 즉시 접안하역 서비스
요인 2 **배후지여건**	- 항만운영인력의 전문성과 숙련도 - 항만배후지역의 자유무역지대의 규모 활용수준 - 총 컨테이너물동량 교역규모
요인 3 **가용성정도**	- 선석가용성 - 항만체선
요인 4 **편의성정도**	- 수심 - 항만정보시스템의 수준 및 활용도 - 항만노동의 안정성
요인 5 **물류관련비용**	- 내륙운송운임 - 선박/화물 입출항관련 비용 - 무료장치기간
요인 6 **지역적 중심성**	- 항만 접근성 - 기간항로의 위치여부
요인 7 **지역적 연계성**	- 주요화물 발생지까지의 거리 - 효율적인 배후 연계네트워크

○ 이를 도식화 하여 보면 항만경쟁력은 아래의 구조에 의하여 평가됨을 알 수 있습니다.

3. 동북아 항만의 '항만만족도'에 관한 응답방법입니다.

□ 예제 : 7 개의 항만경쟁력 요소 중 (**서비스여건) 측면**에서 판단 할 때, **부산항의 만족도가 (중간정도), 홍콩의 만족도가 (약간높다)**일경우, 아래와 같이 표시하시면 됩니다. 나머지 항만은 같은 방법으로 답변하시면 됩니다.

동북아시아 항만평가	<서비스여건>측면에서 볼 때, 다음 항만들의 <만족도>를 평가해 주십시오?						
	아주낮다	낮다	약간낮다	중간	약간높다	높다	아주 높다
Busan				√			
Hong Kong					√		

4. 동북아 항만의 '항만만족도'에 관한 본 질문입니다.

1. <서비스여건> 측면에서 다음의 항만들을 판단해 주십시오.

동북아시아 항만평가	<서비스여건>측면에서 볼 때, 다음 항만들의 <만족도>를 평가해 주십시오?						
	아주 낮다	낮다	약간 낮다	중간	약간 높다	높다	아주 높다
Busan							
Hong Kong							
Kaohsiung							
Qingdao							
Shanghai							
Shenzhen							
Tokyo							

2. <배후지여건> 측면에서 다음의 항만들을 판단해 주십시오.

동북아시아 항만평가	<배후지여건>측면에서 볼 때, 다음 항만들의 <만족도>를 평가해 주십시오?						
	아주 낮다	낮다	약간 낮다	중간	약간 높다	높다	아주 높다
Busan							
Hong Kong							
Kaohsiung							
Qingdao							
Shanghai							
Shenzhen							
Tokyo							

3. <가용성정도> 측면에서 다음의 항만들을 판단해 주십시오.

동북아시아 항만평가	<가용성정도>측면에서 볼 때, 다음 항만들의 <만족도>를 평가해 주십시오?						
	아주 낮다	낮다	약간 낮다	중간	약간 높다	높다	아주 높다
Busan							
Hong Kong							
Kaohsiung							
Qingdao							
Shanghai							
Shenzhen							
Tokyo							

4. <편의성정도> 측면에서 다음의 항만들을 판단해 주십시오.

동북아시아 항만평가	<편의성정도>측면에서 볼 때, 다음 항만들의 <만족도>를 평가해 주십시오?						
	아주 낮다	낮다	약간 낮다	중간	약간 높다	높다	아주 높다
Busan							
Hong Kong							
Kaohsiung							
Qingdao							
Shanghai							
Shenzhen							
Tokyo							

5. <물류관련비용> 측면에서 다음의 항만들을 판단해 주십시오.

동북아시아 항만평가	<물류관련비용>측면에서 볼 때, 다음 항만들의 <만족도>를 평가해 주십시오?						
	아주 낮다	낮다	약간 낮다	중간	약간 높다	높다	아주 높다
Busan							
Hong Kong							
Kaohsiung							
Qingdao							
Shanghai							
Shenzhen							
Tokyo							

6. <지역적중심성> 측면에서 다음의 항만들을 판단해 주십시오.

동북아시아 항만평가	<지역적중심성>측면에서 볼 때, 다음 항만들의 <만족도>를 평가해 주십시오?						
	아주 낮다	낮다	약간 낮다	중간	약간 높다	높다	아주 높다
Busan							
Hong Kong							
Kaohsiung							
Qingdao							
Shanghai							
Shenzhen							
Tokyo							

7. <지역적연계성> 측면에서 다음의 항만들을 판단해 주십시오.

동북아시아 항만평가	<지역적연계성>측면에서 볼 때, 다음 항만들의 <만족도>를 평가해 주십시오?						
	아주 낮다	낮다	약간 낮다	중간	약간 높다	높다	아주 높다
Busan							
Hong Kong							
Kaohsiung							
Qingdao							
Shanghai							
Shenzhen							
Tokyo							

8. 설문에 대하여 추가로 기술하시고 싶은 내용이 계시면 기술해 주십시오.

* 연구요약을 받아보시고 싶으면, 아래에 연락처를 남겨주십시오.

성　　함 : (　　)

이메일주소 : (　　)

연 락 처 : (　　)

☻ 답변에 진심으로 감사드립니다.

APPENDIX E

Questionnaire for Weighting the Degree of Overlap (for Chinese Respondents)

International Shipping and Logistics Group
University of Plymouth
Drake Circus, Plymouth PL4 8AA
United Kingdom

调 查 问 卷

您好?

感谢你们百忙之中抽出时间配合我们的这个调查，本调查问卷是为评价东北亚港口的竞争力而制，调查的目的是为了取得有关专家对东北亚港湾的意见和看法。为了得到有价值的调查结果， 希望您能给予真诚的协助，在调查过程中，所有公司、机关的名称是作为研究目的，均作为匿名处理，保证绝对不会对贵公司和机关单位造成利益损害。

祝贵公司财源广进、鸿图大展!

谢谢!

吕 奇 泰 敬上

2005. 10

Gi-Tae Yeo
International Shipping and Logistics Group
University of Plymouth
Drake Circus, Plymouth PL4 8AA
E-mail : gi-tae.yeo@plymouth.ac.uk
Tel : ++ 44 (0)1752 232412
Fax : ++ 44 (0) 1752 232249

1. 下面是关于本次项研究港湾竞争力的说明

(下面是本研究组所定的关于港湾间竞争力评价模式，请充分了解本次设定内容以后，给予回答。)

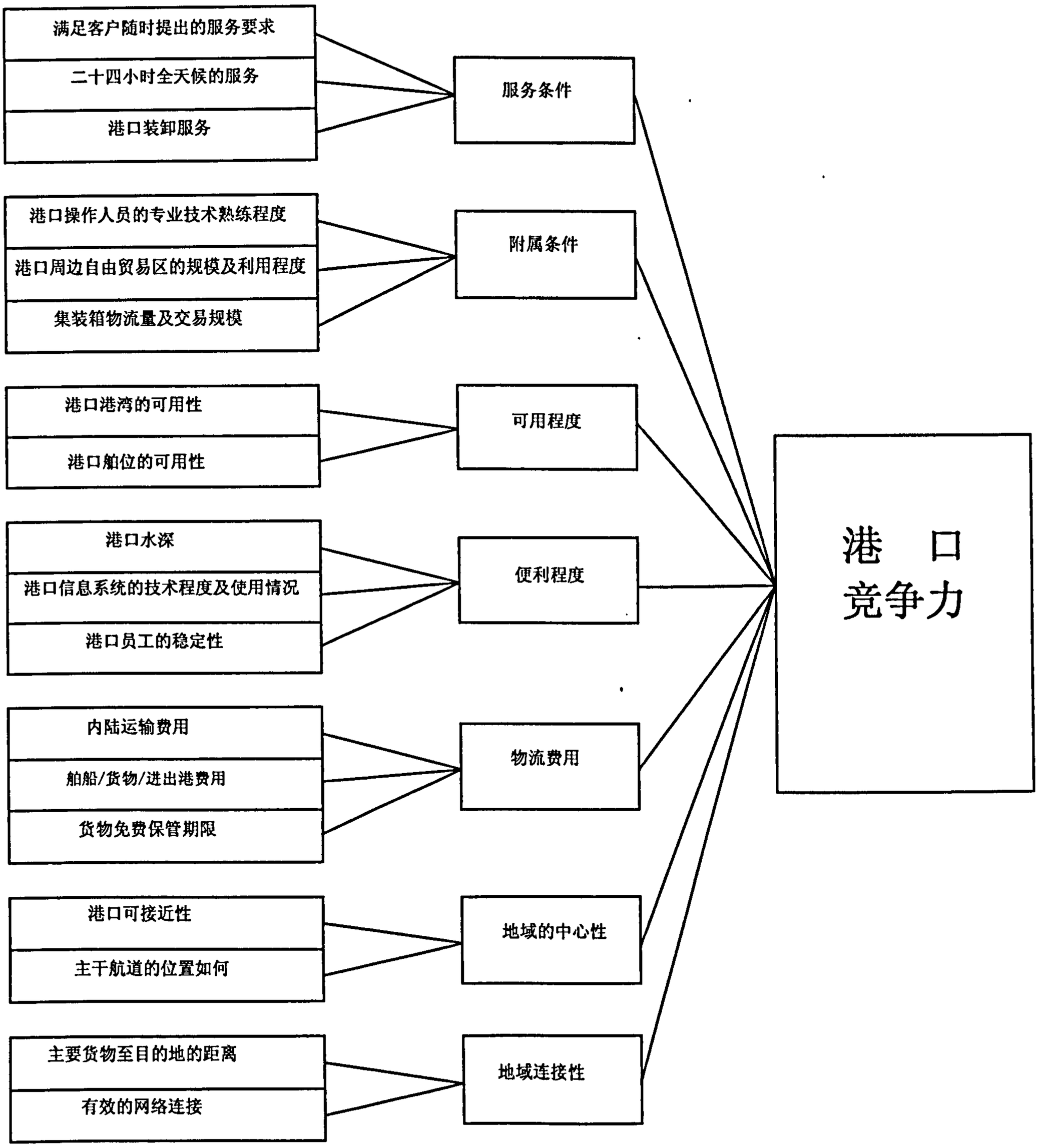
▶ 港湾竞争力评价要素的主要内容

○ 东北亚港湾竞争力的构成有 7 个代表性要素与 18 个细则要素，如下表。

〈表〉港湾竞争力要素构成表

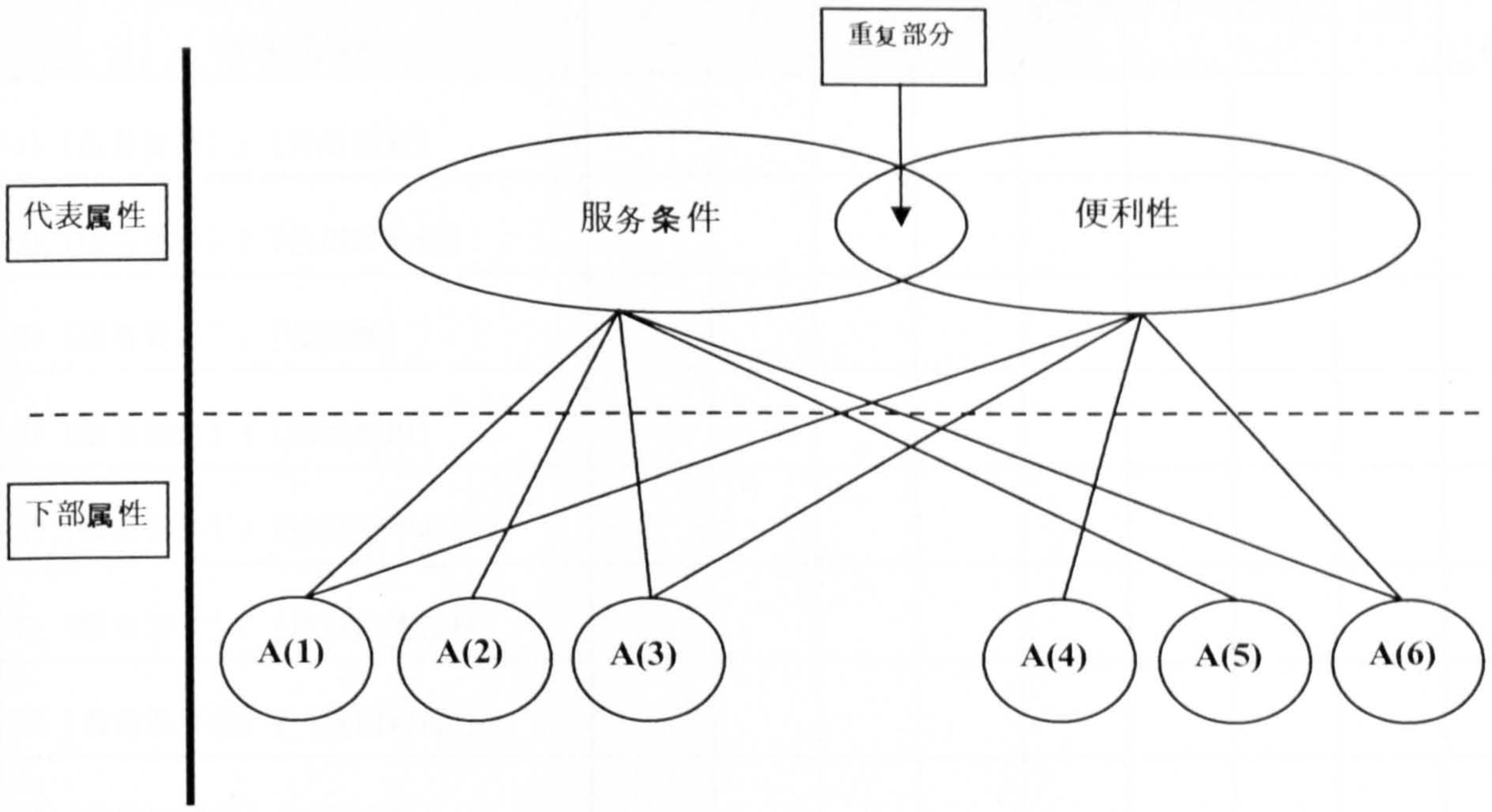
要素 1 **服务条件**	- 满足客户随时提出的服务要求 - 二十四小时全天候的服务 - 港口装卸服务
要素 2 **附属条件**	- 港口操作人员的专业技术熟练程度 - 港口周边自由贸易区的规模及利用程度 - 集装箱物流量及交易规模
要素 3 **可用性**	- 港口港湾的可用性 - 港口舶位的可用性
要素 4 **便利性**	- 港口水深 - 港口信息系统的技术程度及使用情况 - 港口员工的稳定性
要素 5 **物流费用**	- 内陆运输费用 - 舶船/货物/进出港费用 - 货物免费保管期限
要素 6 **地域中心性**	- 港口可接近性 - 主干航道的位置如何
要素 7 **地域连接性**	- 主要货物至目的地的距离 - 有效的网络连接

○ 从下面图形化的港湾构成要素可以了解对港湾竞争力的评价



2. 关于构成港湾竞争力属性之间《重复现象》的说明

说明：从以上结果看出港湾竞争力是由7个代表属性组成的，但是大多数现实问题当中，还存在代表属性间的《重复现象》，如下图“服务条件”与“便利性”存在概念上的重复性。请您以2个属性间存在的《重复现象的有无》及《重复现象的大小》回答以下问题。



A（1）：满足客户随时提出的服务要求　A（4）：港口水深
A（2）：二十四小时全天候的服务　A（5）：港口信息系统的技术程度及使用情况
A（3）：港口装卸服务　A（6）：港口员工的稳定性

■例 ：*比较《服务要素》与《便利性》2个项目之间的《有无重复性？》问题时请在《重复的现象的程度》上表示。*

—— 如回答《有》或《差一点》时请您按表①表示。

——如回答《无》时请您按表②表示，您的答案重复时不用再表示。

2个项目之间的比较	重复现象 有 / 无		重复现象的差异						
请比较以下2个项目之间的《重复现象》	无	有	非常低	低	稍微低	中	稍微高	高	非常高
①［服务要素］/［便宜性］		V			V				
②［服务要素］/［使用可能性］	V								

3. 关于项目间《重复现象》的问题

2个项目间比较	重复现象 有 / 无		重复现象的差异						
请比较以下2个项目之间的《重复现象》	无	有	非常低	低	稍微低	中	稍微高	高	非常高
1)［服务要素］/［背后要素］									
2)［服务要素］/［使用可能性］									
3)［服务要素］/［便宜性］									
4)［服务要素］/［物流费用］									
5)［服务要素］/［地域的中心性］									
6)［服务要素］/［地域的连接性］									
7)［背后地要素］/［使用可能性］									
8)［背后地要素］/［便宜性］									
9)［背后地要素］/［物流费用］									
10)［背后地要素］/［地域的中心性］									
11)［背后地要素］/［地域的连接性］									
12)［使用可能性］/［便宜性］									
13)［使用可能性］/［物流费用］									
14)［使用可能性］/［地域的中心性］									
15)［使用可能性］/［地域的连接性］									
16)［便宜性］/［物流费用］									
17)［便宜性］/［地域的中心性］									
18)［便宜性］/［地域的连接性］									
19)［物流费用］/［地域的中心性］									
20)［物流费用］/［地域的连接性］									
21)［地域的中心性］/［地域的连接性］									

非常感謝

APPENDIX F

Questionnaire for Scoring Port Performance (for Chinese Respondents)

1. 下面是关于答卷者本人的一般事项，请您核对后在（ ）里打 ✔ 或直接记录

1. 请问您所在的机关名称是什么？

（ ）

2. 请问您负责哪一方面的业务？

船社（ ） Forwarder（ ） Terminal 运营（ ）

Port Authority 或政府（ ） 研究部门（ ） 货主（ ）

3. 请问您从事这方面的业务有多久？

不到 5 年（ ） 5 - 10 年（ ） 11 - 15 年（ ） 16 - 20 年（ ） 20 年 以上（ ）

4. 请问您的职位是？

高级干部（ ） 中级干部（ ） 职员（ ）

5. 您只需回答与您的职务有关的问题。

5-1. 贵公司所利用的船舶的平均船型是哪一种？

500 TEU 未满（ ） 500 - 1000 TEU 未满（ ）

1000 - 3000TEU 未满（ ） 3000TEU - 5000TEU 未满（ ） 5000TEU 以上（ ）

5-2. 请记录贵公司的年货物量。（以 TEU 为准）

输出货物量（ TEU）

输入货物量（ TEU）

5-3. 请记录贵公司的主要输出货物。

输出货物（ ）

输入货物（ ）

5-4. 请问贵公司主要运行的航线是下列哪一种？（可选择多项）

欧洲航路（ ） 美洲航路（ ） 中国/韩国/日本 航路（ ）

东南亚 航路（ ） 其他（ ）

5-5. 贵公司的职员人数是多少？ （ ）名

5-6. 贵公司的年收入是多少？ （ /元）

2. 下面是关于本研究小组所定的港湾竞争力评价模型的构成要素及有关构造说明

(下面是本研究小组所定的有关港湾间竞争力评价模型的属性的说明，请您详细了解后回答问题)

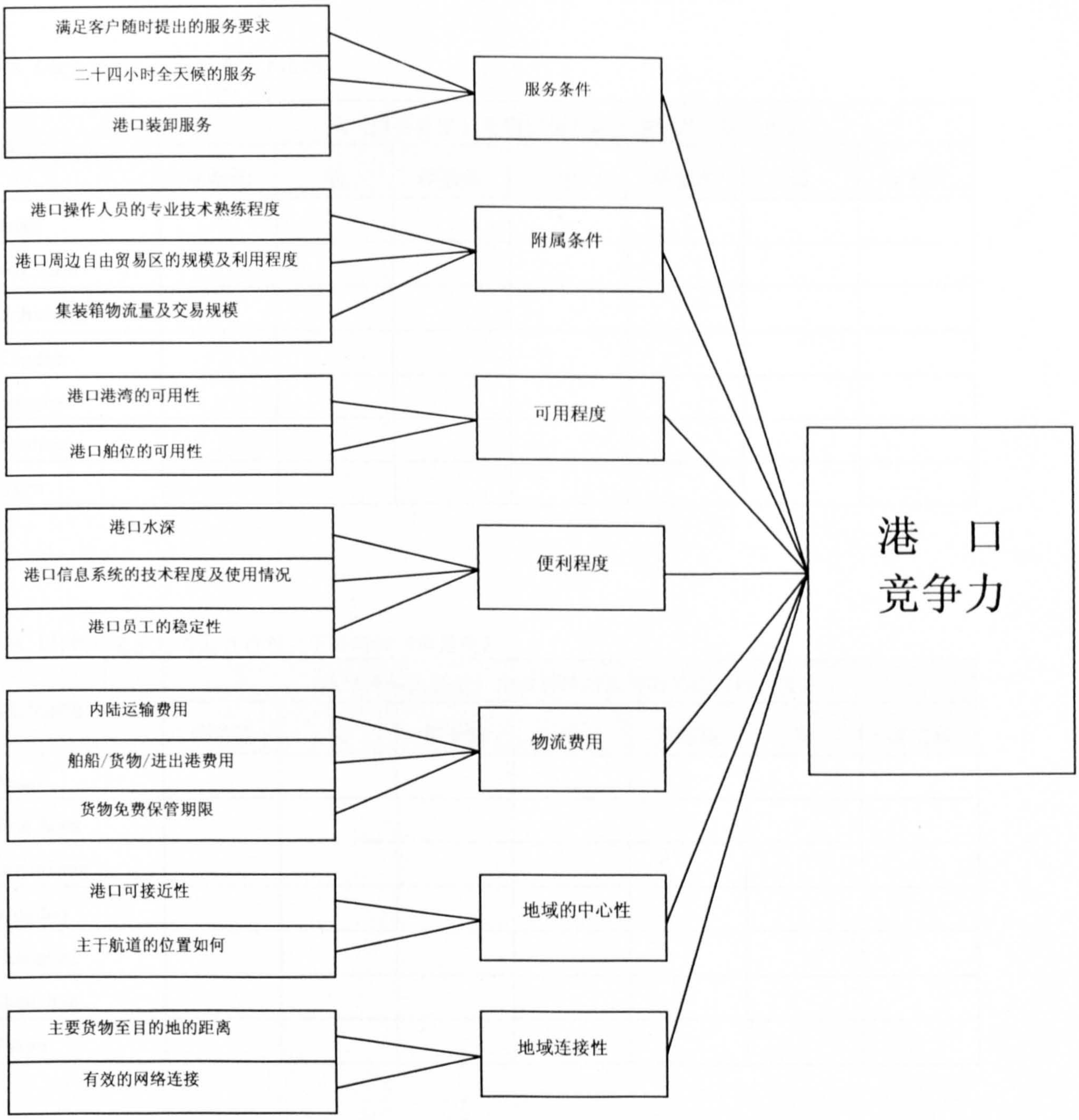
▶ 港湾竞争力评价模型的概要

○东北亚港湾竞争力的构成有 7 个代表性要素与 18 个细则要素，如下表。

〈表〉港湾竞争力构成要素

要素 1 **服务条件**	- 满足客户随时提出的服务要求 - 二十四小时全天候的服务 - 港口装卸服务
要素 2 **附属条件**	- 港口操作人员的专业技术熟练程度 - 港口周边自由贸易区的规模及利用程度 - 集装箱物流量及交易规模
要素 3 **可用性**	- 港口港湾的可用性 - 港口舶位的可用性
要素 4 **便利性**	- 港口水深 - 港口信息系统的技术程度及使用情况 - 港口员工的稳定性
要素 5 **物流费用**	- 内陆运输费用 - 舶船/货物/进出港费用 - 货物免费保管期限
要素 6 **地域中心性**	- 港口可接近性 - 主干航道的位置如何
要素 7 **地域连接性**	- 主要货物至目的地的距离 - 有效的网络连接

○从下面图形化的港湾构成要素可以了解对港湾竞争力的评价



3. 有关东北亚港湾“港湾满足度”问题的回答方法

◇ 例：7 个港湾竞争力要素中从《服务要素》判断，对釜山(Busan)港的满足度为《中间程度》，对香港(Hong Kong)的满足度《略高》时，按以下方式表示即可，其余部分方法相同。

东北亚港湾评价	从<服务要素>角度评价评价对以下港湾的《满足度》						
	非常低	低	稍微低	中	稍微高	高	非常高
Busan				V			
Hong Kong					V		

4. 关于东北亚港湾“港湾满足度”的提问

1. 从《服务要素》方面判断以下港湾。

东北亚港湾评价	从《服务要素》角度评价对以下港湾的《满足度》						
	非常低	低	稍微低	中	稍微高	高	非常高
Busan							
Hong Kong							
Kaohsiung							
Qingdao							
Shanghai							
Shenhen							
Tokyo							

2. 从《拜候地要素》方面评价对以下港湾的《满足度》

东北亚港湾评价	从《拜候地要素》角度评价对以下港湾的《满足度》						
	非常低	低	稍微低	中	稍微高	高	非常高
Busan							
Hong Kong							
Kaohsiung							
Qingdao							
Shanghai							
Shenzhen							
Tokyo							

3. 从《使用可能性》方面评价对以下港湾的《满足度》

东北亚港湾评价	从《使用可能性》角度评价对以下港湾的《满足度》						
	非常低	低	稍微低	中	稍微高	高	非常高
Busan							
Hong Kong							
Kaohsiung							
Qingdao							
Shanghai							
Shenzhen							
Tokyo							

4. 从《便宜性》方面评价对以下港湾的《满足度》

东北亚港湾评价	从《便宜性》角度评价对以下港湾的《满足度》						
	非常低	低	稍微低	中	稍微高	高	非常高
Busan							
Hong Kong							
Kaohsiung							
Qingdao							
Shanghai							
Shenzhen							
Tokyo							

5. 从《物流费用》方面评价对以下港湾的《满足度》

东北亚港湾评价	从《物流费用》角度评价对以下港湾的《满足度》						
	非常低	低	稍微低	中	稍微高	高	非常高
Busan							
Hong Kong							
Kaohsiung							
Qingdao							
Shanghai							
Shenzhen							
Tokyo							

6. 从《地域中心性》方面评价对以下港湾的《满足度》

东北亚港湾评价	从《地域中心性》角度评价对以下港湾的《满足度》						
	非常低	低	稍微低	中	稍微高	高	非常高
Busan							
Hong Kong							
Kaohsiung							
Qingdao							
Shanghai							
Shenzhen							
Tokyo							

7. 从《地域的连接性》方面评价对以下港湾的《满足度》

东北亚港湾评价	从《地域的连接性》角度评价对以下港湾的《满足度》						
	非常低	低	稍微低	中	稍微高	高	非常高
Busan							
Hong Kong							
Kaohsiung							
Qingdao							
Shanghai							
Shenzhen							
Tokyo							

8. 对问卷上的问题有补充或另有内容请您在下栏填写。

＊ 如您需要研究结果，请留下您的联系方式。

姓　　名：(　　)

E-mail：　(　　)

联系地址:(　　)

☺ 真心感谢您配合答卷

References

Alderton, P. (1999) *Port management and operations*, LLP Reference Publishing, London.

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

Amano, T., Yamashita, K., Arao, S., Kitayama, A., Hayashi, A., Suemori, S. and Ohkura, Y. (2000) Inclusive integral evaluation for mammograms using the hierarchical fuzzy integral model, *Japanese Journal of Radiological Technology*, Volume 56 Number 1, pp.103-112.

Aouam T., Chang S. and Lee E. (2003) Fuzzy MADM : An outranking method, *European Journal of Operational Research*, Volume 145, pp.317-328.

Baird, A. (1995) Privatisation of trust ports in the United Kingdom: Review and analysis of the first sales, *Transport Policy*, Volume 2, Number 2, pp. 135-143.

Baird, A. (2000) The Japan coastal ferry system, *Maritime Policy and Management*, Volume 27, Number 1, pp.3-16.

Barros, C. and Athanassiou, M. (2004) Efficiency in European seaports with DEA: Evidence from Greece and Portugal, *Maritime Economics and Logistics*, Volume 6, pp.122-140.

Bevilacqua, M and Petroni, A. (2002) From traditional purchasing to supplier management: a fuzzy logic-based approach to supplier selection, *International Journal of Logistics: Research and Applications,* Volume 5 Number 3, pp.235-255.

Bichou, K. and Gray, R. (2004) A logistics and supply chain management approach to port performance measurement, *Maritime Policy and Management*, Volume 31 Number 1, pp.47-67.

Bichou, K. and Gray, R. (2005) A critical review of conventional terminology for classifying seaports. *Transportation Research Part A: Policy and Practice*, 39 Number 1, pp.75-92.

Britannica's Encyclopedia (2005), [Online] 30 January 2006. < http://www. britannica. com/eb/>.

Brooks, M. (1984) An alternative theoretical approach to the evaluation of liner shipping-Part 1. Situational factors. *Maritime Policy and Management,* Volume 11 Number 1, pp.35-43.

Brooks, M. (1985) An alternative theoretical approach to the evaluation of liner shipping-Part 2: Choice criteria. *Maritime Policy and Management,* Volume 12 Number 2, pp.145-155.

Brooks, M. (2000) *Sea Change in Liner Shipping: Regulation and Managerial Decision-Making in a Global Industry*, Pergamon, Amsterdam.

Chan, Y. (2005) A statistical study of intrastate vs. interstate regulatory reforms, *Journal of Transport Geography*, Volume 13, pp. 165-171.

Chang, S. (2000) Disasters and transport systems: loss, recovery and competition at the Port of Kobe after the 1995 earthquake, *Journal of Transport Geography,* Volume 8 Number 8, pp.53-65.

Chen C- T. (2001) A fuzzy approach to select the location of the distribution centre, *Fuzzy Sets and Systems*, Volume 118, pp.65-73.

Chen C- T., Lin C- T. and Huang S- F. (2006) A Fuzzy approach for supplier evaluation and selection in supply chain management, *International Journal of Production Economics*, Volume 102, Number 2, pp.289-301.

Chi, Z., Yan, H. and Pham, T. (1996) Fuzzy Algorithms: With Applications to Image Processing and Pattern Recognition, *World Scientific*, Singapore.

Chiou, H- H., Tzeng, G- H., and Cheng, D- C. (2005) Evaluating sustainable development strategies using fuzzy MCDM approach, *The International Journal of Management Science*, Volume 33, pp.223-234.

Chou, T. and Liang, G. (2001) Application of a fuzzy multi-criteria decision-making model for shipping company performance evaluation,*Maritime Policy and Management*, Volume 28, Number 4, pp.375-392.

Chou, T- Y., Chou, S- C, and Tzeng, G- H. (2006) Evaluating IT/IS investments: A fuzzy multi-criteria decision model approach, *European Journal of Operation Research*, Volume 173, Number 3, pp.1026-1046.

Collison, F.(1984) North to Alaska : marketing in the Pacific Northwest-Central Alaska liner trade. *Maritime Policy and Management*, Volume 11 Number 2, pp.99-112.

Containerisation International Yearbook (2003).

Cullinane, K. and Khanna, M. (2000) Economies of scale in large containerships: optimal size and geographical implications, *Journal of Transport Geography*, Volume 8, pp.181-195.

Cullinane, K., Song, D-W., and Gray, R. (2002) A stochastic frontier model of the efficiency of major container terminals in Asia: assessing the influence of administrative and ownership structures, *Transportation Research Part A: Policy and Practice*, Volume 36, pp.743-762.

Cullinane, K., Wang, T, and Cullinane, S. (2004) Container terminal development in mainland China and its impact on the competitiveness of the port of Hong Kong, *Transport Reviews,* Volume 24, Number 1,pp. 33–56.

Cullinane, K. and Wang, T-F. Song, D-W and Ji, P. (2006) The technical efficiency of container ports: Comparing data envelopment analysis and stochastic frontier analysis, *Transportation Research Part A: Policy and Practice*, Volume 40, pp.354-374.

De, P. and Ghosy, B. (2003) Causality between performance and traffic: an investigation with Indian ports, *Maritime Policy and Management*, Volume 30 Number 1, pp.5-27.

Doi, M., Tiwari, P. and Itoh, H. (2001) Computable General Equilibrium Analysis of Efficiency Improvements at Japanese Ports, *Review Of Urban and Regional Development Studies*, Volume 13, Number 3, pp.187-206

Drewry (2004) *Ship management*, Drewry Shipping Consultants.

Driankov, D., Hellendoorn, H. and Reinfrank, M. (1993) *An Introduction to Fuzzy Control*, Springer, Berlin.

Dweiri, F. and Kablan, M. (2006) Using Fuzzy decision making for the evaluation of the project management internal efficiency, *Decision Support Systems*, Volume 42, Number 2, pp.712-726.

Economic·and Social Commision for Asia and the Pacific Ocean (2002) *Major Issues in Transport, Communications, Tourism and Infrastructure and Port Development Strategies under a Changing Strategies under a Changing Maritime Environment,* [Online] 18 November 2005. <http://www.unescap.org/tctd/water/committee/committee5a.htm>

Everett, S. (2003) Corporatization: a legislative framework for port inefficiencies, *Maritime Policy and Management*, Volume 30 Number 3, pp.211-219.

Fleming, D. and Baird, A. (1999) Some reflections on port competition in the United States and western Europe, *Maritime Policy and Management*, Volume 26 Number 4, pp.383-394.

Frankel, E. (1992) Hierarchical logic in shipping policy and decision-making, *Maritime Policy and Management*, Volume 19 Number 3, pp.211-222.

Fremont, A. and Ducruet, C. (2005) The emergence of a mega port- from the global to the local, the case of Busan, *Tijdschrift voor Economische en Sociale Geografie,* Volume 96, Number 4, pp. 421–432.

Fujimoto, K. (1996) On Identification of Hierarchical Structure of Fuzzy Integral Systems, *International Conference of Soft Computing*, Japan, pp.312-315.

Fung, K. (2001) Competition between the ports of Hong Kong and Singapore: a structural vector error correction model to forecast the demand for container handling services, *Maritime Policy and Management*, Volume 28 Number 1, pp.3-22.

Ha, M. (2003) A comparison of service quality at major container ports: implications for Korean ports, *Journal of Transport Geography,* Volume 11, pp.131-137.

Haezendonck, E. and Notteboom, T. (2002) The competitive advantage of seaports. In: Winkelmans, W. eds. *Port Competitiveness: An economic and legal analysis of the factors determining the competitiveness of seaports*. Antwerp: De Boeck, pp. 67-87.

Hanjin Shipping (2005) *Company Profile*, [Online] 23 November 2005. <http://www.hanjin.com>.

Haralambides, H. (2002) Competition, excess capacity, and the pricing of port infrastructure, *International Journal of Maritime Economics*, Volume 4 Number 1, pp.323-347.

Haralambides, H. and Yang, J. (2003) A fuzzy set theory approach to flagging out: towards a new Chinese shipping policy, *Maritime Policy*, Volume 27 Number 1, pp.13-22.

Heaver, T., Meersman, H. and Voorde, V. (2001) Co-operation and competition in international container transport: strategies for ports, *Maritime Policy and Management*, Volume 28 Number 3, pp.293-305.

Hoffmann, J. (2004) *Asian Countries' Specialization in Different Maritime Business: Challenges and Opportunities arising from the Process of Concentration in Shipping.* IPSC International Seminar, Karachi.

Hong, W. and Zhu, K. (2006) Migrating to internet-based e-commerce: Factors affecting e-commerce adoption and migration at the firm level, *Information and Management,* Volume 43, Number 2, pp.204-221.

Hoogeweegena, M., Streng, R. and Wagenaar, R. (1998) A comprehensive approach to assess the value of EDI, *Information and Management*, Volume 34, pp.117-127.

Kippenberger, T. (1999) Talking about scenarios, *The Antidote*, Volume 4, Number 4, pp.7-8

Imai, A., Nishimura, E., Papadimitriou, S. and Liu, M. (2006) The economic viability of container mega-ships, *Transportation Research Part E*, Volume 42, pp.21-41.

Itoh, H. (2002) Efficiency changes at major container ports in Japan: a window application of data envelopment analysis, *Review Of Urban and Regional Development Studies*, Volume 14, Number 2, pp.133-152.

Jang, S. and Wu, C. (2006) Seniors' travel motivation and the influential factors: An examination of Taiwanese, *Tourism Management,* Volume 27, Number 2, pp.306-316.

Jeon, I.-S., Kim, H.-S. and Kim, B.-J. (1993) *Strategy for improvement of competitive power in Korea container port.* Korea Maritime Institute, Seoul.

Journal of Commerce (2003) April

Journal of Commerce (2005a) September

Journal of Commerce (2005b) October

Gardiner, J., Ison, S. and Humphreys, I. (2005) Factors influencing cargo airlines' choice of airport: An international survey, *Journal of Air Transport Management,* Volume 11, Number 6, pp.393-399.

Goh, M. and Ling, C. (2003) Logistics development in China, *International Journal of Physical Distribution and Logistics Management*, Volume 33 Number 10, pp.886-917.

Kaufmann, A. and Gupta, M. (1988) *Fuzzy Mathematical Models in Engineering and Management Science*, North-Holland,Amsterdam.

Kaufmann, A. and Gupta, M. (1991) *Introduction to Fuzzy Arithmetic: Theory and Applications*. Van Nostrand Reinhold, New York.

Kent, J., Parker, R. and Luke, R. (2001) An empirical examination of shipper perceptions of service-selection attributes in five truckload industry segments, *Transportation Journal*, Volume 41 Number 1, pp.27-36.

Kent, P. and Ashar, A. (2001) Port competition regulation: a tool for monitoring for anti-competitive behaviour, *International Journal of Maritime Economics*, Volume 3, pp.27-51.

Kerlinger, F. N. (1964) *Foundations of behavioral research.* New York: Holt, Rinehart and Winston.

Kim, H.-S. (1993) *Decision components of Shippers' port choice in Korea.* Korea Maritime Institute, Seoul.

Kim, J-W., Kim, J-T., Park, S-U., and Sugumaran, V. (2004) A multi-view approach for requirements analysis using goal and scenario, *Industrial Management and Data Systems*, Volume 104, Number 9, pp. 702-711.

Konstandinidou, M., Nivolianitou, Z., Kiranoudis, C. and Markatos, N. (2006) A fuzzy modelling application of CREAM methodology for human reliability analysis, *Reliability Engineering and System Safety*, Volume 91, Number 6, pp.706-716.

Korea Maritime Institute (2003) *Forecast of Container Ports Throughts in Korea*, Seoul.

Korea Maritime Institute (2004) *Dynamic Changes on Transhipment Cargos among Northeast Asian Ports,* 2004-10, Seoul.

Kulak, O. and Kahraman, C. (2005) Fuzzy multi-attribute selection among transportation companies using axiomatic design and analytic hierarchy process, *An International Journal of Information Sciences*, Volume 170, pp.191-210.

Kumar, S. (2002) A Decision Support Model for the Liner Shipping Competition Policy Debate, *Proceedings of the International Association of Maritime Economists conference*, Panama, 12-15 November.

Kuo, Y- F., and Chen, P- C. (2006) Selection of mobile value-added service for system operators using fuzzy synthetic evaluation, *Expert Systems with Applications*, Volume 30 Number 4, pp.612-620.

Lai, K., Ngai, E., and Cheng, T. (2002) Measures for evaluating supply chain performance in transport logistics *Transportation Research Part E: Logistics and Transportation Review,* Volume 38, pp.439-456.

Laine, J. and Vepsäläinen, A(1994) Economies of speed in sea transportation, *International Journal of Physical Distribution and Logistics Management*, Volume 24 Number 8, pp.33-41.

Larson, P. and Poist, R. (2004) Improving response rates to mail surveys: a research note, *Transportation Journal*, Volume 34, Number 4, pp.67-74.

Lee, C., Liu, L.-C. and Tzeng, G.-H. (2001) Hierarchical fuzzy integral evaluation approach for vocational education performance: Case of Junior Colleges in Taiwan, *International Journal of Fuzzy Systems*, Volume 3 Number 3, pp.476-484.

Lim, B-T. (2000) *A study on the development and application of fuzzy evaluation algorithm to complex systems*, unpublished PhD Thesis, Korea Maritime University.

Lirn, T., Thanopoulou, H., Beynon, M. and Beresford, A. (2003) Transhipment port selection and decision-making behaviour: Analysing the Taiwanese case, *International Journal of Logistics: Research and Applications*, Volume 6 Number 4, pp.229-244.

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

Lu, C. (2000) Logistics services in Taiwanese maritime firms, *Transportation Research Part E: Logistics and Transportation Review,* Volume 36, pp.79-96.

Lu, C. and Marlow, P. (1999) Strategic groups in Taiwanese liner shipping, *Maritime Policy and Management*, Volume 26 Number 1, pp.1-26.

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

Malchow, M. and Kanafani, A. (2004) A disaggregate analysis of port selection. *Transportation Research Part E: Logistics and Transportation Review*, Volume 40 Number 4, pp.317-337.

Mansur, Y. (1995) *Fuzzy sets and economics: application of mathematics to non-cooperative oligopoly*. Aldershot, UK: Edward Elgar Publishing Limited.

McCalla, R. (1994) Canadian Container: How have they fared? How will they do? *Maritime Policy and Management,* Volume 21 Number 3, pp.207-217.

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

Midoro, R and Pitto, A. (2000) A critical evaluation of strategic alliances in liner shipping, *Maritime Policy and Management*, Volume 27 Number 1, pp.31-40.

Miller, G. (1956) The magical number seven, plus or minus two: some limits on our capacity for processing information. *Psychological Review* Volume 63, pp.81–87.

Monie, G. (1985) *Terminal Management*, ITMMA (University of Antwerp)

Murphy, P., Dalenberg, D. and Daley, J. (1988) A contemporary perspective on international port operations. *Transportation Journal*, Volume 28 Number 1, pp.23-32.

Murphy, P., Dalenberg, D. and Daley, J. (1989) Assessing international port operations. *International Journal of Physical Distribution and Materials Management*, Volume 19 Number 9, pp.3-10.

Murphy, P., Dalenberg, D. and Daley, J. (1991) Analysing international water transportation: the perspectives of large U.S. industrial corporations. *Journal of Business Logistics*, Volume 12 Number 1, pp.169-190.

Murphy, P., Daley, J. and Dalenberg, D. (1992) Port selection criteria: an application of a transportation research framework. *Logistics and Transportation Review*, Volume 28 Number 3, pp.237-255.

Nir, A., Lin, K. AND Liang G. (2003) Port choice behaviour-from the perspective of the shipper, *Maritime Policy and Management*, Volume 30 Number 2, pp.165-173.

Notteboom, T., Coeck, C, and Broeck, J. (2000) Measuring and explaining the relative efficiency of container terminals by means of Bayesian Stochastic Frontier Models, *International Journal of Maritime Economics,* Volume 2 Number 2, pp.83-106.

Ocean Shipping Consultants (2003) *World Containerport Outlook to 2015.*

Ocean Shipping Consultants (2005a), *Marketing of Container Terminals*, [Online] 21 November 2005. <http://www.osclimited.com/releases/MOCT.pdf>

Ocean Shipping Consultants (2005b), *Shipping Profits: Mixed Outlook Ahead,* [Online] 21 November 2005. <http://www.osclimited.com/releases/ShipProfto2015.pdf>

Ohashia, H., Kim, T, Oum, T and Yuc, C. (2005) Choice of air cargo Transhipment airport: an application to air cargo traffic to/from Northeast Asia, *Journal of Air Transport Management*, Volume 11, pp.149-159

Pallis, A. and Vaggelas, G. (2005) Port Competitiveness and the EU 'Port Services' Directive: the case of Greek ports, *Maritime Economics & Logistics*, Volume 7, pp.116-140.

Panayides, P. (2003) Competitive strategies and organizational performance in ship management, *Maritime Policy and Management*, Volume 30 Number 2, pp.123-140.

Panayides, P. and Cullinane, K. (2002) The vertical disintegration of ship management: choice criteria for third party selection and evaluation, *Maritime Policy and Management*, Volume 29 Number 1, pp.45-64.

Park, B. (2005) Spatially selective liberalization and graduated sovereignty: Politics of neo-liberalism and ''special economic zones'' in South Korea, *Political Geography*, Volume 24 , 850-873.

Park, T. and Jeong, B. (2002), *Analysis of economic effects of large container vessels*, Korea Maritime Institute, Seoul.

Parola, F. and Sciomachen, A. (2005) Intermodal container flows in a port system network: Analysis of possible growths via simulation models, *International Journal of Production Economics*, Volume 97, pp.75-88.

Patton, M. (1987) *How to Use Qualitative Methods in Evaluation*, SAGE Publications, London.

Pedrycz, W. (1996) *Fuzzy Modelling: Paradigms and Practice*, Kluwer Academic Press, Dordrecht.

Perez-Labajos, C. and Blanco, B (2004) Competitive policies for commercial sea ports in the EU, *Marine Policy,* Volume 28, pp.553-556.

Pearson, R. (1980) *Containerline Performance and Service Quality*, University of Liverpool.

Peters, H. (2001) Developments in global seatrade and container shipping markets: Their effects on the port industry and private sector involvement, *International Journal of Maritime Economics*, Volume 3, pp.3-26.

Peters., H. (1990) Structural Changes in International Trade and Transport Markets: The Importance of Markets, *The 2nd KMI International Symposium*. Seoul, pp.58-75.

Petri, K. and Smith, A. (1996) A Hierarchical Fuzzy Model for Predicting Casting Time in a Slip-casting Process, *Proceedings of the 5th Industrial Engineering Research Conference*, Minneapolis, pp.217-222.

Rimmer, P. (1998) Ocean liner shipping services: corporate restructuring and port selection/competition, *Asia Pacific Viewpoint*, Volume 39 Number 2, pp.193-208.

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

Roman, H. and Chalco, Y. (2006) H-continuity of fuzzy measures and set defuzzification, *Fuzzy Sets and Systems*, Volume 157, pp. 230–242.

Roscoe, J. (1975) *Fundamental research statistics for the behavioural sciences*, (2nd Ed), New York: Holt, Rinehart and Winston.

Rossi, P. and Freeman, H. (1989) *Evaluation: A Systematic Approach*, SAGE Publications, London.

Saaty, T., Ma, F. and Blair, P. (1977) Operational gaming for energy policy analysis. *Energy Policy,* Volume 5, pp.63–75.

Saaty, T. (1980) *Multicriteria decision making: the analytic hierarchy process*, McGraw-Hill: New York.

Saaty, T. (1984) Scaling method for priorities in hierarchical structures. *Journal of Mathematical Psychology,* Volume 15, pp.234–281.

Samsung heavy industries (2005) *Company Profile Profile*, [Online] 24 November 2005. <http://www.shi.samsung.co.kr/eng/>.

Sanchez, E. (1976) Resolution of compositional fuzzy relational equation, *Information and Control*, Volume 30, pp.38-48.

Sanchez, R., Hoffmann, J., Micco, A., Pizzolitto, G., Sguti, M. and Wilmsmeier, G. (2003) Port efficiency and international trade: port efficiency as a determinant of maritime transport costs, *Maritime Economics and Logistics*, Volume 5, pp.199-218.

Seabrooke, W., Hui, E., Lam, W. and Wong, G. (2003) Forecasting cargo growth and regional role of the port of Hong Kong, *Cities*, Volume 20, Number 1, pp. 51-64.

Shiizuka, H. and Sugiyama, T. (1992) Subjective Decision-making using Hierarchical Fuzzy Integral, *Proceedings of the 8th Fuzzy Systems Symposium*, Kobe, pp.33-36.

Simon, J. and Burstein, P. (1985) *Basic Research Methods in Social Science*, McGraw-Hill, Inc., New York.

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

Slack, B., Comtois, C. and Mccalla, R. (2002) Strategic alliances in the container shipping industry: a global perspective, *Maritime Policy and Management*, Volume 29 Number 1, pp.65-76.

Song, D-W (2002) Regional container port competition and co-operation: the case of Hong Kong and South China, *Journal of Transport Geography*, Volume 10, pp.99-110.

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

Song, D-W. and Yeo G-T. (2004) A competitive analysis of Chinese container ports using the Analytic Hierarchy Process. *Maritime Economics and Logistics*, Volume 6 Number 1, pp.34-52.

Sonmez, M., Holt, G., Yang, J. and Graham, G. (2002) Applying evidential reasoning to pre-qualifying construction contractors, *Journal of Management in Engineering*, Volume 18 Number 3, pp.111-119.

Stank, T., Goldsby, T and Vicery, S. (2003) Logistics service performance: estimating its influence on market share, *Journal of Business Logistics*, Volume 24, Number 1, pp. 27-55.

Starr, J. (1994) The mid-Atlantic Load Centre: Baltimore or Hampton Road? *Maritime Policy and Management,* Volume 21 Number 3, pp.219-227.

Sugeno, M. and Fujimoto, K. (1995), Hierarchical Decomposition Theorems for Choquet Integral Models, *Proceedings of International Joint Conference of the 4th IEEE International Conference on Fuzzy Systems and the 2nd International Fuzzy Engineering Symposium*, Yokohama, 2245-2252.

Terada, H. (2002) An analysis of the overcapacity problem under the decentralized management system of container ports, *Maritime Policy and Management*, Volume 29 Number 1, pp.3-15.

Tiwari, P., Itoh, H. and Doi, M. (2003) Shippers' port and carrier selection behaviour in China: a discrete choice analysis, *Maritime Economics & Logistics*, Volume 5, pp.23-39.

Thanopoulou, H. and Ryoo, D- K (1999) Korean liner shipping in the era of global alliances, *Maritime Policy and Management*, Volume 26 Number 3, pp.209-229.

Tongzon, J. (2001) Efficiency measurement of selected australian and other international ports using data envelopment analysis, *Transportation Research Part A: Policy and Practice*, Volume 35, Number 3, pp.317-330.

Tongzon, J. and Heng, W. (2005) Port privatization, efficiency and competitiveness: Some empirical evidence from container ports (terminals), *Transportation Research Part A: Policy and Practice,* Volume 39, Number 5, pp.405-424.

Tsai, H- H., and Lu, I- Y. (2006) The evaluation of service quality using generalized Choquet integral, *An International Journal of Information Sciences*, Volume 176 Number 6, pp.640-663.

Tsai, M. and Su, C. (2005) Political risk assessment of five East Asian ports-the viewpoints of global carriers, *Marine Policy*, Volume 29, pp. 291-298.

Turner, H. (2000) Evaluating seaport policy alternatives: a simulation study of terminal leasing policy and system performance, *Maritime Policy and Management*, Volume 27 Number 3, pp.283-301.

UNCTAD (1992) *Port Marketing and the Challenge of the Third Generation Port.* Geneva, pp.358-361.

UNCTAD (2003) *Report on the Expert Meeting on the Development of Multimodal Transport and Logistics Service*, TD/B/COM.3/59, United Nations.

UNCTAD (2004) *Assessment of a Seaport Land Interface: an Analytical Framework*, UNCTAD/SDTE/TLB/MISC/2004/3, United Nations.

UNCTAD (2005a) *Trade and Development Report*, UNCTAD/TDR/2005, United Nations.

UNCTAD (2005b) *Review of Maritime Transport*, UNCTAD/RMT/2005, United Nations.

Valentine, V. and Gray, R. (2001) The Measurement of Port Efficiency Using Data Envelopment Analysis, *Proceedings of the 9th World Conference on Transport Research, 22-27 July, Seoul, South Korea.*

Veldman, S. and Buckmann, E (2003) A model on container port competition: an application for the West European container hub-ports, *Maritime Economics and Logistics*, Volume 5, pp.3-22.

Voorde, E. and Winkelmans, W (2002) A general introduction to port competition and management. In: Winkelmans, W. eds. *Port Competitiveness: An economic and legal analysis of the factors determining the competitiveness of seaports*. Antwerp: De Boeck, pp. 1-15.

Wang, J. and Foinikis, P (2001) Formal safety assessment of containerships, *Marine Policy*, Volume 25, pp.143-157.

Wang, T. (2004) *Analysis of the Container Port Industry Using Efficiency Measurement: A Comparison of China with its International*, Ph.D. Dissertation, Department of Industrial and Systems Engineering, The Hong Kong Polytechnic University.

Wang, J., Ng, A and Olivier, D. (2004) Port governance in China: a review of policies in an era of internationalizing port management practices, *Transport Policy*, Volume 11, pp. 237-250.

Wang, J. and Slack, B. (2004) Regional governance of port development in China: a case study of Shanghai International Shipping Center, *Maritime Policy and Management*, Volume 31 Number 4, pp.357-373.

Websters Dictionary(2005)

Wilkinson, J. (1965) *The algebraic eigen-value problem*, Clarendon Press: Oxford.

Willingale, M. (1981) The port routing behaviour of short sea ship operator theory and practices. *Maritime Policy and Management*, Volume 8 Number 2, pp.109-120.

Wu, J. and Radbone, I. (2005) Global integration and the intra-urban determinants of foreign direct investment in Shanghai, *Cities*, Volume 22, Number 4, pp.275–286.

Wang, J. and Mcowan, S. (2000), Fast passenger ferries and their future, *Maritime Policy and Management*, Volume 27 Number 3, pp.231-251.

Wang, J. Ng, K and Oliviera, D (2004) Port governance in China: a review of policies in an era of internationalizing port management practices, *Transport Policy*, Volume 11, pp.237-250.

Wang, J. and Slack, B. (2004) Regional governance of port development in China: a case study of Shanghai International Shipping Center, *Maritime Policy and Management*, Volume 31 Number 4, pp.357-373.

Willmington, R. (2002) *The bigger the better?* Containerisation International, Volume 35, pp.52–53.

Xu, J. and Quaddus, M. (2005) Exploring the perceptions of knowledge management systems, *Journal of Management Development*, Volume 24, Number 4, pp. 320-334.

Yang, J., and Singh, M. (1994a) An evidential reasoning approach for multiple-attribute decision making with uncertainty, *IEEE transactions on system, man, and cybernetics,* Volume 24 Number 1, pp.1-18.

Yang, J., Sen, P. (1994b), A general multi-level evaluation process for hybrid MADM with uncertainty, *IEEE transactions on system, man, and cybernetics*, Volume 24 Number 10, pp.1458-1472.

Yap, W. and Lam, J. (2006) Competition dynamics between container ports in East Asia, *Transportation Research Part A*, Volume 40, pp.35-51.

Yeo, G- T., Roe, M. S., and Dinwoodie, J. (submitted paper), Evaluating the competitiveness of container ports in Korea and China, *Transportation Research Part A: Policy and Practice.*

Yeo, G- T., Song, D- W, Dinwoodie, J. and Roe, M. S., (submitted paper), The determination of compromise weights in an MDMG problem studying the competitiveness of container ports, *European Journal of Operational Research.*

Yu, C., Chen, M., Oum, T. and Zhang, A. (2002) Transport Demand, Infrastructure Capacity and Transport Cost in Northeast Asia: Current Status and Forecast Fact-Finding Report: China, In: The Korea Transport Institute ed. *Building an Integrated Transport Market for China, Japan, and Korea: Elimination of Barriers*. KOTI International Seminar, Seoul.

Yu, H- C., Lee, Z- Y. and Chang, S- C. (2005) Using a fuzzy multi-criteria decision making approach to evaluate alternative licensing mechanisms, *Information Management*, Volume 42 pp.517-531.

Yun, W-C, and Zhang, X (2006) Electric power grid interconnection in Northeast Asia, *Energy Policy*, Volume 133 Number 1, pp.225-230.

Zadeh, L. (1965) Fuzzy sets, *Information and Control*, Volume 8, pp.338-353.

Zadeh, L. (1975) The concept of a linguistic variable and its applications to approximate reasoning. *Information and Science*, Volume 8, pp.199-249.

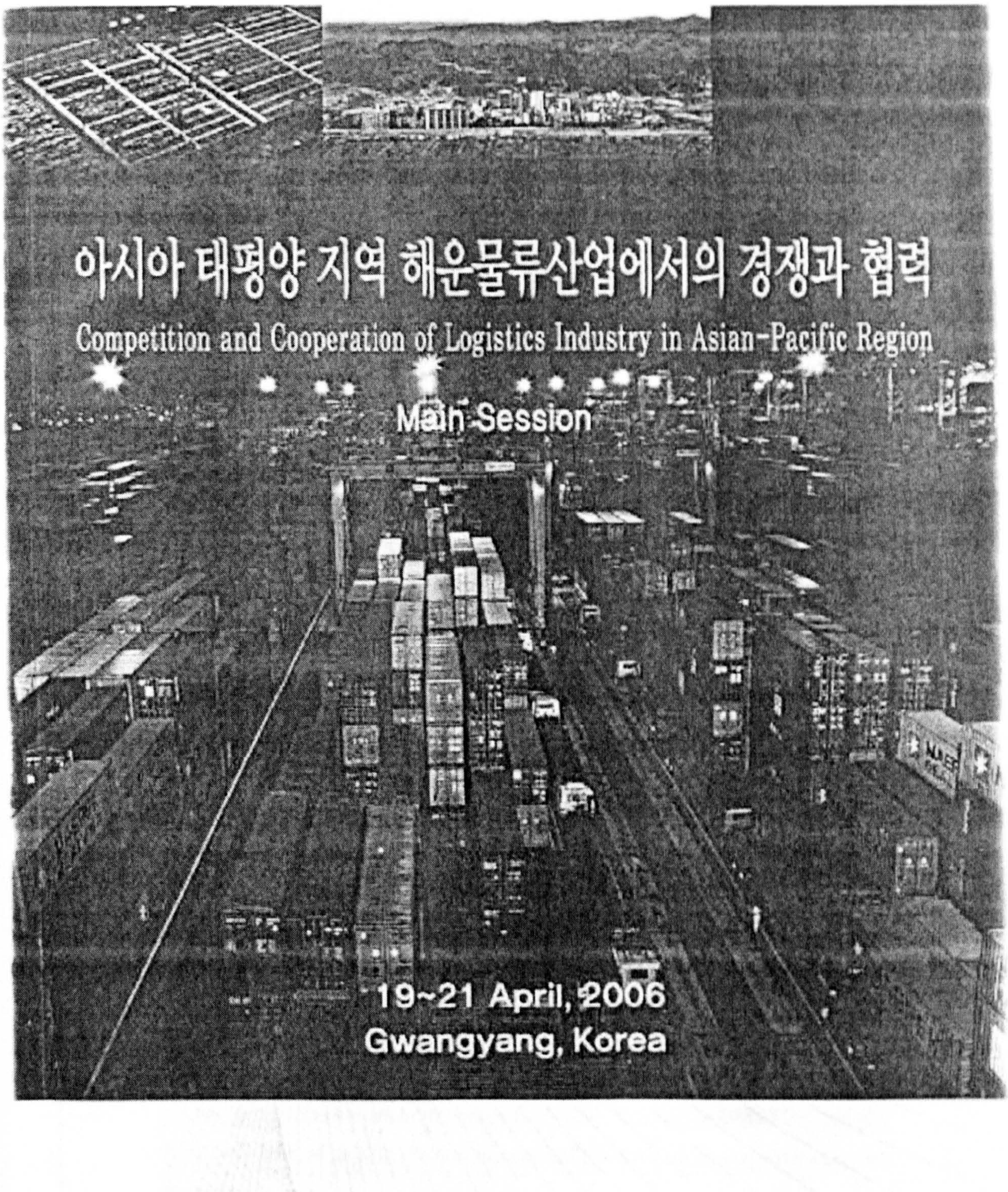
Zhang, A. (2002) Assessment of China Transportation and Logistics Services industry: Focus on Shanghai Region, In: The Korea Transport Institute ed. *Building an Integrated Transport Market for China, Japan, and Korea: Elimination of Barriers.* KOTI International Seminar, Seoul.

Zhu, D. (2004) Chinese Logistics Report, In: Lim, J. eds. *An environment changes in world logistics*, Korea Maritime Institute, Seoul p.23.

Zimmermann, H. (1991) *Fuzzy set theory and its applications*, Kluwer Academic Publishers, Boston.

PUBLICATIONS A

Published refereed conference paper
(*Proceeding of the 4th International Gwangyang Port Forum and International Conference of Journal of Shipping and Logistics*, Kwangyang, South Korea, pp. 665-682, entitled 'Quantification of experts' knowledge for port competitiveness using trapezoid fuzzy number')



■ 주최 : 전라남도, 광양시, 여수지방해양수산청, 한국컨테이너부두공단
Hosted by Jeollanam-do Province, Gwangyang City, Yeosu Regional Ministry of Maritime Affairs and Fisheries Office

■ 주관 : 사단법인 한국해운물류학회
Organized by The Korean Association of Shipping and Logistics, INC.

1. Introduction

Northeast Asia (NEA) consists of China, Japan, Mongolia, North Korea, the Russian Federation and South Korea (Yun and Zhang, in press). It is also part of the Asia-Pacific community and has grown to become the largest of Asian markets (Akashi et al., 2010). Among these NEA nations, the representatives of major growth markets are China, Korea and Japan. Recently, using their geographical advantage of being close to the world's major trade routes, they have developed expansion of their container ports and logistics hubs which have resulted in severe port competition for securing calls made by shipping lines, increased transshipment throughput and the expansion of hinterland domination. In particular, as a consequence of China's booming economy and increased import and export container cargo volumes in the past, six ports have been ranked in the world top ten list and new emerging ports are rapidly expanding (UNCTAD 2010).

In the light of increasing port competitiveness, the focus of interest in sea ports has changed from the traditional sea and land interface to that of value added logistics (UNCTAD 2010). Various strategies have been used and introduced to improve profits and attract port throughputs. Shipping companies, which usually interact with ports as customers, have always chosen the most efficient ports and services, and also concentrated on a limited number of ports due to scale economies. For these reasons port competitiveness has concerned stakeholders with port-related interests.

The evaluation of port competitiveness can give encrypted information to every stakeholder; however, when evaluation is dependent on confidentiality and corporate business secrets, obtaining secondary data is impossible. These are the main difficulties in dealing with such evaluation factors.

This paper aims to overcome these problems and to solve those associated with port competitiveness using a fuzzy methodology. This paper consists of six sections. After the introduction, the second section deals with difficulties in the quantification of port competitiveness factors. In the third section, the research methodology will be suggested, and the fourth section explains the survey procedures. The fifth section mainly analyses the quantification of experts' knowledge, and finally in the sixth section conclusions will be provided.

2. Difficulties in the Quantification of Port Competitiveness Factors

2.1 Definition of variables (factors) in Northeast Asia

Changes in world trade and the shipping environment have created [illegible] competition between ports in Northeast Asia. To evaluate the competitiveness of major ports in the region, it was necessary to identify the components which were influential. Based on literature related to port selection and competitiveness, responses of shipping companies and shippers, exploratory factor analysis to reveal their port service perceptual position, and their investment behaviors, we isolated seven underlying factors in these regions. A varimax rotation used to transform a set of interrelated variables into a set of unrelated linear combinations of these variables was employed to identify structural dimensions. Valid information-only variables with factor loadings greater than 0.5 were extracted. Seven factors extracted account for an accumulated explanation of variance of 72.6% and thus may be adequate to represent the 18 strategic dimensions. The detailed explanations regarding variables are as follows:

Port Service: As the overall quality of service provided to users in a port area increases, so does the port's competitiveness. Port service includes "prompt response", "24 hours a day, seven days a week service" and "zero waiting time service".

Hinterland Condition: As the condition of the hinterland improves, so does the port's competitiveness. Hinterland condition includes "professionals and skilled labour in port operations", "size and activity of Free Trade Zone (FTZ) in port hinterland" and "volume of total container cargo" of which the latter is the most important attribute. This implies that Busan and Shanghai have huge hinterlands encompassing the Korean peninsula and China mainland respectively. For more efficient movement of increased cargoes, port operators concentrate on port productivity and investments. This determination acts to increase port competitiveness.

Availability: This includes "availability of a vessel berth on arrival at port" and "port congestion". The latter element is most highly correlated with this factor. Korean and Chinese ports experience heavy port traffic, and for just in time delivery, the availability of berths is a vital attribute for port users.

Connectivity This component includes "water depth in approach channel and in berth" "sophistication of port information and its application" and "reliability of port labour"

Logistics Cost The lower the cost the greater the level of competitiveness. Logistics costs include "inland transportation cost" "cost related to customs and cargo clearance" and "freight and time on the harbour"

Regional Centre Hinterland location is deemed to render a port more competitive. The concept of a regional centre includes geographical aspects such as "proximity to main trade routes" and "port accessibility".

Connectivity The greater the connectivity the higher the level of competitiveness. Connectivity includes both "land distance and connectivity to major shippers" and "an efficient inland transport network"

2.2 Difficulties in measuring factors

The evaluation of port competitiveness in Southeast Asia consisted of the five principal factors and the 18 detailed attributes described in the previous section. As for data collection and the optimal quantity of input data, Wang (2001) argued that "*to incorporate all variables into the study is almost impossible, not only because of the data collection problems involved but also because of the statistical constraints in the estimation. In fact, a compromise solution is to find a few indicators that provide the closest quantitative proxies to the problem*"

However, there has been an increasingly acute debate on the definition of input factors and finding quantitative proxies. The 'availability of a vessel berth on arrival at port and 'port congestion' in terms of availability have been seen as closely related to berth availability. To quantify this into an input factor, Tongzon (2001) used 'number of berths' as a measuring indicator, while Cullinane *et al* (2002) and Notteboom *et al* (2000) included 'length of berth' as a measurement. It is currently being debated which indicator is more preferable.

With reference to the 'professional and skilled labour 'factor in terms of hinterland

conditions it is very difficult to estimate these two. Valentine and Gray (2001) also mentioned the problem of inaccuracy of manpower information in the port area. In port, vessels' vessel container cargoes is also difficult to trace to an agent further because there are many agents in the exported throughput from each terminal and the operations of the whole port as reported by Wang (2001).

In the light of the environmental factors, the operational level of port investment and its implication on ships' is also difficult to measure. According to the Shanghai Port Authority (2001), port performance can be regarded as a system consisting of the environment, port resources, port operations, cargo handling efficiency and port management information system (Port-MIS). However, how to measure the correctness of the system is still a problem.

In addition to the above mentioned obstacles, further difficulties exist in measuring uncertainty and ambiguity in certain knowledge qualification and estimating inherent factors, the so-called fuzziness. Tiwari et al. (2001, p281) claim fuzziness can exist in the evaluation process, as stated in the following:

"*When a shipper says that shipping through port A rather than port B is efficient, he may or may not know the number of berths available, but he definitely knows that shipping through port A would be quicker and efficient. The shipper is actually unconscious the port characteristics in the decision process. Similarly, natural behavior by a shipper would mean that he chooses a port by intermediate service factors*"

From the above statement, experts' opinions do not focus on exact factors, but also seem to rely on their experiences, which consists of subjective and qualitative information (Chen et al. in press). To deal with such problems, natural language, which can express the experts' thinking and preferences, stable semantic words have been employed within the fuzzy evaluation methodologies (Han et al. 2003; Chou et al. 2003).

To summarize, the evaluators in each group of port stakeholders need to evaluate the port port according to their need to know which ports are the more competitive for them to select and use. In this case, they use their 'experiences' and 'perceptions' of ports, so-called experts' judgements. These judgements do not rely on detailed variables and

literature, are mostly related to qualitative evaluation. From this point of view, it is unsuitable to use all the 16 detailed attributes which pose along with the results by Wang (2000). In this paper, these two aspects potential factors will be used for further analysis.

3. Research Methodology

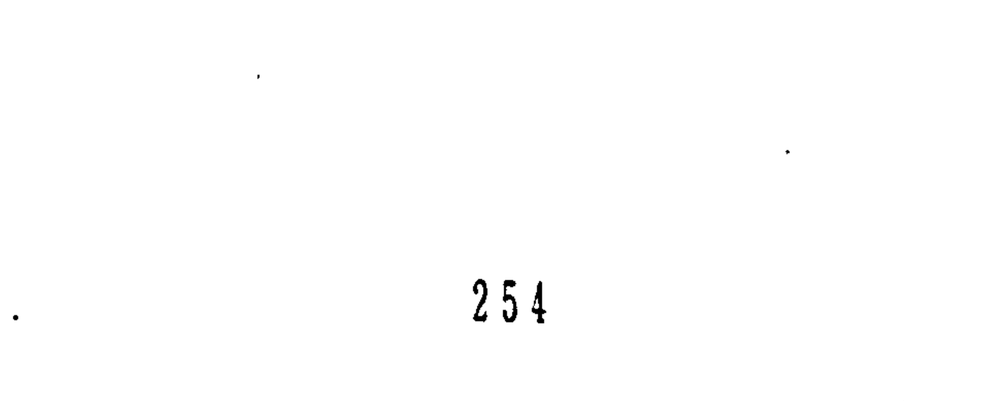
For the measurement of experts' perceptions/judgements, the fuzzy method has been introduced. This method accepts a linguistic expression for subjective factors such as very low, low, fair, high, and very high (Zadeh, 1975; Zimmermann, 1987). Moreover, there are many shapes of fuzzy numbers, the triangular and trapezoidal ones are the most commonly used (Kaufmann and Gupta, 1988 and 1991). In this research, for more precise measurement, the trapezoidal fuzzy number has been adopted to reflect the uncertainty in the details.

- Definition of membership function

A membership function of trapezoidal fuzzy number $A=(a_1,a_2,a_3,a_4)$, $(a_1 \le a_2 \le a_3 \le a_4)$ is defined to be:

$$\mu_A(x)=\begin{cases} 0, & x \le a_1, \\ (x-a_1)/(a_2-a_1), & a_1 \le x \le a_2, \\ 1, & a_2 \le x \le a_3, \\ (x-a_4)/(a_3-a_4), & a_3 \le x \le a_4, \\ 0, & x \ge a_4 \end{cases}$$

Figure 3.1 Trapezoidal fuzzy numbers



• Definition of operation

Operation laws of two positive trapezoidal fuzzy numbers $A=(a_1,a_2,a_3,a_4)$ and $B=(b_1,b_2,b_3,b_4)$ are defined to be:

$$A(+)B=(a_1,a_2,a_3,a_4)(+)(b_1,b_2,b_3,b_4)=(a_1+b_1,a_2+b_2,a_3+b_3,a_4+b_4).$$

$$A(-)B=(a_1,a_2,a_3,a_4)(-)(b_1,b_2,b_3,b_4)=(a_1-b_4,a_2-b_3,a_3-b_2,a_4-b_1).$$

$$A(\times)B=(a_1,a_2,a_3,a_4)(\times)(b_1,b_2,b_3,b_4)=(a_1b_1,a_2b_2,a_3b_3,a_4b_4).$$

$$A(\div)B=(a_1,a_2,a_3,a_4)(\div)(b_1,b_2,b_3,b_4)=(a_1/b_4,a_2/b_3,a_3/b_2,a_4/b_1)$$

• Definition of defuzzification

For a defuzzification of trapezoidal fuzzy numbers $A=(a_1,a_2,a_3,a_4)$ is defined to be $x=(a_1+a_2+a_3+a_4)/4$.

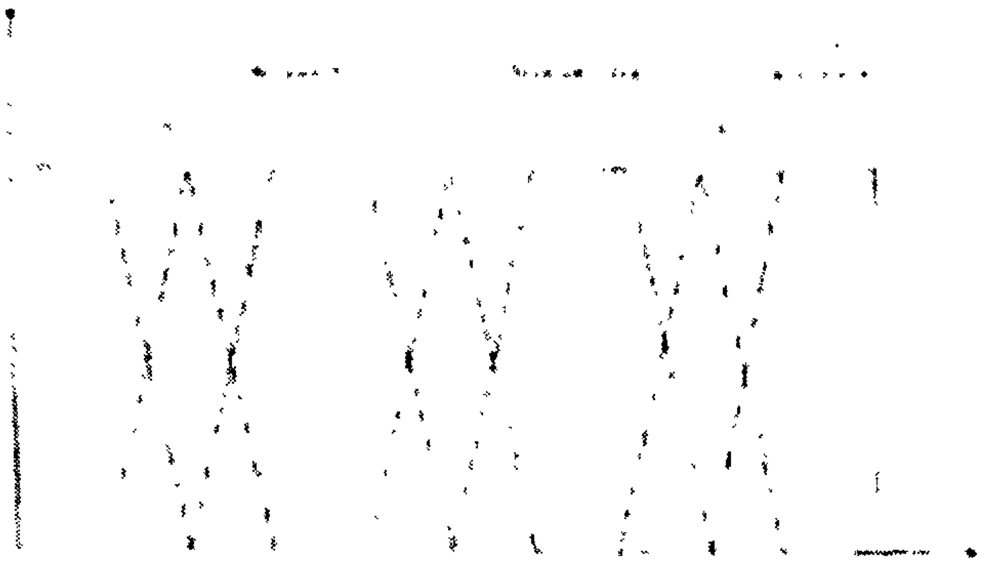
• Definition of linguistic variables

A decision maker should be able to use the linguistic variables easily to evaluate the scoring of each part. The trapezoidal membership functions are adequate for capturing the vagueness of linguistic assessments.

Table 3.1 Membership functions for linguistic variables of scoring for each part

[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]

Figure 3.2 Linguistic expression of scoring for each port



4. Survey Procedures

4.1 Port selection for analysis

For the selection of leading ports in East targeted area, Lim *et al.* (2010) used the total container throughput as the major index. Also in this paper, container throughputs obtained from the data in Containerisation International Yearbook (2011) were adopted as the selection criteria. Accordingly, ports located in NEA and ranked within the top 20 were selected for fuzzy evaluation.

Table 4.1 Top 20 ports selected

Rank	Ports	Container throughputs (thousands)	Country
1	Hong Kong	24,384	China
2	Singapore	29,937	Singapore
3	Busan	14,425	South Korea
4	Shenzhen	22,510	China
5	Kaohsiung	9,774	Taiwan
6	Shanghai	29,069	China
7	Rotterdam	11,877	Netherlands
8	Los Angeles	7,941	USA
9	Hamburg	9,900	Germany
10	Antwerp	8,664	Belgium
11	Port Klang	7,309	Malaysia
12	Long Beach	6,455	USA
13	Dubai	11,827	UAE
14	Tianjin	11,590	China
15	New York/New Jersey	5,265	USA
16	Qingdao	13,020	China
17	Bremen	5,888	Germany
18	Guangzhou	14,744	China
19	Piraeus	4,316	Greece
20	Tokyo	4,479	Japan

Source: Containerisation International Yearbook (2011)

The selected ports are Hong Kong (1st), Busan (3rd), Shanghai (4th), Kaohsiung (5th), Shenzhen (6th), Yantian (14th), Qingdao (16th) and Tokyo (20th). With respect to the ports being representative for the region, the selected ports were major hub ports for each nation i.e. Busan from South Korea, Kaohsiung from Taiwan and Tokyo from Japan. However, the elimination of Yantian port from the evaluation was regarded as reasonable because Shenzhen comprises the container terminals of Yantian, Shekou and Chiwan (Cullinane et al. 2004).

4.2 Sample selection

For the purpose of selecting respondents, the sample frame was divided into three groups, i.e. the academic/researcher group, the customer group and the provider group. Using an on-line questionnaire format on the Internet, a total of 300 questionnaires were posted to each expert from October 2006 to January 2007 and the valid response rates for each group varied from 13% to 17%. The detailed business areas and numbers of respondents are shown in Table 4.2 below.

Table 4.2 Detailed status of response

	Academic /researcher Group		Customer group		Provider group		
Usable responses	UN	IS	SC	FF	TO	PA	GO
Total distributed	100		100		100		
Total received	10	4	13	4	8	4	2
Unable responses	9	4	13	4	7	4	2
Usable response rate (%)	13		17		13		

Notes: UN: University, IS: Regional Institute, SC: Shipping Company, FF: Freight Forwarder, TO: Terminal Operator, PA: Port Authority, GO: Government

Regarding the response rate, Larson and Poist (2004) noted that they have been declining year by year, and suggested the following four types of survey methods and return rates:

1) No incentive, no follow-up: 8.4%

2) No incentive, follow-up mailing with replacement questionnaire: 19.6%

3) $ 1.00 prepaid monetary incentive, no follow-up: 17.2%

4) $ 1.00 prepaid monetary incentive, follow-up up mailing with replacement questionnaire: 23.5%

The authors stressed that offering a monetary incentive doubled the return rates compared to the no incentive method. In the present study the second option, no incentive and follow-up mail was selected.

In order to increase the response rates, follow-up mail was sent two weeks after the initial mailing. After all these procedures, the rates stood at 14.3%. This result is due to the previously mentioned obstacles which decrease the response rate, i.e. delicate questions related to competition, and respondents' perception of them being related to corporate operational secrets.

4.3 Respondents' profiles

Respondent profiles are summarised in Table 4.3

Table 4.3 Years employed and job position for each group

Parameter	Percentage of respondents		
	Academic/ research group	Customer group	Provider group
Years employed in the organisation			
less than 5	18	20	0
5–10	18	15	23
11–15	46	35	47
16–20	9	12	15
More than 20	9	6	15
Respondents' job positions			
Junior level	9	29	15
Middle level	36	35	77
Senior level	55	36	8

Turning to the average ship size, 69% of the organisations investigated usually used containerships of between 3,000 and 5,000 TEUs, 6% over 5,000 TEUs and 13% less than 300 TEU's. This means that various classes of containership were being used in the targeted organisations. Hence, reflections of various aspects could be obtained in the assessment of port competitiveness.

Regarding the sea routes used by the targeted organizations, the Northeast Asia to USAwere predominant with a share of 31%, internal routes within the targeted region standing at 31% and both the European and the Southeast Asian ones account for 17%.

5. Evaluating Port Competitiveness Factors for Targeted Ports

Due to difficulties experienced with quantifying and measuring factors, the existing studies have used proxies or representative attributes that were easy to use to collect quantitative data. To solve this problem the questionnaire and 'the *fuzzy* number concept' were introduced, as suggested in section 3. To obtain experts' judgements for each factor on each port, the questions, which consisted of linguistic variables, were expressed in scales i.e. very poor, poor, medium poor, fair, medium good, good or very good. The results of the mean by trapezoidal fuzzy numbers are provided in Table 5.1.

Table 5.1 Mean of each port score using *fuzzy* number

	Port service	Hinterland Condition	Availability	Convenience	Logistics Cost	Regional Centre	Connectivity
Busan	0.63186, 0.81186, 0.96112, 0.71107	0.41385, 0.59375, 0.79375, 0.61687	0.58137, 0.78137, 0.93813, 0.76806	0.49321, 0.69321, 0.85677, 0.73122	0.46868, 0.66868, 0.82306, 0.71357	0.56170, 0.76170, 0.91810, 0.86164	0.47706, 0.67706, 0.88229, 0.81611
Hong Kong	0.66727, 0.76727, 0.51825, 0.78683	0.55173, 0.65173, 0.70464, 0.78230	0.63746, 0.72745, 0.76590, 0.84139	0.60003, 0.70003, 0.75686, 0.83706	0.63804, 0.73682, 0.43224, 0.52971	0.75013, 0.85013, 0.25645, 0.67888	0.76104, 0.86104, 0.82430, 0.88044
Kaohsiung	0.56772, 0.76772, 0.61011, 0.70045	0.44314, 0.64314, 0.58416, 0.67831	0.60613, 0.80613, 0.64128, 0.72882	0.49729, 0.69729, 0.64431, 0.73169	0.38683, 0.63683, 0.52851, 0.62501	0.46350, 0.66350, 0.23154, 0.38150	0.56160, 0.76160, 0.39814, 0.66848
Qingdao	0.39231, 0.49231, 0.62711, 0.62292	0.46582, 0.66582, 0.56861, 0.63905	0.45967, 0.65967, 0.62438, 0.68351	0.41961, 0.51961, 0.70701, 0.66139	0.17028, 0.37028, 0.62700, 0.72443	0.37873, 0.47873, 0.52715, 0.62150	0.29187, 0.49186, 0.54311, 0.63052
Shanghai	0.46727, 0.56727, 0.61506, 0.70043	0.60065, 0.70065, 0.75046, 0.82299	0.50784, 0.60784, 0.64781, 0.71325	0.46833, 0.56833, 0.62763, 0.70760	0.45913, 0.55043, 0.62681, 0.70721	0.63306, 0.63091, 0.73193, 0.81629	0.56552, 0.66552, 0.74061, 0.80528
Shenzhen	0.48311, 0.58311, 0.61314, 0.72408	0.53685, 0.63685, 0.68416, 0.77817	0.50721, 0.60721, 0.66150, 0.75351	0.48311, 0.58311, 0.63725, 0.73629	0.13946, 0.53066, 0.61551, 0.71101	0.54163, 0.64163, 0.68689, 0.77553	0.59117, 0.69117, 0.76780, 0.76184
Tokyo	0.43650, 0.53650, 0.59712, 0.68109	0.44766, 0.51766, 0.58562, 0.68103	0.44847, 0.54847, 0.59251, 0.68409	0.11382, 0.54382, 0.59055, 0.69136	0.24006, 0.29819, 0.37681, 0.45581	0.47466, 0.57168, 0.62113, 0.71045	0.13063, 0.52763, 0.56627, 0.67919

Reference: Chen, Lesaja, Hussain & Ouhra (2011, p.43) clearly defined it as "the inverse step is approximate reasoning and it consists in the replacement of a fuzzy set with a crisp set that is somehow similar or matches it".

Using the equation suggested in section 3, the above mean of each port score can be changed from trapezoidal fuzzy numbers to crisp numbers, as shown in the table below

Table 5.2 Crisp values of each port scoring using defuzzification

	Port service	Hinterland Condition	Availability	Convenience	Logistics Cost	Regional Centre	Connectivity
Busan	0.65079	0.53071	0.60223	0.61435	0.78123	0.69261	0.69546
Hong Kong	0.78156	0.69338	0.74850	0.72831	0.41145	0.77657	0.78113
Kaohsiung	0.64370	0.56262	0.62311	0.61810	0.61353	0.65956	0.70430
Qingdao	0.56815	0.58068	0.57673	0.54103	0.55800	0.60690	0.61067
Shanghai	0.66870	0.72570	0.69219	0.58601	0.59032	0.70345	0.68641
Shenzhen	0.61184	0.66729	0.63550	0.57969	0.56747	0.64136	0.67240
Tokyo	0.57018	0.56516	0.56241	0.57251	0.72652	0.66612	0.70015

The final stage in obtaining each port score involved applying a level process procedure between zero and one. To obtain these values, the largest crisp values were set to be one and each evaluation value by port was obtained as a relative ratio against this which is illustrated in Table 5.3 below.

Table 5.3 Final scoring for each port

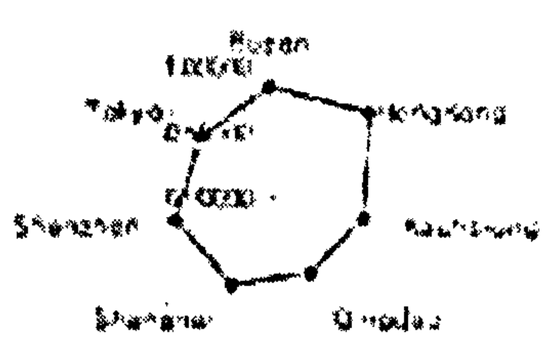
	Port service	Hinterland Condition	Availability	Convenience	Logistics Cost	Regional Centre	Connectivity
Busan	0.83580	0.73810	0.80141	0.84728	0.92869	0.85716	0.85956
Hongkong	1.0000	0.92737	1.0000	1.0000	0.68306	1.0000	1.0000
Kaohsiung	0.74725	0.77804	0.81118	0.85426	0.85623	0.75110	0.73979
Qingdao	0.84780	0.79303	0.77963	0.74820	1.0000	0.81084	0.82851
Shanghai	0.79313	1.0000	0.84788	0.81227	0.97579	0.91347	0.87176
Shenzhen	0.77363	0.91932	0.85416	0.84222	0.97837	0.85116	0.86726
Tokyo	0.71372	0.77830	0.76043	0.78486	0.83621	0.76770	0.72289

6. Conclusions and Discussions

A more detailed interpretation of the previous section's evaluation results in seven principal factors i.e. port service, hinterland condition, availability, convenience, logistics cost, regional centre and connectivity is provided in this section. McCalla (1999) stated that, port service can be defined as 'the global issues and the local responses'. More specifically, the detailed definition for port service suggested in section 2, included "prompt response", "24 hours a day, seven days a week service" and "zero waiting time service".

Using the integrated experts' judgements, each port service score could be obtained as shown in Figure 6.1. Experts perceived that Hong Kong had the highest score (1.00000), followed by Busan (0.82680) and Shenzhen (0.77953).

Figure 6.1 Scoring for port service on each port



To measure the hinterland condition as a principal factor, experts were asked to consider three attributes i.e. "professionals and skilled labour in port operations", "size and activity of Free Trade Zone (FTZ) in port hinterland" and "volume of total container cargos" simultaneously. Very interestingly, Busan had the lowest score while Shanghai had the highest. Due to the closeness of a mountain to the major container terminals, the very nearness of the city center and road traffic congestion, the hinterland condition acts as a major disadvantage to Busan port. Furthermore, to cover the lack of area for container terminals, Busan operates off-dock container terminals (ODCY).

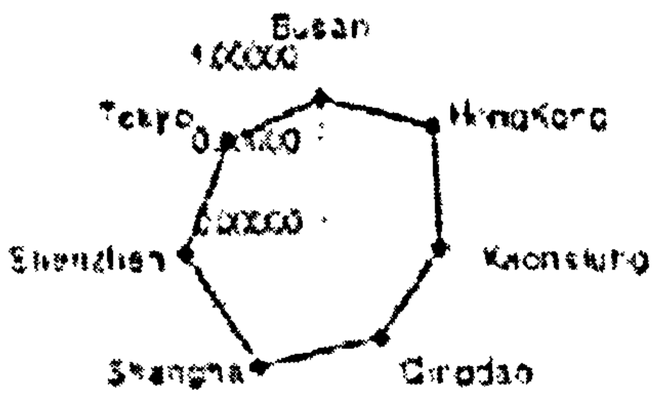
Frémont and Ducruet (2005, p.127) note the inefficiency of Busan's hinterland by stating that

"Port traffic is dispersed all over the urbanized area because 37 off-dock container yards are scattered around the city. In 2000 they handled 3.1 million import/export containers"

In contrast, in order to attract foreign direct investment (FDI), Shanghai has created four special zones i.e. the Lujiazui Finance and Trade Zone, the Jinqiao Export Processing Zone, the Waigaoqiao Free Trade Zone and the Zhangjiang Hi-Tech Park (Wu and Radburne, 2005). From this point of view, hinterland condition plays a role that is of major advantage

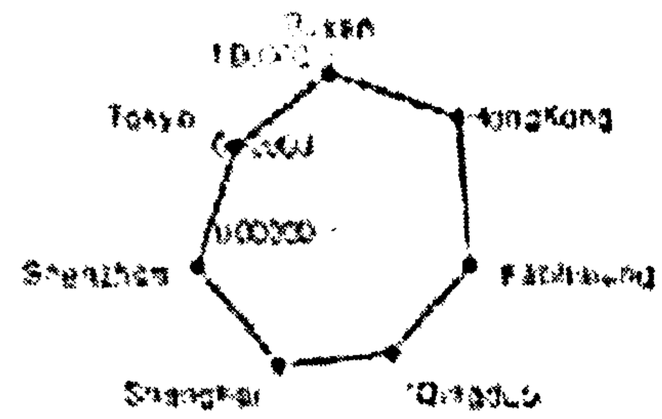
to Shanghai.

Figure 6.2 Scoring for hinterland condition on each port



In this paper, availability included two factors "availability of a vessel berth on arrival in port" and "port congestion". In NEA, these two factors are regarded as the most important attributes, which is in line with the factors suggested by Hu (2000) with regard to the availability of facilities e.g. provision of vessel traffic system, availability of adequate container yards and backup facilities and availability of container handling equipment. Regarding availability, Hong Kong occupied the top position over the other ports.

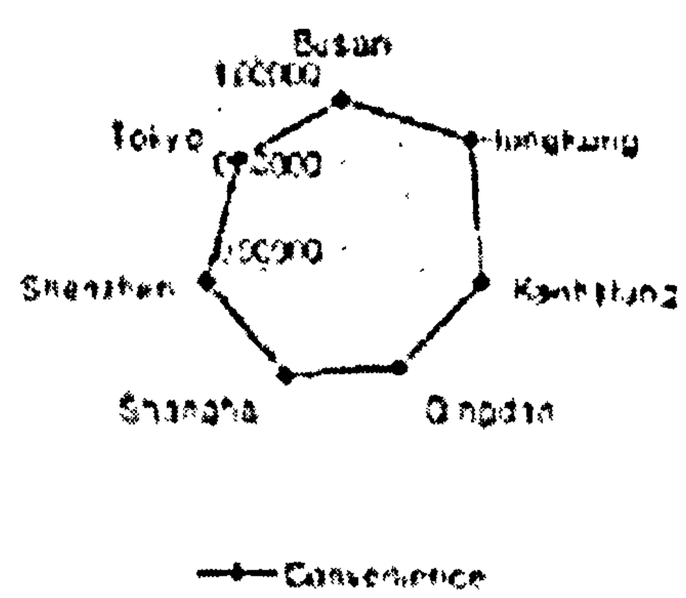
Figure 6.3 Scoring for availability on each port



The evaluation of scoring for convenience on each port was processed by using the integrated judgement, that is, experts simultaneously considering the three attributes i.e. "water depth in approach channels and at berth", "sophistication of port information and its application" and "the stability of port labour" and providing a score for the convenience

factor. As a result, Hong Kong had the highest value followed by Kaohsiung, Busan and Shenzhen, which had similar scores to each other.

Figure 64 Scoring for convenience on each port

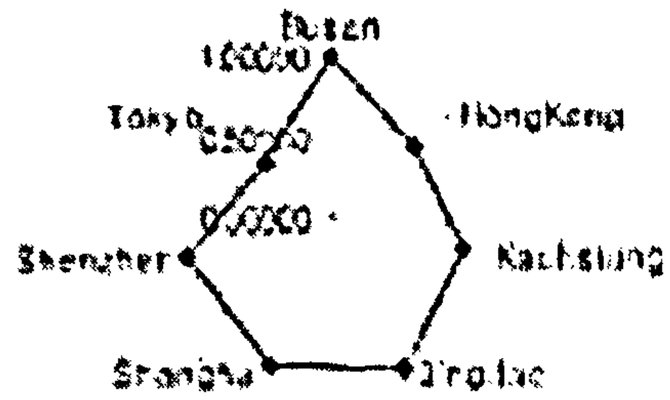


Cullinane *et al.* (2002), Sanchez *et al.* (2003), Michaward Kaufani (2004) and Tongzon and Heng (2005) experienced difficulties assessing the logistics cost factor due to various reasons. This is especially true for NEA, due to severe competition and the ports' operational secrecy, where obtaining secondary data for this factor still remains a problematic issue. To overcome this, the fuzzy number concept was introduced and resulted in a successful evaluation. Except for Hong Kong, the Chinese ports (Qingdao, Shanghai and Shenzhen) and Busan had a high ranking. However, Hong Kong, which was in the top position for port service availability, convenience, regional centre and connectivity, had the lowest score, thus making it the port's weakest point.

This result is in line with the following analysis by Seabrooke et al. (2003, 50p):

"*Hong Kong's terminal handling charges are the highest in the world. Terminal handling charges at Hong Kong are at least 65% more expensive than other Asian ports and in many cases much higher than that*"

Figure 6.5 Scoring for logistics cost on each port

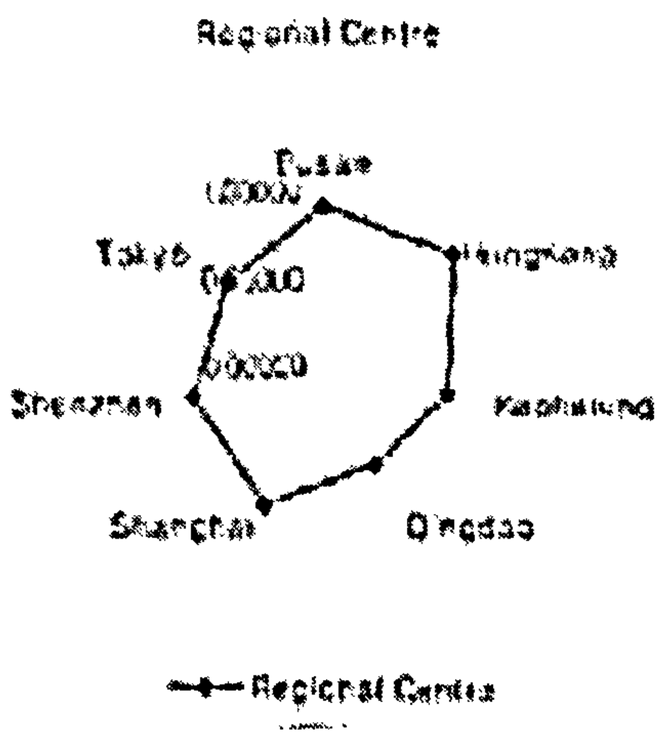


The regional centre as an evaluation factor is defined as a sea port having a good location combined with the attributes of "deviation from main trunk routes" and "port accessibility". According to the results from the experts' judgements, Hong Kong received the highest score followed by Shanghai and Busan.

In the case of Busan, the Korean government has been focusing on spatial strategy recently, as mentioned by Park (2005, p561):

"The South Korean government recently announced an ambitious plan to develop global hubs of international movement of capital and skilled labour in several localities, designating these "special economic zones", "economic free zones", and "international free cities"

Figure 6.6 Scoring for regional centre on each port



The findings noted in this paper regarding port competitiveness, procedures for quantification of experts' knowledge of the factors and evaluating values for each factors for each port in Northeast Asia provided basic groundwork for future research. Using these fundamental elements, the precise evaluation of port competitiveness in Northeast Asia will be possible.

References

Chen C- T., Lin C- T. and Huang S- F. (In press) A Fuzzy approaches for supplier evaluation and selection in supply chain management, *International Journal of Production Economics*

Chiou H- H., Tzeng, G- H., and Cheng, D- C. (2005) Evaluating sustainable development strategies using fuzzy MCDM approach, The International Journal of Management Science, Volume 33, pp223-234

Containerisation International Yearbook (2001).

Cullinane, K., Song, D-W., and Gray, R (2002) A stochastic frontier model of the efficiency of major container terminals in Asia: assessing the influence of administrative and ownership structures, *Transportation Research Part A: Policy and Practice*, Volume 36, pp.743-762.

Cullinane, K., Wang, T., and Cullinane, S. (2001) Container terminal development in mainland China and its impact on the competitiveness of the port of Hong Kong, *Transport Reviews*, Volume 21, Number 1, pp. 3356.

Fremont, A. and Debrie, C. (2005) The emergence of a mega port- from the global to the local, the case of Busan, *Tijdschrift voor Economische en Sociale Geografie*, Volume 96, Number 4, pp. 421432.

Ha, M (2003) A comparison of service quality at major container ports: implications for Korean ports, *Journal of Transport Geography*, Volume 11, pp.131-137.

Kaufmann A., Gupta, M (1988) *Fuzzy Mathematical Models in Engineering and Management Science*, North-Holland, Amsterdam.

Kaufmann, A., Gupta, M. (1991) *Introduction to Fuzzy Arithmetic: Theory and Applications*, Van Nostrand Reinhold, New York.

Larson, P. and Poist, R. (2004) Improving response rates to mail surveys: a research note, *Transportation Journal*, Volume 31, Number 4, pp.67-74.

Lirn, T., Thanopoulou, H. and Beresford, A. (2003) Transhipment port selection and decision-making behaviour: Analysing the Taiwanese case, *International Journal of*

Logistics Research and Applications Volume 6 Number 4, pp.229-244.

Lim, T., Theocaulous, H. and Beresford, A. (2004) An Application of AHP on Transhipment Port Selection: A Global Perspective, *Maritime Economics & Logistics* Volume 6, pp.70–91.

Malchow, M. and Kanafani, A. (2001) A disaggregate analysis of port selection, *Transportation Research Part E: Logistics and Transportation Review*, Volume 40 Number 4, pp.317-337.

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

Nathanson, T., Cheek, C. and Brooks, J. (2003) Measuring and explaining the relative efficiency of container terminals by means of Bayesian Stochastic Frontier Models, *International Journal of Maritime Economics*, Volume 2 Number 2, pp.83–103.

Oum, H., Kim, T., Oum, T. and Yan, C. (2005) Choice of air cargo transhipment airport: an application to air cargo traffic to/from Northeast Asia, *Journal of Air Transport Management*, Volume 11, pp.149–159.

Park, B. (2003) Spatially selective liberalization and graduated sovereignty: Politics of neo-liberalism and "special economic zones" in South Korea, *Political Geography*, Volume 24 , 850-873.

Roman, H. and Chalco, Y. (2007) H-Decontinuity of fuzzy measures and set defuzzification, *Fuzzy Sets and Systems*, Volume 157, pp. 230212.

Sanchez, R., Hoffmann, J., Micco, A., Pizzolitto, G., Sgut, M. and Wilmsmeier, G. (2003) Port efficiency and international trade: port efficiency as a determinant of maritime transport costs, *Maritime Economics & Logistics*, Volume 5, pp.199–218.

Sealtracker, W., Hui, E., Lam, W. and Wong, G. (2003) Forecasting cargo growth and regional role of the port of Hong Kong, *Cities*, Volume 20, Number 1, pp. 51–61.

Song, D-W. and Yeo, G-T. (2004) A competitive analysis of Chinese container ports using the Analytic Hierarchy Process, *Maritime Economics & Logistics*, Volume 6 Number 1, pp.34–52.

Tiwari, P., Itoh, H. and Doi, M. (2003) Shippers' port and carrier selection behaviour in China, a discrete choice analysis, *Maritime Economics & Logistics*, Volume 5, pp.23–39.

Tongzon, J. (2001) Efficiency measurement of selected australian and other international ports using data envelopment analysis, *Transportation Research Part A: Policy and Practice*, Volume 35, Number 3, pp.107-122.

Tongzon, J. and Heng, W. (2005) Port privatization, efficiency and competitiveness: Some empirical evidence from container ports (terminals), *Transportation Research Part A:*

Policy and Practice, Volume 39, Number 5, pp.406-424.

UNCTAD (2004) *Assessment of a Seaport Land Interface: an Analytical Framework*, UNCTAD/SDTE/TLB/MISC/2004/3, United Nations.

Valentine, V. and Gray, R. (2001), The Measurement of Port Efficiency Using Data Envelopment Analysis, *Proceedings of the 9th World Conference on Transport Research, 22-27 July, Seoul, South Korea*

Wang, T. (2004) *Analysis of the Container Port Industry Using Efficiency Measurement: A Comparison of China with its International*, Ph.D. Dissertation, Department of Industrial and Systems Engineering, The Hong Kong Polytechnic University.

Wu, J. and Radbone, I. (2006) Global integration and the intra-urban determinants of foreign direct investment in Shanghai, *Cities*, Volume 23, Number 4, pp.275284.

Yan, W-C. and Zhang, X (in press) Electric power grid interconnection in Northeast Asia, *Energy Policy*.

Zadeh, L. (1975) The concept of a linguistic variable and its applications to approximate reasoning, *Information and Science*, Volume 8, pp.199-249.

Zimmermann, H. (1991) *Fuzzy set theory and its applications*, Kluwer Academic Publishers, Boston

PUBLICATIONS B

Submitted refereed paper
(A paper submitted to *Transportation Research Part A: Policy and Practice)*

Evaluating the Competitiveness of Container Ports in Korea and China

Abstract

Changes in world trade and the shipping environment have created ever-increasing competition between ports in Northeast Asia, especially Korea and China. Following intensive state investment in port developments through large scale projects, Chinese ports now threaten to oust Busan in Korea as the regional hub. To identify and evaluate the competitiveness of major ports in the region, this paper identifies the components influencing their competitiveness and presents a structure for evaluating them. Based on literature related to port selection and competition, a regional survey of shipping companies and owners employed factor analysis to reveal that port service, hinterland condition, availability, convenience, logistics cost, regional centre and connectivity are the determining factors in these regions.

Keywords: Port Competitiveness, Factor Analysis, Northeast Asia

1. Introduction

Since the late 1990's the Far East region which includes Korea and China has recorded vigorous economic growth (De and Park, 2003; Yap and Lam, 2005). As host to six of the world's major hub ports and 16 of the 30 largest ports, intraregional port competition is intense (Cullinane et al., 2002; 2004). In China, many container ports have rapidly improved their infrastructure and superstructure following increased cargo throughputs (UNCTAD, 2002). Such improvements have also stimulated Korea's ports, which are proximate and compete directly. To maintain competitiveness, Korean port authorities have implemented government-aided programmes aimed at expanding facilities, updating services and promoting port marketing (Ha and Zhang, 2000).

To assist understanding and management of developments in this complex and dynamic environment, an analytical structure is required within which port competition between Korea and China can be evaluated. Findings from earlier studies in this field are often inapplicable in this region, given their differing geographical focus, timing and differing reference points. In particular, components highlighted by many studies carried out in Europe and America, are not regarded as suitable components for Korea and China.

With this in mind, this paper aims to empirically investigate a structure for evaluating container ports in Korea and China using factor analysis to identify the components which influence competitiveness. Section 2 outlines some relevant statistics. Section 3 discusses literature focused on the issues involved in port competitiveness and Section 4 reports an empirical analysis. Section 5 describes the implications and conclusions are provided in Section 6.

2. Port Competition in Korea and China

Ocean Shipping Consultants (2003) have estimated that world trade cargo volumes will be 620 million Twenty-foot Equivalent Units (TEUs) in 2015, with North-east Asia handling 184.7 million TEUs and South-east Asia handling 110.2 million TEUs. The ports in Southern and Northern China, although hampered by limited water depth and a lack of port facilities, are expected to grow rapidly (Table 1).

[INSERT TABLE 1]

Direct callings by major shipping companies including Maersk and P&O Nedlloyd to ports in China including Qingdao, Tienjin and Dalian (Figure 1) also influence the status of ports in Central and Northern China and have motivated China to carry out large scale port development. The overall status of direct calling by major shipping companies in Northern China and Korea is illustrated in Tables 2 and 3. In addition, more favourable conditions for undertaking investment stimulated by China's open door policy have induced many foreign shipping companies and terminal operators to locate operations there. This situation challenges Korea's ports and government, in direct competition with China.

[INSERT FIGURE 1]
[INSERT TABLE 2]
[INSERT TABLE 3]

Due to the changing environment, the traditional main trunk route: Europe- Singapore-Hong Kong- Taiwan (Kaosung, Keelung)- Korea (Busan, Kwangyang)- Japan (Kobe, Yokohama)-America has diversified to incorporate several and/or special routes including Chinese ports (Figure 2). From a Korean perspective, this implies losing many feeder cargoes, because up to now the ports in Northern China have usually used Korean ports for feeder services (Figures 3, 4).

[INSERT FIGURE 2]
[INSERT FIGURE 3]
[INSERT FIGURE 4]

Container ports in Korea are confronted with severe competition from both leading container ports such as Hong Kong and emerging container ports including those in Northern China. To address this situation, the Korean government produced an investment plan to transform Busan and Kwangyang into world hub logistics centres through constructing berths, infrastructure and superstructure, and developed hinterlands (Ministry of Maritime Affairs and Fisheries, 2003; Han, 2004).

3. Port Competitiveness

The analysis of port competitiveness has mainly concentrated on port selection criteria. In the 1980s, Pearson (1980), Willingale (1981), Collison (1984) and Slack (1985) suggested various components of port selection which covered Europe, America and Southeast Asia. Moreover in the 1990s, Peters (1990), Murphy et al. (1988, 1989, 1991 and 1992), UNCTAD (1992), Brooks (1984 and 1985) and McCalla (1994) revealed varying analytical dimensions and major factors influencing them. Studies in the 1990s included American studies of the geographic location of ports, inland railway transportation, investment in port facilities and the stability of port labour (Starr, 1994).

In 1995, Tengku's PhD thesis at Cardiff University entitled 'Marketing of freight liner shipping services with reference to the far East-Europe trade: a Malaysian perspective' highlighted port tariffs, safe handling of cargoes, confidence in port schedules and port service. A year later at the same institution Chiu's PhD thesis 'Logistics performance of liner shipping in Taiwan' noted that customs service, rapidity of processing, simplicity of documentation in port, cargo damage and skills of port labour influenced port competitiveness (Table 4).

[INSERT TABLE 4]

Later, Malchow and Kanafani (2001) analysed the flow of four commodities in eight major U.S. ports. Moreover, they extended their studies in ten major U.S. ports by incorporating additional attributes finding that the most significant characteristic of a port was its location (Malchow and Kanafani, 2004). Recently, Tongzon and Heng (2005) suggested eight determinants of port competitiveness and Bichou and Gray (2005) argued that port competition will shift from the institutional, functional and/or spatial levels to channel management.

Some regional research into port competition between Korea and China has been undertaken. Kim (1993) analyzed the port selection decisions of Korean shippers, consignees and shipping liners. In reducing order of significance, export port selection depended on distance between origin and destination, annual cargo handling volume, loading hours, average detention hours at port, goods value per tonne and inland trucking cost per kilometre affected. Sea transportation distance, number of liners calling-in, annual volume imported and inland transportation charges per unit distance were the major factors affecting import port selection. In Jeon's study in 1993, port selection depended on navigation facilities and equipment holding status, port productivity, price competition, and port service quality. Song and Yeo (2004) identified the five most important criteria for the competitiveness of port businesses in Asia. These are cargo volume, port facilities, port location, service level and port expenses.

However, research on port selection criteria must reflect the improving quality of port services offered, the changing business environment and particularly in Korea and China, fierce competition between ports. Based on this literature review, 38 determinants of port

competitiveness were selected for further analysis (Table 5) and mapped using the concept of a port system suggested by Bichou and Gray (2005).

[INSERT TABLE 5]

However, many determinants were interrelated and covered several port sub systems. To eliminate overlap and less important determinants, a survey instrument was administered to 30 professionals including shipowners, shipping company executives, shippers, logistics related companies, and freight forwarders in Korea and China. Following this, 18 components were extracted during pilot surveys as shown in Figure 5.

[INSERT FIGURE 5]

4. Identifying factors influencing port competitiveness

4.1 Data Collection

Face-to-face and telephone interviews were conducted in October and November 2003, with 75 useable responses from 170 questionnaires distributed in Korea and 24 from 48 in China. Respondents' business profiles are illustrated in Table 6. Attitudes on each of the variables were assessed using five point Likert scales anchored by the satisfaction level of performance 1= very poor and 5= excellent.

[INSERT TABLE 6]

4.2 Factor Analysis Results

Factor analysis has been employed as an appropriate methodology to concurrently validate measurements in port and transport studies (Blanc and Wyckoff, 1988; Lu and Marlow, 1999; Kent et al., 2001; Ha, 2003; Tracey, 2004). Generally, it has two purposes. The first of these, exploratory factor analysis, is used for exploring and surveying purposes to establish trends and variable structures and the second, confirmatory factor analysis, is used for evaluation and analysis. This study adopted the first approach, to form clusters of components and the evaluation structure.

In the first step, a varimax rotation, used to transform a set of interrelated variables into a set of unrelated linear combinations of these variables, was employed to identify strategic dimensions. To aid interpretation, only variables with factor loadings greater than 0.5, were extracted. Table 7 shows that these seven factors account for an accumulated explanation of variance of 72.6% and thus may be adequate to represent the 18 strategic dimensions.

[INSERT TABLE 7]

For the second step, a reliability test, based on Cronbach's alpha, was used to test the internal consistency of questionnaire responses. Given that Cronbach's Alpha values from 0.5 to 0.7 indicate normal consistency and are sufficiently reliable, and those exceeding 0.7 indicate high consistency, computed results indicate normal internal consistency (Cronbach, 1951; Ware, 1998; Novák et al., 2004).

[INSERT TABLE 8]

A taxonomy for evaluating the structure of port competition between Korea and China emerged after factors were named as shown in Figure 6.

[INSERT FIGURE 6]

Further details of each factor are, as follows:

Port Service As the overall quality of service provided to users in a port area increases, so does the port's competitiveness. Port service includes "prompt response", "24 hours a day, seven days a week service" and "zero waiting time service". The port service factor accounts for 13.6% of total variance and confirms that "24 hours a day, seven days a week service" is the most important dimension of service attribute perceived by respondents.

Hinterland Condition As the condition of the hinterland increases, so does a port's competitiveness. Hinterland condition includes "professionals and skilled labour in port operations", "size and activity of Free Trade Zone (FTZ) in port hinterland" and "volume of total container cargos". The latter is the most important attribute. This implies that Busan and Shanghai have huge hinterlands encompassing the Korean peninsula and Chinese mainland respectively. For more efficient treatment of increased cargoes, port operators concentrate on port productivity and investments. This phenomenon acts to increase port competitiveness.

Availability This includes "availability of a vessel berth on arrival in port" and "port congestion". The former element is most highly correlated with this factor. Korean and Chinese ports experience heavy port traffic, and for just in time delivery, availability of berths is a vital attribute for port users.

Convenience This component includes "water depth in approach channels and at berth", "sophistication of port information and its application" and "the stability of port labour".

Logistics Cost The lower the cost, the greater the competitiveness. Logistics costs include "inland transportation cost", "costs related to vessels and cargoes entering port" and "free dwell time on the terminal".

Regional Centre Having a good location is deemed to render a port more competitive. The concept of a regional centre includes geographical aspects such as "deviation from main trunk routes" and "port accessibility".

Connectivity The greater the connectivity, the higher the competitiveness. Connectivity includes both "land distance and connectivity to major shippers" and "an efficient inland transport network".

5 Implications

The analytical structure for evaluating port competition between Korea and China includes qualitative components including professionals and skilled labour force in port operations and their stability, and quantitative components including water depth in the approach channel and at berth, inland transportation cost and free dwell time on the terminal. Notably, the role of professionals and skilled labour force in port operations, and the sophistication level of port information and the scope of its application, proved to be important factors. In this study, hinterland related components such as the size and activity of FTZ, efficient inland transport network and inland transportation cost were considered critical.

These results indicate that key factors for port competitiveness have shifted away from hardware and labour towards software and technology, implying that the most competitive ports rely on efficient hinterland logistics systems. Other interesting components included

the availability of a vessel berth on arrival in port. This replaced previous components such as the numbers of loading and unloading facilities and the capacity of the container yard. This implies that port competitiveness requires more infrastructure combined with high levels of operational management. Enhanced port competitiveness, as perceived in Korea and China, requires not simply increased port investment but also high quality port service and technology focused port operations.

6. Conclusions

The paper aimed to determine the components of, and an evaluation structure for, assessing port competitiveness in Korea and China. It contributes to relevant literature by presenting the first study of port competitiveness in this region. The attributes of port competitiveness identified included port service, hinterland condition, availability, convenience, logistics cost, regional centre and connectivity. This evaluation structure could be used to rank container ports in China, Korea and possibly elsewhere and eventually for identifying port development policies and strategies.

References

Bichou, K. and Gray, R. (2005) A critical review of conventional terminology for classifying seaports. *Transportation Research Part A: Policy and Practice*, 39(1), 75-92.

Blanc, L. and Wyckoff, P. (1988) A strategic success factor analysis of the New Orleans vessel traffic service. *Transportation Journal,* 38(3), 44-50.

Brooks, M. (1984) An alternative theoretical approach to the evaluation of liner shipping-Part 1. Situational factors. *Maritime Policy and Management,* 11(1), 35-43.

Brooks, M. (1985) An alternative theoretical approach to the evaluation of liner shipping-Part 2: Choice criteria. *Maritime Policy and Management,* 12(2), 145-155.

Collison, F.(1984) North to Alaska : marketing in the Pacific Northwest-Central Alaska liner trade. *Maritime Policy and Management*, 11(2), 99-112.

Cullinane, K., Song, D-W. and Gray, R.(2002) A stochastic frontier model of the efficiency of major container terminals in Asia: assessing the in.uence of administrative and ownership structures. *Transportation Research Part A: Policy and Practice*, 36(8), 75-92.

Cullinane, K., Wang, T. and Cullinane, S. (2004) Container terminal development in mainland China and its impact on the competitiveness of the Port of Hong Kong. *Transport Reviews*, 24(1), 33-56.

Cronbach, L. (1951) Coefficient alpha and the internal structure of tests. *Psychometrika*, 16, 297-334.
De, P. and Park, R. (2003) Container port system concentration. *Transportation Quarterly*, 57(4), 69-82.
Ha, M. and Zhang, L.-H. (2000) A Study on the historical developments of Chinese ocean shipping. *The Journal of the Korean Association of Shipping Studies*, 30, 253-280.
Ha, M. (2003) A comparison of service quality at major container ports: implications for Korean ports. *Journal of Transport Geography*, 11(1), 131-137.
Han, C.-H. (2004) Strategy of a Global Terminal Operator. *Korea Maritime Institute Reports*, 86-99.
Jeon, I.-S., Kim, H.-S. and Kim, B.-J. (1993) *Strategy for improvement of competitive power in Korea container port.* Korea Maritime Institute, Seoul.
Kent, J., Parker, R. and Luke, R. (2001) An empirical examination of shipper perceptions of service selection attributes in five truckload industry. *Transportation Journal*, 51(3), 27-36.
Kim, H.-S. (1993) *Decision components of Shippers' port choice in Korea.* Korea Maritime Institute, Seoul.
Lu, C. and Marlow, P. (1999) Strategic groups in Taiwanese liner shipping, *Maritime Policy and Management.* 26(1), 1-26.
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: Logistics and Transportation Review*, 40(4), 317-337.
McCalla, R. (1994) Canadian Container: How have they fares? How will they do? *Maritime Policy and Management*, 21(3), 207-217.
Ministry of Maritime Affairs and Fisheries (2003) Korean Ports Statistics, Report 2003. Seoul.
Murphy, P., Dalenberg, D. and Daley, J. (1988) A contemporary perspective on international port operations. *Transportation Journal*, 28(1), 23-32.
Murphy, P., Dalenberg, D. and Daley, J. (1989) Assessing international port operations. *International Journal of Physical Distribution and Materials Management*, 19(9), 3-10.
Murphy, P., Dalenberg, D. and Daley, J. (1991) Analysing international water transportation: the perspectives of large U.S. industrial corporations. *Journal of Business Logistics*, 12(1), 169-190.
Murphy, P., Daley, J. and Dalenberg, D. (1992) Port selection criteria: an application of a transportation research framework. *Logistics and Transportation Review*, 28(3), 237-255.
Novák, A., Christine, L. and Abetz, L. (2004) Development and validation of an acceptability and satisfaction questionnaire for a contraceptive vaginal ring. *PharmacoEconomics*, 22(4), 245-256.
OCS (2003) *World Containerport Outlook to 2015.* Ocean Shipping Consultants, London
Pearson, R. (1980) *Containerline Performance and Service Quality*, University of Liverpool.
Peters., H.(1990) Structural Changes in International Trade and Transport Markets: The Importance of Markets, The 2nd KMI International Symposium. Seoul, 58-75.
Slack, B. (1985) Containerization inter-port competition and port selection. *Maritime Policy and Management*, 12(4), 293-303.
Song, D-W. and Yeo G-T. (2004) A competitive analysis of Chinese container ports using the Analytic Hierarchy Process. *Maritime Economics & Logistics*, 6(1), 34-52.
Starr, J. (1994) The mid-Atlantic Load Centre: Baltimore or Hampton Road? *Maritime Policy and Management*, 21(3), 219-227.

Tongzon, J. and Heng, W. (2005) Port privatization, efficiency and competitiveness: Some empirical evidence from container ports (terminals). *Transportation Research Part A: Policy and Practice*, 39(5), 405-424.

Tracey, M. (2004), Transportation effectiveness and manufacturing firm performance. *International Journal of Logistics Management*, 15(2), 31-49.

UNCTAD (1992) *Port Marketing and the Challenge of the Third Generation Port*. Geneva, 358-361.

UNCTAD (2002) *Review of Maritime Transport*, UNCTAD/RMT/2002, New York.

Ware, J., Kosinski, M. and Gandek, D. (1998) The factor structure of the health survey in 10 countries. *International Quality of Life Assessment*, 51, 159-165.

Willingale, M. (1981) The Port Routing Behaviour of Short Sea Ship Operator Theory and Practices. *Maritime Policy and Management*, 8(2), 109-120.

Yap, W. and Lam, J. (2005) Competition dynamics between container ports in East Asia. *Transportation Research Part A: Policy and Practice*, in press.

Figure 1. Major shipping companies calling directly at ports in northern China.

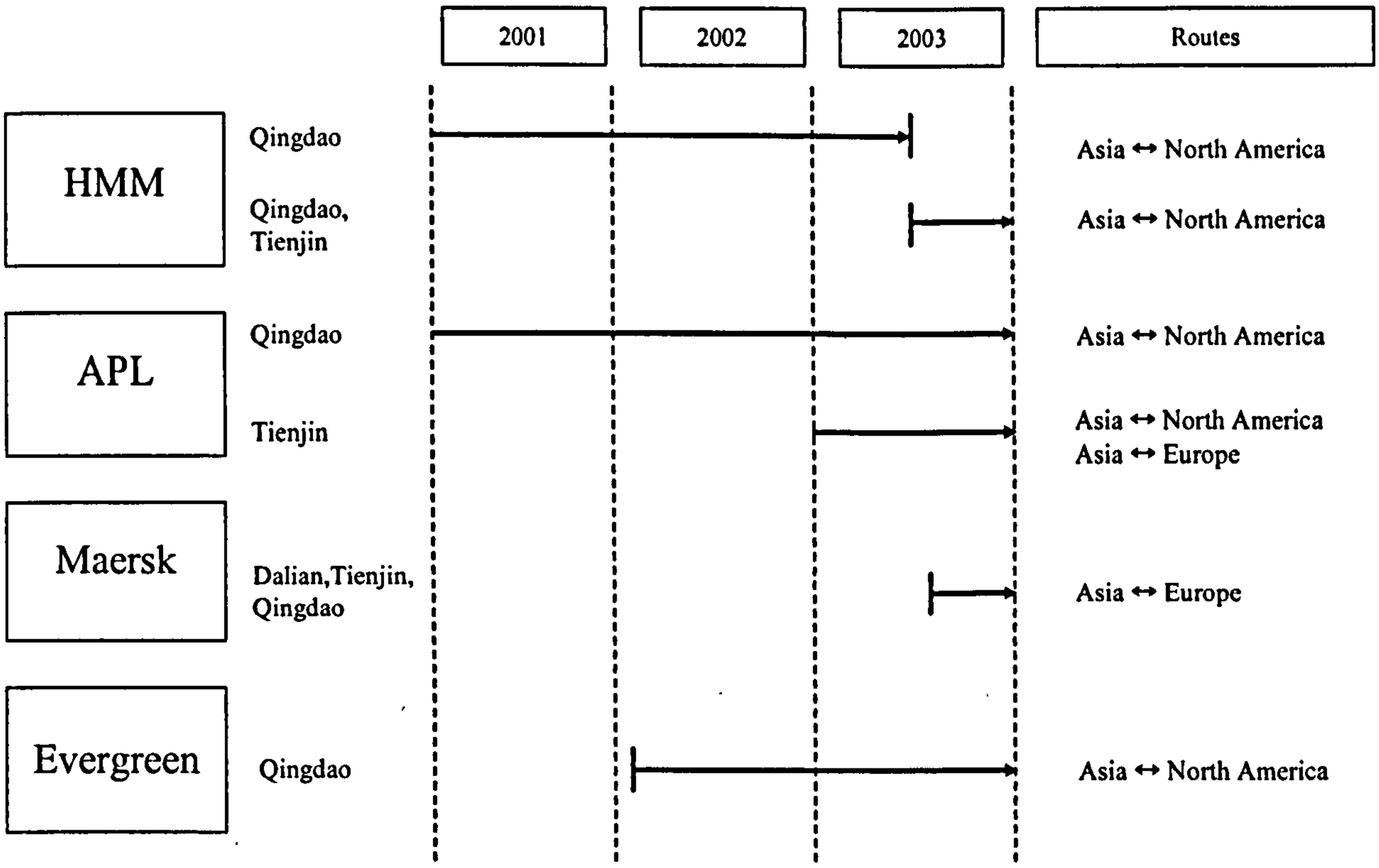
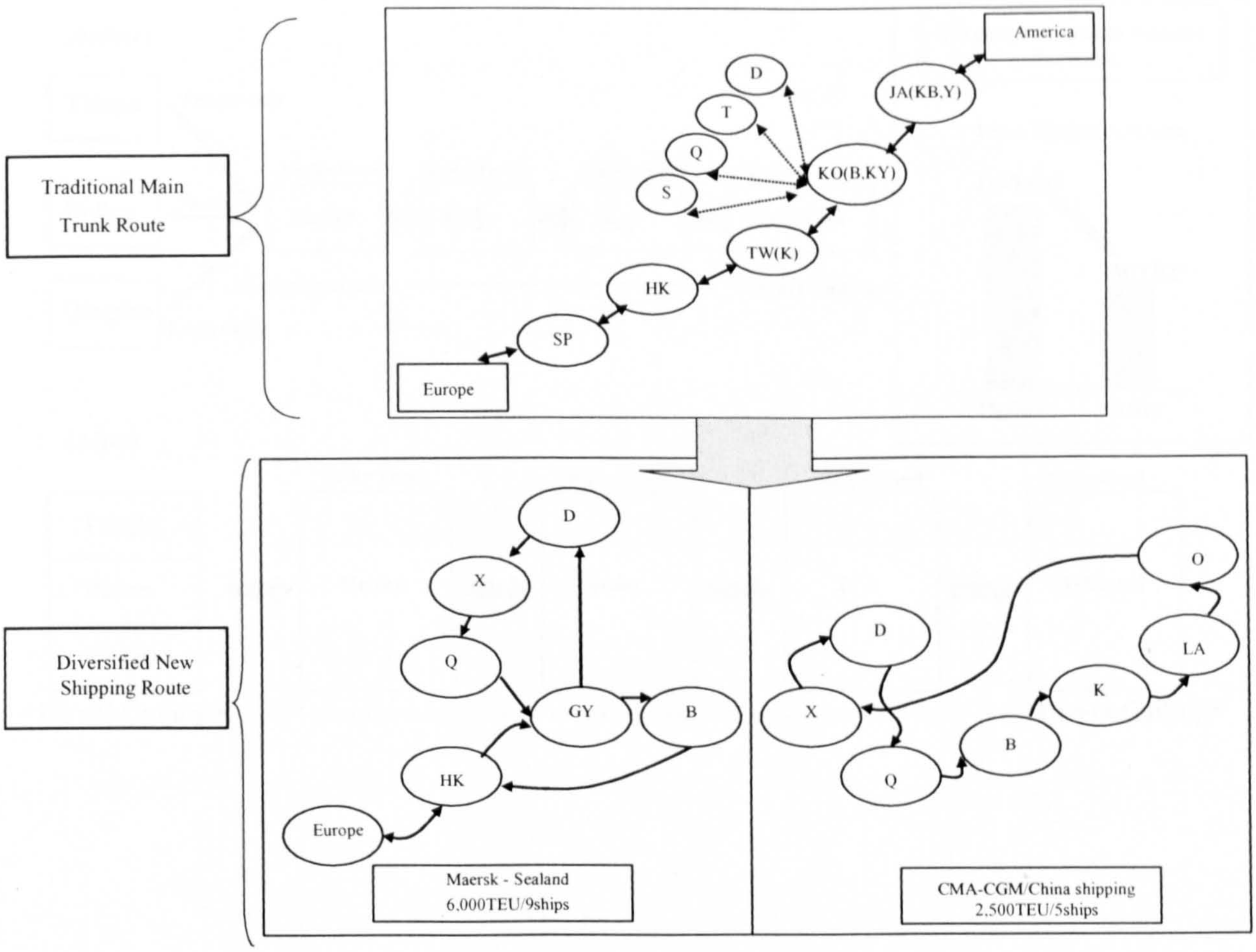


Figure 2. Changes in traditional main trunk routes



Note: B(Busan), D(Dalian), GY(Gwangyang), HK(Hong Kong), JA(Japan), K(Kaosung), KB(Kobe), KO(Korea), KY(Kwangyang), LA(Los Angeles), O(Oakland), Q(Qingdao), S(Shanghai), SP(Singapore), T(Tienjin), TW(Taiwan), X(Xingang), Y(Yokohama)

Figure 3. Feeder cargoes in Korean Ports (China Shipping-USA)

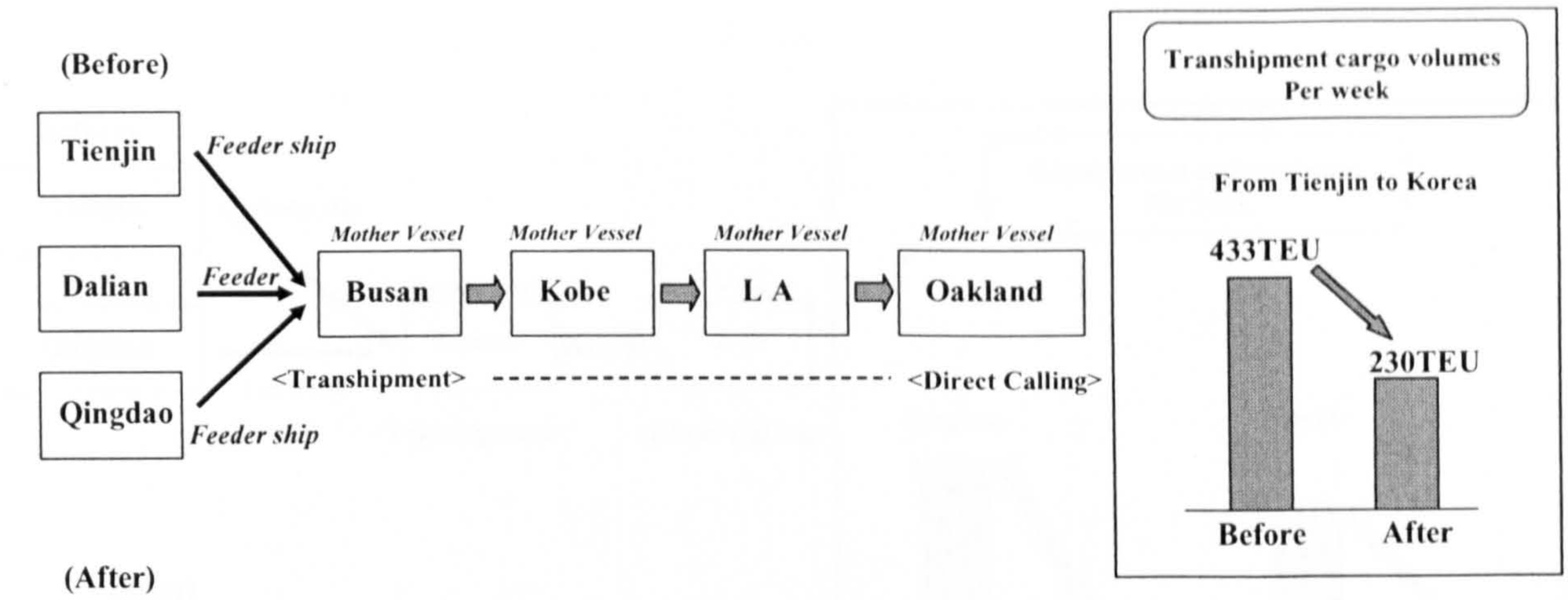


Figure 4. Feeder Cargoes in Korean Ports (MSC-USA)

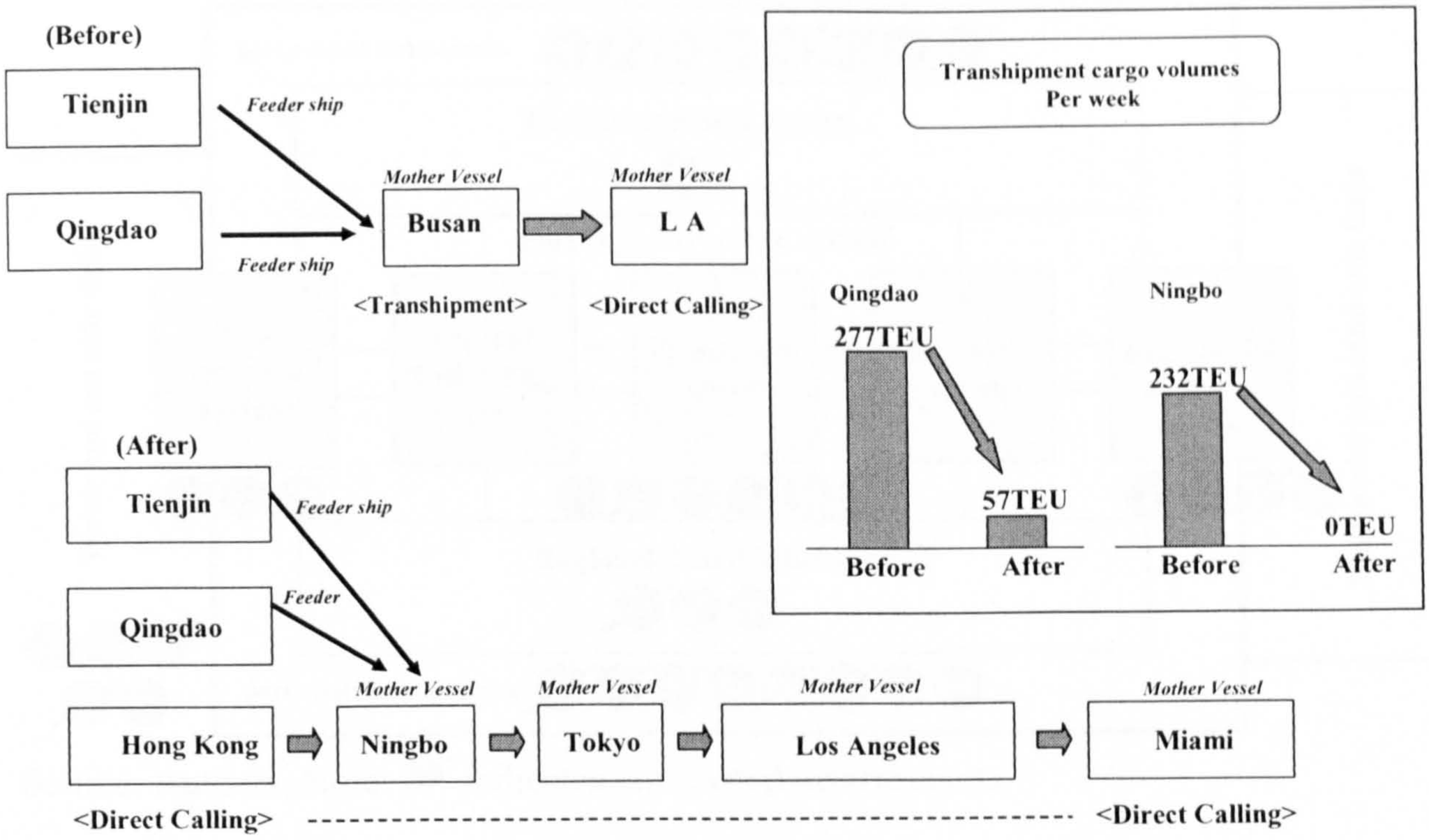
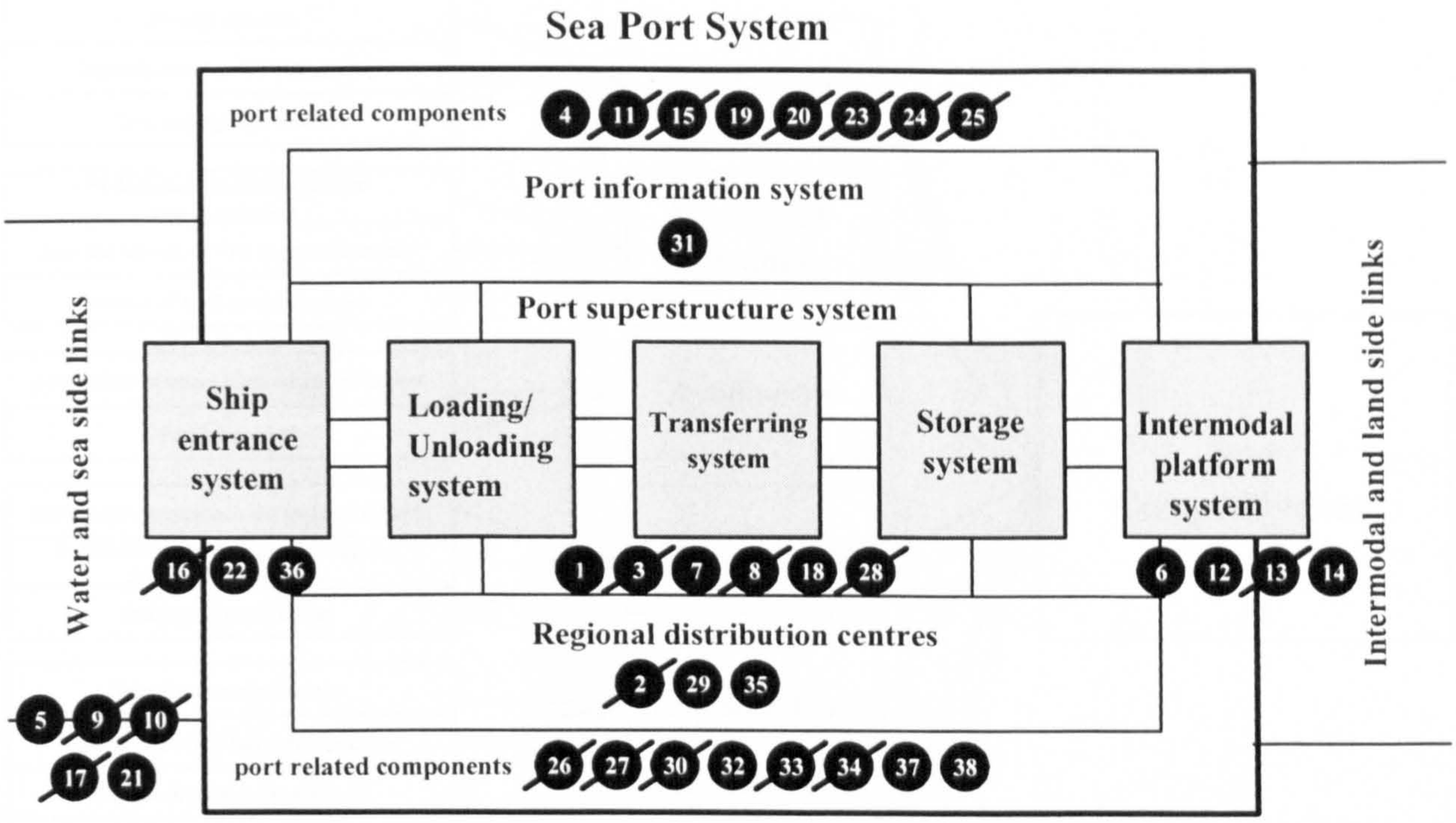


Figure 5. Selection of the determinants of port competitiveness



Source: Authors, Note: indicates eliminated determinants

Figure 6. Structure for evaluating container port competitiveness in Korea and China

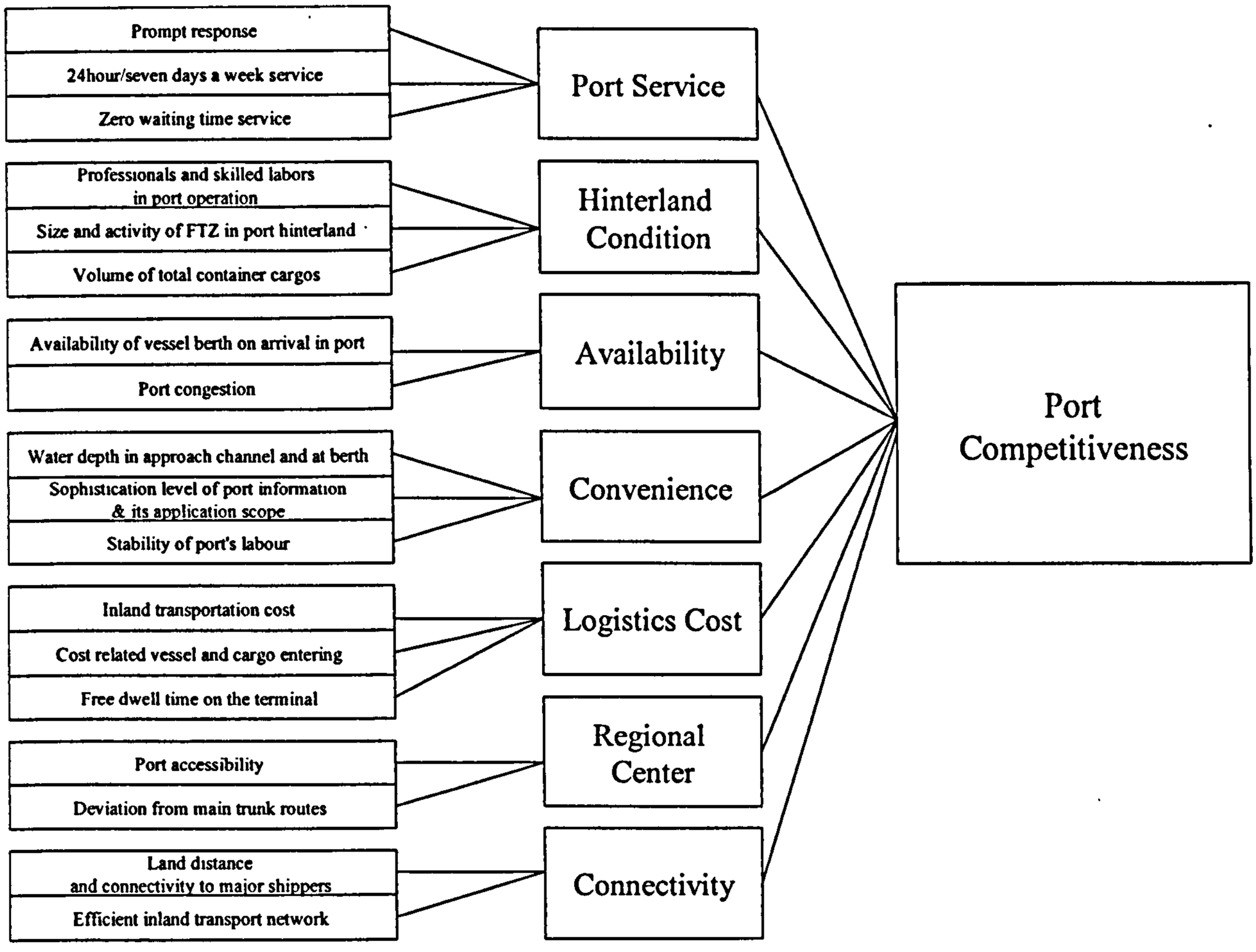


Table 1.
Port cargo volumes in China.
(Unit: Thousand TEUs per annum)

	2001	2004	2007	2010
Northern China	6 800	11 325	15 340	18 460
Tienjin	2 000	3 150	4 240	5 260
Qingdao	2 600	4 800	7 400	9 500
Dalian	1 800	2 975	3 300	3 300
Others	400	400	400	400
Sourthern China	21 210	27 088	33 894	37 044
Shanghai	6 300	7 500	8 300	9 100
Yangshan	0	0	1 000	2 500
Ningbo	1 200	1 950	2 600	3 250
Fuzhou	450	800	800	800
Xiamen	1 500	2 400	2 400	2 400
Yantian	3 000	3 500	5 000	5 000
Shekou	1 300	2 100	2 900	2 900
Chiwan	2 100	2 800	2 800	2 800
Guangzhou	1 800	1 800	2 500	2 500
H.Delta Ports	1 350	1 350	1 350	1 350
Others	2 210	2 888	4 244	4 444

Source: Ocean Shipping Consultants(2003).

Table 2.

Shipping companies making direct calls (US bound)

Shipping Companies	Size of Vessel(TEU)	Ningbo	Shanghai	Qingdao	Dalian	Tanjin	HongKong	Busan	Kwangyang
APL/Hyundai/MOL	2885	o	o						
	3298			o				o	
	4469		o				o	o	
	6479						o	o	o
China Shipping	3090	o					o		
CMA-CGM/P&O Nedlloyd	3438		o				o	o	
CAN-CGM Norasia(Wallem)	3966		o				o	o	
COSCO	2868			o	o	o		o	
	3560	o	o						
COSCO/Hanjin/KL/Yang Ming	4000		o				o	o	
	3400			o			o		
CSAV(Wallem)	3800-4000		o				o	o	
Evergreen/L. Triestino	1672		o	o				o	
	2728	o	o						
Hanjin	3000	o	o					o	o
Hapag/NYK/OOCL	2888		o						
P&O Nedlloyd	3832	o	o	o				o	
	2958		o	o			o	o	
KL/Yang Ming	5598	o	o				o		
	3332		o	o					
Maersk Sealand	2816	o	o				o	o	o
MSC	4329		o				o	o	
Sinotrans	2523		o				o	o	
Zim(GMK)	2912		o				o		

Source: Ocean Shipping Consultants(2003).

Table 3.

Shipping companies making direct calls (Europe bound)

Shipping Companies	Size of Vessel(TEU)	Ningbo	Shanhai	Qingdao	Dalian	Tanjin	Kaosung	Busan	Kwangyang
APL/Hyundai/MOL	5094		O						
China Shipping	3771	O	O						
CAN-CGM(Ben)	6510	O	O						
/Norasia(Wallem)	4152			O		O		O	O
COSCO	5299		O	O	O				
Evergreen/ L. Triestino	5616	O	O		O		O		
Hanjin/Senator	5000		O						
	5000			O		O	O	O	
Hapag/MISC/NYK/OOCL	5670			O			O	O	
/P&O Nedlloyd	7051		O						
KL/Yang Ming	5598	O	O						
Maersk Sealand	6128	O	O					O	O
MSC	6737	O		O		O		O	
CAN-CGM(Ben) /Norasia(Wallem)	4226		O					O	
COSCO/KL/Yang Ming	3359		O						
Evergreen/L. Triestino	2899	O					O		
	2899	O	O				O		
Hanjin/Senator	2700		O					O	
Hapag/MISC/NYK/OOCL /P&O Nedlloyd	4511		O					O	
MSC	3169		O						
	3169	O		O				O	
ZIM(GMK)	2679		O					O	
PIL	2601	O	O					O	O

Source: Ocean Shipping Consultants (2003).

Table 4.
Literature review of components of port competitiveness

Author (date)	Components identified
Pearson (1980)	Confidence in port schedules, Frequency of calling vessels, Variety of shipping routes, Accessibility of port
Willingale (1981)	Navigation Distance, Hinterland nearness, Connectivity to ports, Port facilities, Availability of port, Port tariffs
Collison (1984)	Average waiting time in port, Confidence in port schedules, Port service capacity
Slack (1985)	Calling frequency, Tariffs, Accessibility to the port, Port congestion, Inter-linked transportation networks
Brooks (1984, 1985)	Port costs, Frequency of calling vessels, Port reputation and/or loyalty, Ship direct calling, Experience of cargo damage.
Murphy et al. (1988, 1989, 1991, 1992)	Has loading and unloading facilities for large and/or odd-sized freight, Allows for large volume shipments, Has low freight handling shipments, Provides a low frequency of loss and damage, Has equipment available, Offers convenient pickup and delivery times, Provides information concerning handling, Offers assistance in claims handling, Offers flexibility in meeting special handling requirements
Peters (1990)	Internal factors; Service level, Available facility capacity, Status of the facility, Port operation policy External factors; International politics, Change of social environment, Trade market, Economic factors, Features of competitive ports, Functional changes of transportation and materials handling.
UNCTAD (1992)	Geographical location, Hinterland networks, Availability and efficiency of transportation, Port tariffs, Stability of port, Port information system
McCalla (1994)	Port facilities, Inland transportation networks, Container transport routes
Starr (1994)	Geographic location of ports, Inland railway transportation, Investment of port facilities, Stability of port labor
Tengku (1995)	Port tariffs, Safety handling of cargoes, Confidence in port schedules
Chiu (1996)	Custom service, Rapidness, Simple documents in port, Cargo damage and skills of port

Table 5.
Selected components of port competitiveness

Component
1. Availability of vessel berth on arrival in port
2. Cargo proportion of transhipment cargo
3. Cost for cargo handling, transfer and storage
4. Cost related vessel and cargo entering
5. Deviation from main trunk routes
6. Efficient inland transport network
7. Free dwell time on the terminal
8. Frequency of cargo loss and damage
9. Frequency of large container ship's calling
10. Frequency of ship's calling and diversify of ship's route
11. Government, local autonomous entity, private sectors
12. Inland transportation cost
13. Inter-modal link
14. land distance and connectivity to major shippers
15. Level of service for fresh water, bunkering and ship's products
16. Level of ship's entrance and departure navigation aids systems
17. Number of direct calling of ocean-going vessel
18. Professionals and skilled labours in port operation
19. Prompt response
20. Promptness of issue document handling
21. Port accessibility
22. port congestion
23. Port sales: port promotion
24. Port's safety
25. Real working time
26. Recognition and reputation of port
27. Reliability of schedules in port
28. Service capacity for ship's size
29. Size and activity of FTZ in port hinterland
30. Size of contiguous city's economy
31. Sophistication level of port information & its application scope
32. Stability of port's labour
33. Terminal productivity
34. Volume of inducing cargoes by your company
35. Volume of total container cargoes
36. Water depth in approach channel and at berth
37. Zero waiting time service
38. 24 hours a day, seven days a week service

Table 6.
Respondent profile

Parameter	Group	Number of respondents
Business, firm-size		
	Shipping: Large	16
	Shipping: Small-Medium	22
	Logistics related	13
	Freight Forwarder	48
Number of employees		
	1-100	55
	101-500	25
	501-1000	7
	Over 1000	12
Annual sales (Million US$)		
	Under 10	41
	10-100	19
	100-500	20
	Over 500	19
Job position		
	Senior manager	28
	Middle manager	52
	General employee	19
Years employed in the orgarnization		
	Under 5	21
	5-10	32
	11-15	19
	Over 15	27

Table 7.
Loadings on each factor

Variable	Factor						
	1	2	3	4	5	6	7
Prompt response	0.793						
24 hours a day /seven days a week service	0.827						
Zero waiting time service	0.664						
Professionals and skilled labours in port operation		0.514					
Size and activity of FTZ in port hinterland		0.741					
Volume of total container cargos		0.880					
Availability of vessel berth on arrival in port			0.878				
Port congestion			0.735				
Water depth in approach channel and at berth				0.530			
Sophistication level of port information and its application				0.596			
Stability of port's labour				0.720			
Inland transportation cost					0.786		
Cost related vessel and cargo entering					0.732		
Free dwell time on the terminal					0.532		
Port accessibility						0.763	
Deviation from main trunk routes						0.823	
Land distance and connectivity to major shippers							0.746
Efficient inland transport network							0.826
Percentage variance	13.582	10.609	10.390	9.976	9.881	9.579	8.596

Table 8.
Cronbach's Alpha Values

Factors	Cronbach's alpha
Port service	0.73
Hinterland condition	0.65
Availability	0.71
Convenience	0.71
Logistics cost	0.54
Regional centre	0.53
Connectivity	0.66

PUBLICATIONS B

Submitted refereed paper
(A paper submitted to *European Journal of Operational Research)*

The determination of compromise weights in an MDMG problem investigating the competitiveness of container ports

Abstract

Generally, the Evaluation of Container Port Competitiveness (ECPC) is regarded as a multiple criteria decision making (MCDM) problem which involves various stakeholders with conflicting interests. To solve an MCDM problem such as ECPC, the Analytic Hierarchy Process (AHP) method is usually invoked. However, it has several limitations. The key issue discussed in this paper is to obtain the Compromise Weights (CWs) using a combined AHP procedure which incorporates Dempster-Shafer theory for eliminating the uncertainty in evaluation, and a levelling process for adjusting the contradictory opinions of each group, a so-called multiple decision making group (MDMG) problem. For the empirical analysis, container ports located in Northeast Asia (NEA), known to exhibit severe port competition, were selected. Using an adaptation of the methodology, the matrix of CWs was obtained. Using this matrix permits an exact evaluation of competitiveness in NEA.

Keywords: Decision aiding, Multi-criteria analysis, Multiple decision making group problems, Analytic Hierarchy Process, Compromise Weights, Dempster-Shafer Theory.

1. INTRODUCTION

Northeast Asia (NEA) consists of China, Japan, Mongolia, North Korea, the Russian Federation, and South Korea (Yun and Zhang, in press). It is also part of the Asia–Pacific community and has grown to become the largest of Asian markets (Ohashia et al., 2005). Amongst these nations in NEA, the most rapidly growing markets are in China, Korea and Japan. NEA members occupy leading positions in world production and shipping. In terms of shipping deadweight tonnage, the NEA countries account for 33.51% of the world (UNCTAD, 2005); they account for over 20% of world trade, and head rankings of major trading nations and leading container terminal operators.

More interestingly, as a consequence of China's booming economy and increased import and export container cargo volumes in the area, in 2003, four of the top five and 20 of the top 30 container ports were located in NEA and Asia, respectively (Hoffmann, 2004; UNCTAD, 2004). NEA's central position in liner shipping and handling of container cargo volumes have made container port competition and competitiveness in NEA contentious issues.

However, it was found that only a few limited studies have been carried out on this theme in this region, despite abundant studies in Europe and the USA. Moreover, no exact definition of container port competition and competitiveness for ports located in NEA could be found. In particular, the ECPC in this region has been neglected due to the commercial confidentiality of data and rapid changes in the competing ports. For all these reasons, the ECPC in NEA has become a problematic and urgent issue for policy makers, who require assistance in obtaining a fuller understanding of the status of particular container ports so as to make sound business decisions.

With regard to the ECPC, Voorde and Winkelmans (2002) noted that evaluation is very difficult, because it involves various stakeholders with conflicting interests. Aouam et al. (2003) argued that the ECPC is a complicated problem, where a number of alternatives and actions or stakeholders need to be chosen based on a given set of criteria and hierarchies, hence the name Multiple Criteria Decision Making (MCDM), or Multiple Attribute Decision Making (MADM) (Frankel, 1992; Brooks, 2000; Malchow and Kanafani, 2001; Kumar, 2002; Haralambides and Yang, 2003).

In this respect, Song and Yeo (2004) have attempted to solve the problem connected with Chinese container port competitiveness using the Analytic Hierarchy Process (AHP) which was regarded as the methodology for an optimal solution for the MCDM problem. However, the following limitations have been identified.

- A degree of uncertainty exists in evaluation by experts. Although they may offer reliable judgements in their own specializations, their judgments may become less reliable and consistent outside of their field of expertise (Kahneman et al., 1983). Inevitably, expert evaluations of port competitiveness involve a degree of uncertainty which empirical evaluation processes must accommodate (Simon and Burstein, 1985). To solve this problem, Beynon (2002a, 2005) suggests a DS/AHP, which incorporates Dempster-Shafer (DS) theory on the AHP.

- The opinions in one group of experts may contradict with those of other groups (Karacapilidis and Pappis, 1997; Lim, 2000; Aouam et al., 2003). For this typical multiple decision making group (MDMG) problem it is necessary to obtain the compromise weights (CWs) for the given evaluation factors to resolve the conflict between differing preferences (Wei et al., 2000). However, in this paper, MDMG was not applied to an investigation of experts' evaluations of container port competitiveness.

With the above background in mind, this research aims to suggest the evaluation structure and factors for container ports located in NEA, to analyse the weight values of each evaluation factor for each expert group using AHP and to introduce uncertainty in the evaluation of each group using DS theory. It then adjusts the contradictory opinions regarding port competitiveness factors, considered as an MDMG problem, by introducing a levelling process and finally finds the CWs of factors enabling an overall evaluation of port competitiveness.

Following this introduction, section 2 briefly describes the research methodology and section 3 investigates the weighting of port competitiveness factors using the AHP method and its links with unit decision making group (UDMG) problems. Section 4 reports empirical analysis of MDMG problems and section 5 discusses their implications and conclusions.

2. MODEL FOR DETERMINATION OF WEIGHTS VALUES

As reviewed in the previous section, Song and Yeo (2004) argued that the ECPC is regarded as an MCDM problem which can be solved using AHP. However, to reinforce the limitations of existing studies using AHP, Beynon (2002a, 2005) claims that DS theory should be introduced to eliminate the uncertainty. Moreover, Karacapilidis and Pappis (1997) insist that a levelling process is needed to obtain the CWs for the given evaluation factors. To synthesize these suggestions, the schematic diagram for the ECPC can be depicted as in Figure 1.

[INSERT FIGURE 1]

In the AHP procedure shown in the diagram, the overall values of container port competitiveness in NEA will be draw out by multiplying the weight values of each factor, $w(i)$ and each alternative, $h(g)$. However, when step 1 and step 2 are added, $w(i)$ should be changed to the compromise weight values, $W(i)$, as indicated by the dotted line in the diagram while $h(g)$ has the same value for each port. $W(i)$ could be calculated through the two step approaches in the diagram.

For the first step, a process for managing uncertainty in evaluations can be outlined as follows. Consider measurement k, taken from group $G_j(j=1, m)$ which is evaluating n attributes (A_i, $i=1, n$). The measurement values brought by decision making experts k (DM_k, $k=1, l$), calculated by the eigen-vector method to produce measurements (m_{ik}), are shown as matrix M_j^1 in equation 1. M_j^1 is acquired by the AHP method.

$$M_j^1 = \begin{bmatrix} m_{11} & m_{12} & \dots & m_{1i} & \cdots & m_{1n} \\ m_{21} & m_{22} & \dots & m_{2i} & \cdots & m_{2n} \\ \vdots & \vdots & \vdots & \vdots & \vdots & \vdots \\ m_{k1} & m_{k2} & \dots & m_{ki} & \cdots & m_{kn} \\ \vdots & \vdots & \vdots & \vdots & \vdots & \vdots \\ m_{l1} & m_{l2} & \dots & m_{li} & \cdots & m_{ln} \end{bmatrix} \quad (1)$$

To apply the uncertainty process, when calculating the measurement value, each individual expert is asked to assign the degree of confidence (CD) attached to the values found in equation 2.

$$CD_j = [CD_1, CD_2, \cdots, CD_k, \cdots, CD_l]^T \quad (2)$$

Where, the superscript T shows transformation.

$$M_j^2(m_{ki}) = CD_k \cdot m_{ki},\ i=1, n \tag{3}$$

$$M_j^2 = \begin{bmatrix} m_{11}\ m_{12}\ \ldots\ m_{1i}\ \cdots\ m_{1n} & m_{\phi 1} \\ m_{21}\ m_{22}\ \ldots\ m_{2i}\ \cdots\ m_{2n} & m_{\phi 2} \\ \vdots\ \vdots\ \vdots\ \vdots\ \vdots\ \vdots & \vdots \\ m_{k1}\ m_{k2}\ \ldots\ m_{ki}\ \cdots\ m_{kn} & m_{\phi k} \\ \vdots\ \vdots\ \vdots\ \vdots\ \vdots\ \vdots & \vdots \\ m_{l1}\ m_{l2}\ \ldots\ m_{li}\ \cdots\ m_{ln} & m_{\phi l} \end{bmatrix} \tag{4}$$

$$\text{where, } m_{\phi k} = 1 - (\sum_{i=1}^{n} m_{ki}),\ k = 1, l \tag{5}$$

From equation (4), each evaluator's judgements recorded in group G_j, must be combined into values representing all experts in their group. Various methods for calculating such averages have been proposed (Kruskal, 1964: Srinivasan et al., 1973: Hwang et al., 1981: Fan et al., 2002). However, it is inappropriate to apply simple averages to the total weights allocated to each item in equation (4), because the computed total weights have not been normalized to 1.0. Because normalization at this stage could nullify the effects of introducing the process for managing uncertainty, in this situation, this study recommends DS theory as the most appropriate effective integrating method to apply (Yang and Singh, 1994; Yang and Sen, 1994). Processes in equation (6) are applied to equation (4), resulting in equation (7), which is the integrated results of measurement values (M_j^3).

$$m(E) = k^{-1} \cdot \sum_{F \cap G = E} m_1(F) \cdot m_2(G),\ \forall E \neq \phi \tag{6}$$

$$\text{where, } m(\phi) = 0,\ k = 1 - \sum_{F \cap G = \phi} m_1(F) \cdot m_2(G)$$

$$M_j^3 = [m_1, m_2, \cdots, m_i, \cdots, m_n, m_\phi] \tag{7}$$

Since equation (7) includes values for non-assigned evaluation items, (m_ϕ) this process fails to normalize these items to 1.0. In this case, M_j^4 is calculated by applying equation (8) with a normalization process.

$$M_j^4(m_i) = m_i \,/\, K,\ K = \sqrt{\sum_{i=1}^{n}(m_i)^2} \tag{8}$$

$$M_j^4 = [m_1, m_2, \cdots, m_i, \cdots, m_n] \tag{9}$$

With respect to the MDMG problem in step 2, the following summarized procedures can be utilized. One UDMG value is required to represent each group but combining individual values through simple averaging is inappropriate because evaluations conflict (Chwolka and Raith, 2001; Lai et al., 2002). Given that divergences in evaluation away from group norms emanate from self-opinion in the UDMG and competition amongst participants, equation (10) generates weights for each UDMG group based on rank orders, that is, the row average, m_{jk}^L (L=1, n). Equation (11), computes the deviation (V_l, l=1, n-1) starting from m_{jk}^1 to the lowest row in the pair.

$$m_{jk}^L = (\sum_{j=1}^{m} m_{jk}) \,/\, m,\ L{=}1, n \tag{10}$$

$$V_l = m_{jk}^L - m_{j(k+1)}^{L+1},\ l = 1, n-1 \tag{11}$$

$$m_{jk}^* = m_{jl} \pm V_l,\ l = n-1, 1,\ j = 1, m \tag{12}$$

The compromise weights, $W(\cdot)$, in the final MDMG in equation (13) are generated by computing matrix values on the arithmetic mean by rows, generating the items for evaluation.

$$M^5 = [m_1^{**}, m_2^{**}, \cdots, m_i^{**}, \cdots, m_n^{**}] \tag{13}$$

3. WEIGHTS OF EVALUATION FACTORS ON EACH STAKEHOLDER

3.1 Survey Data

With respect to the sample frame for the evaluation of Chinese container ports, Song and Yeo (2004) used shipping companies, shipowners, shippers, terminal operators and academics and researchers as their frame. However, due to the severe competition between the nations, it is not easy to obtain data from terminal operators. Moreover, many characteristics overlap between shipping companies and shipowners, and shippers receive logistics services from freight forwarders and logistics companies. Therefore, as the sample frame in this study, shipping companies, freight forwarders, logistics companies, academics and researchers are selected.

Regarding the sample sizes, generally speaking, they can be adjusted according to the type of investigation, research direction and the methodologies adopted. In the case of the ECPC in NEA, the optimal sample size is obscured by the lack of prior studies. For determining sample size, Roscoe (1975) proposed that, as a rule of thumb, one larger than 30 and smaller than 500 was appropriate for most research. Based on suggestions by Roscoe (1975), 200 experts which include 50 experts from each group, were selected in this study.

A survey to obtain pair-wise comparisons of port competitiveness factors comprised face-to-face and telephone interviews in late 2003, generating 92 useable responses. Respondents comprised shipping and logistics companies (23 each), freight forwarders (22) and researchers (24) with varying experience and responsibilities, representing many ship routes and sizes, and sizes of organization (Table 1).

[INSERT TABLE 1]

An analysis of relevant ports employed factor analysis (FA) to identify principal components that influence their competitiveness, including port service, hinterland condition, availability, convenience, logistics cost, regional centre and connectivity, drawn from 18 components of port competitiveness.

[INSERT FIGURE 2]

3.2 Weights Obtained Using the AHP Method

The AHP is an established methodology used in decision-making and for ranking priorities, where criteria are quantifiable and/or intangible. It is noted by Saaty (1980) and Vaidya and Kumar (2006) that the AHP is a technique combining subjective and objective assessments or perceptions into an integrative framework based on ratio scales from simple pair-wise comparisons. Thanks to its practicality, the AHP has been applied to a number of areas – for example, business and policy decision-making, resource allocation, priority rating, determination of factor weights and performance evaluation problems (Ramanathan and Ganesh, 1995; Chwolka and Raith, 2001; Beynon, 2002b; Tzeng et al., 2002; Vaidya and Kumar, 2006).

A useful feature of AHP is its applicability to the measurement of intangible criteria alongside the tangible, through ratio scales (Badri, 1999). In addition, by breaking problems into their constituent parts and relating them in a logical way (i.e. from the larger scales descending in gradual steps to the smaller ones), an analyst is able to connect the small ones to the large through the use of pair-wise comparison (Vargas, 1990), which is a useful background for obtaining the weight values.

In this study, pair-wise comparisons are made in order to determine relative weights, $w(i)$, for the factors identified. The logic behind this decision is that the more important elements and attributes in the AHP should have higher weights or values when decisions or assessments are being made. The process is based on the computational procedures suggested by Saaty (1984, 2001).

From the survey mentioned above, 92 useable responses were utilized to obtain the relative importance of each of the seven factors (i.e., pair-wise comparison), on a scale ranging from a low 1 to a high 9, discarding 0 (see Saaty, 1980 and 1984; Vaidya and Kumar, 2006 for detailed calculation procedures; Song and Yeo, 2004 for questionnaire details). Table 2 shows the weight values of each factor calculated from the procedures described in Saaty (1980 and 1984) and Vaidya and Kumar (2006). Moreover, in order to perform the empirical analysis, factors comprising port service, hinterland condition, availability, convenience, logistics cost, regional centre, and connectivity are denoted by x_1, x_2, x_3, x_4, x_5, x_6, x_7 respectively.

[INSERT TABLE 2]

4. DETERMINATION OF COMPROMISE WEIGHTS IN MDMG PROBLEM

4. 1 Adapting DS Theory for the Elimination of Uncertainty

Respondents were drawn from four groups and although they may offer reliable evaluations within their specialist fields, beyond them, less reliable evaluations would be expected. To compensate, a degree of confidence (CD) was introduced to represent uncertainty in responses. The researcher group exhibited greatest confidence in their evaluations (CD=0.775), followed by shipping companies (0.700), logistics companies (0.643) and forwarders (0.550). The degree of uncertainty ($m_{\phi k}$) is thus 0.225 for researchers, 0.300 for the shipping company group, 0.357 for the logistics company group and 0.450 for forwarders. Researchers were confident in their judgments, perhaps because they routinely tackle logistical problems. Groups in larger organizations, such as shipping and logistics companies were more confident than forwarders, typically employed in small organizations (Bryson and Mobolurin, 1999; Beynon, 2002a).

Equations (2)-(5) need to be adapted to introduce uncertainty to weight values by AHP. Moreover, uncertainty under the UDMG are eliminated by DS theory as in equations (6)-(7) and the normalization process in (8)-(9)(Beynon 2005). Results for each group are illustrated in Table 3.

[INSERT TABLE 3]

Table 3 reveals a tendency toward self-opinion in the UDMG and a competitive spirit amongst the experts. Considering only the three most important factors in each group, the researcher group ranked 'regional centre' ahead of 'connectivity' and 'hinterland

condition'; shippers ranked 'availability' ahead of 'hinterland condition' and 'logistics cost'; forwarders rated 'logistics cost' ahead of 'connectivity' and 'port service' and logisticians rated 'regional centre' ahead of logistics cost and connectivity.

4. 2 Obtaining Compromise Weight Values

Because the evaluations by each group conflicted, a levelling process using equations (10)-(12) in step 2 was adapted, and the CWs were computed. Results reveal a reduced tendency towards self-opinion in each group, and a more competitive spirit. The final CWs for port competitiveness factors, $W(\cdot)$, are derived from equation (13).

[INSERT FIGURE 3]

Therefore, the input matrix of CW for evaluation of container port competitiveness in NEA is as follows:

$W(i)$ = [Port service, Hinterland condition, Availability, Convenience, Logistics cost, Regional centre, Connectivity]

$W(i)$ = [0.13568, 0.14401, 0.13383, 0.13305, 0.15165, 0.15157, 0.15023]

5. CONCLUSIONS

Container ports located in NEA, considered the world's busiest in terms of cargo volume handled, exhibit severe port competition, demanding that the ECPC receives urgent attention from academics. Generally speaking, the ECPC is regarded as a MCDM problem which involves various stakeholders with conflicting interests. To solve the ECPC, the

AHP method was employed. However, several limitations emerged when it was utilized. In this respect, to overcome the drawbacks experienced in existing studies, this paper suggests a combined AHP method. The technical implications for operational researchers are as follows. Firstly, uncertainty associated with expert judgments increases as judgments become further removed from experts' specialist fields. This paper successfully eliminates the uncertainty in evaluation through incorporating DS theory. Loyalty to their field and a tendency towards self-opinion also influence their judgments. Secondly, this causes conflicts of opinion. In this paper, the MDMG problem was adjusted using a levelling process. From the combined AHP, which involves the above two steps, the CWs were suggested. Using the CWs, exact evaluation of the competition situation becomes possible. Thirdly, as a pilot trail of a methodology, this paper attempts to reconcile the differing signals brought about by the uncertainty in different participants' answers in the ECPC.

In addition, a series of meaningful results were derived from the adaptation of combined AHP, which can yield the following useful insights into port competitiveness in NEA for port related policy makers. The structure and factors for the ECPC were identified including 7 principal factors drawn from 18 components. Regarding the ECPC factors, researchers noted that the most important factors were 'regional centre', 'connectivity' and 'hinterland condition', reflecting logistics hub theory (Gibson et al., 1993; Starr, 1994; Eum, 2002; Ha et al., 2002), in which sea ports as hubs are defined in terms of their role in influencing the centre and connectivity of networks. However, the shipping company group had different opinions. They suggested that 'availability', 'hinterland condition' and 'logistics cost' were important factors thus, reflecting concerns for ships' berthing, continuous use of port facilities and storage and rapid access to hinterland facilities and port charges. Meanwhile, the logistics group felt that 'regional centre' and 'connectivity' were the most important factors, supporting the view taken by researchers, followed by logistics cost. The forwarder group, on the other hand, rated 'logistics cost' as crucial, thus

indicating concerns over cost competitiveness. The CW values showed that logistics cost was the key factor reflecting severe port competition in NEA, and many choices could be possible from the perspective of port related experts. In these circumstances, lower port costs would be the most attractive factor. Another interesting finding was the significance of 'regional centre' and 'connectivity', indicating that port experts emphasize the centre of the network and its connectivity as selection criteria. Hinterland condition was more important than availability and convenience, reflecting interest in Free Trade Zones (FTZ) at the hinterland of sea ports on the east coast of China and south and west coast of Korea, which enjoy more tax breaks and efficient logistics flows.

These approaches are potentially applicable to other logistical decision-making such as logistics network selection, site selection and mode choice. In further research, the employment of the CW values of port competitiveness factors might be considered for the evaluation of port competitiveness, and the rankings of Korean, Chinese and Asian container ports.

ACKNOWLEDGEMENTS

The authors are grateful to the editor Professor Roman Slowinski and two anonymous referees for their kind and constructive comments and suggestions which made a significant contribution to the quality of the paper. Professionals in the field are also thankfully appreciated for their time and willingness to share their experiences and insights with us.

REFERENCES

Aouam, T., Chang, S., Lee, E., 2003. Fuzzy MADM: An outranking method. European Journal of Operational Research 145, 317-328.

Badri, M., 1999. Combining Analytic Hierarchy Process and Goal Programming for Global Facility Location-Allocation Problems. International Journal of Production Economics, 62(3), 237-248.

Beynon, M., 2002a. DS/AHP method: A mathematical analysis, including an understanding of uncertainty. European Journal of Operational Research, 140, 148-164.

Beynon, M., 2002b. An analysis of distributions of priority values from alternative comparison scales within AHP. European Journal of Operational Research, 140, 104-117.

Beynon, M., 2005. Understanding local ignorance and non-specificity within the DS/AHP method of multi-criteria decision making. European Journal of Operational Research, 163, 403-417.

Brooks, M., 2000. Sea Change in Liner Shipping: Regulation and Managerial Decision-Making in a Global Industry. Pergamon, Amsterdam.

Bryson, N., Mobolurin, A., 1999. A process for generating quantitative belief functions. European Journal of Operational Research, 115, 624-633.

Chwolka, A., Raith, M., 2001. Group preference aggregation with the AHP: Implications for multiple-issue agendas. European Journal of Operational Research, 132, 176-186.

Eum, T., 2002. The determinant factor analysis to establish the logistics hub in Northeast Asia, International Academic Seminar for the First Anniversary of the Founding of ILS, Seoul.

Fan, Z., Ma, J., Zhang, Q., 2002. An approach to multiple attribute decision making based on fuzzy preference information on alternatives. Fuzzy Sets and Systems, 131(1), 101-106.

Frankel, E., 1992. Hierarchical logic in shipping policy and decision-making. Maritime Policy and Management, 19(3), 211-222.

Gibson, B., Sink, H., Mundy, R., 1993. Shipper-carrier relationships and carrier selection criteria. Logistics and Transportation Review, 29(4), 371-381.

Ha, H.-K., Lee, S.-W., Yae, C.-Y., 2002. Construction of the logistics centre in the Northeast Asian Region, KOTI/Economic Forum in Northeast Asia, Seoul.

Haralambides, H., Yang, J., 2003. A fuzzy set theory approach to flagging out: towards a new Chinese shipping policy. Maritime Policy, 27(1), 13-22.

Hoffmann, J. 2004. Asian Countries' Specialization in Different Maritime Business: Challenges and Opportunities arising from the Process of Concentration in Shipping. IPSC International Seminar, Karachi.

Hwang, C., Yoon, K., 1981. Multiple Attribute Decision Making: Methods and Applications, Springer, Berlin.

Kahneman, D., Slovic, P., Tversky, A., 1983. Judgement Under Uncertainty. Cambridge University Press, Cambridge.

Karacapilidis, N., Pappis, C., 1997. A framework for group decision support systems: Combining AI tools and OR techniques. European Journal of Operational Research, 103, 373-388.

Kruskal, J., 1964. Nonmetric multidimensional scaling: a numerical method. Psychometrika, 29, 115-129.

Kumar, S., 2002. A decision support model for the liner shipping competition policy debate, Proceedings of the International Association of Maritime Economists, Panama, 12-15 November.

Lai, V., Wong, B., Cheung, W., 2002. Group decision making in a multiple criteria environment: A case using the AHP in software selection. European Journal of Operational Research, 137, 134-144.

Lim, B.-T., 2000. A study on the development and application of fuzzy evaluation algorithm to complex systems, Unpublished PhD Thesis, Korea Maritime University.

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

Ohashia, H., Kim, T, Oum, T and Yuc, C. 2005. Choice of air cargo transshipment airport: an application to air cargo traffic to/from Northeast Asia, Journal of Air Transport Management, 11, 149-159.

Ramanathan, R., Ganesh, L., 1995. Using AHP for resource allocation problems. European Journal of Operational Research, 80, 410-417.

Saaty, T., 1980. Multicriteria Decision Making: The Analytic Hierarchy Process. McGraw-Hill, New York.

Saaty, T., 1984. Scaling method for priorities in hierarchical structures. Journal of Mathematical Psychology, 15(3), 234-281.

Saaty, T., Vargas, L., 2001. Models, Methods, Concepts and Applications of the Analytic Hierarchy Process. Kluwer Academic, London.

Simon, J., Burstein, P., 1985. Basic Research Methods in Social Science. McGraw-Hill, New York.

Song, D.-W. and Yeo, K.-T. (2004), A Competitive Analysis of Chinese Container Ports Using the Analytic Hierarchy Process, Maritime Economics and Logistics, 6, 34-52.

Srinivasan, V., Shocker, A., 1973. Linear programming techniques for multidimensional analysis of preference. Psychometrika, 38, 337-369.

Starr, J., 1994. The mid-Atlantic load centre : Baltimore or Hampton Roads? Maritime Policy and Management, 21(3), 219-227.

Tzeng, G., Teng, M., Chen, J., Opricovic, S., 2002. Multicriteria selection for a restaurant location in Taipei. International Journal of Hospitality Management, 21, 171-187.

UNCTAD 2004. Assessment of a Seaport Land Interface: an Analytical Framework, UNCTAD/SDTE/TLB/MISC/2004/3, United Nations.

UNCTAD 2005. Trade and Development Report, UNCTAD/TDR/2005, United Nations.

Vaidya, O., Kumar, S. 2006. Analytic Hierarchy Process: An Overview of Applications, European Journal of Operational Research, 169, 1-29.

Vargas, L., 1990. An overview of the Analytic Hierarchy Process and its Applications. European Journal of Operational Research, 48, 2-8.

Voorde, E., Winkelmans, W., 2002. A general introduction to port competition and management. In: Winkelmans, W. eds. Port Competitiveness: An economic and legal analysis of the factors determining the competitiveness of seaports. Antwerp: De Boeck, 1-15.

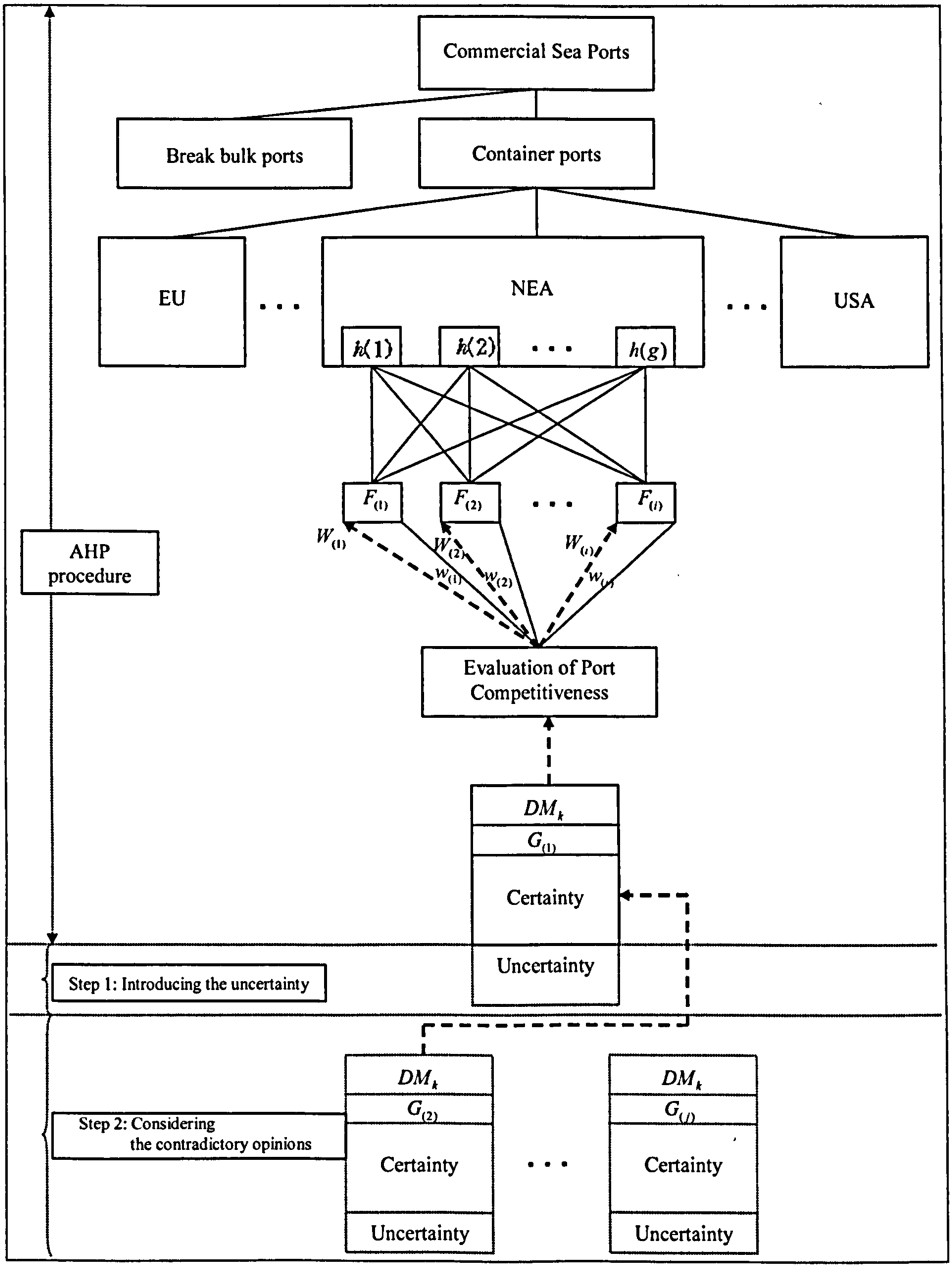
Wei, Q., Yan, H., Fan, Z., 2000. A compromise weight for multi-criteria group decision making with individual preference. Journal of Operational Research Society, 51, 625-634.

Yang, J., Singh, M., 1994. An evidential reasoning approach for multiple-attribute decision making with uncertainty. IEEE Transactions on System, Man and Cybernetics, 24(1), 1-18.

Yang, J., Sen, P., 1994. A general multi-level evaluation process for hybrid MADM with uncertainty. IEEE Transactions on System, Man and Cybernetics, 24(10), 1458-1472.

Yun, W., and Zhang, X., in press. Electric power grid interconnection in Northeast Asia, Energy Policy.

Figure 1. Schematic diagram for the evaluation of container port competitiveness in NEA



Notes: $DM_{(k)}$;Decision Makers on each group, $F(i)$; Evaluation Factors, G_J;Groups of Stake Holders, $h(g)$;Evaluation values of each container port, $w(i)$;Weights of each factor, $W(i)$; Compromise Weights values

Figure 2. Evaluation Structure for Competing Container Ports in Korea and China

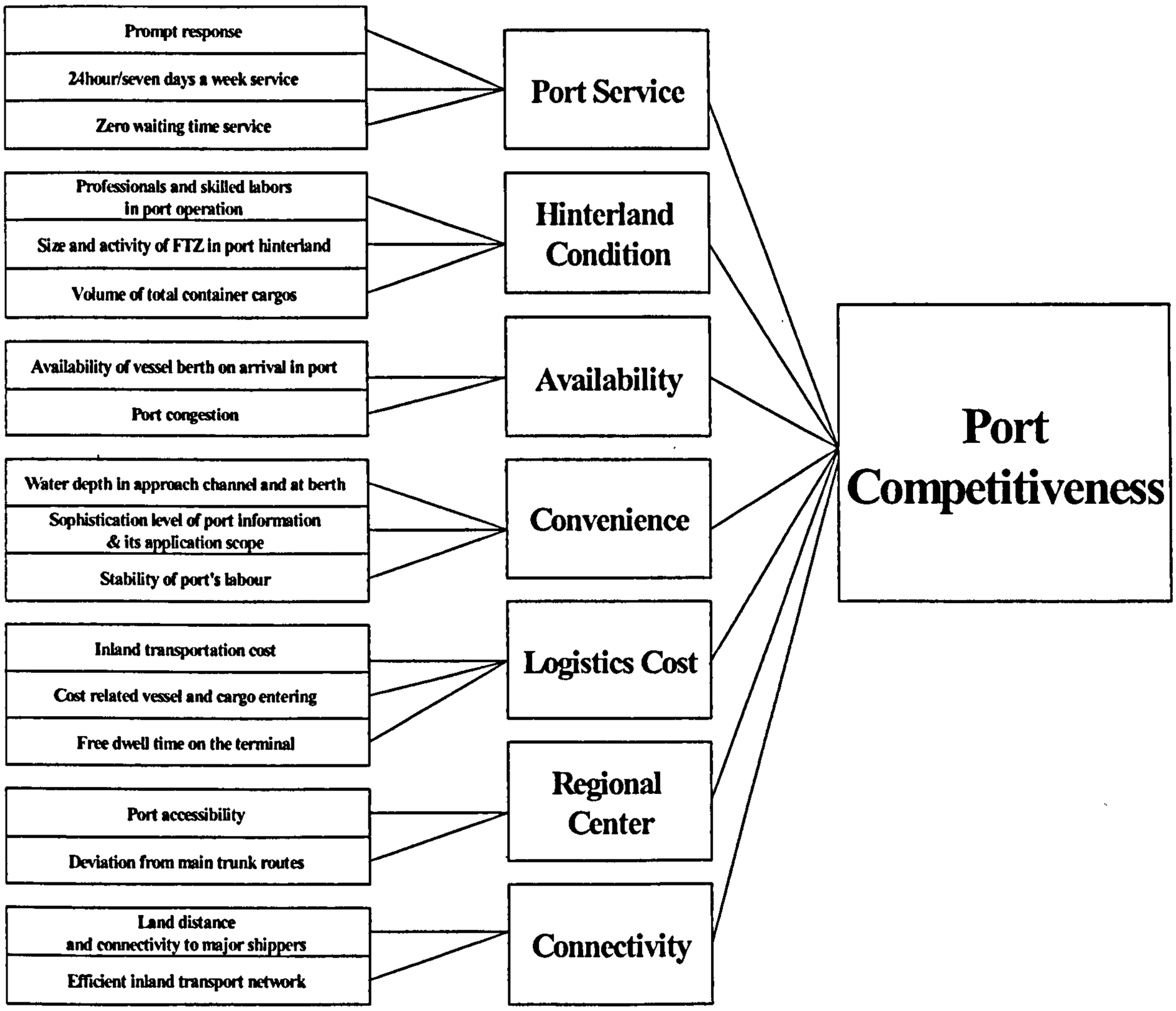
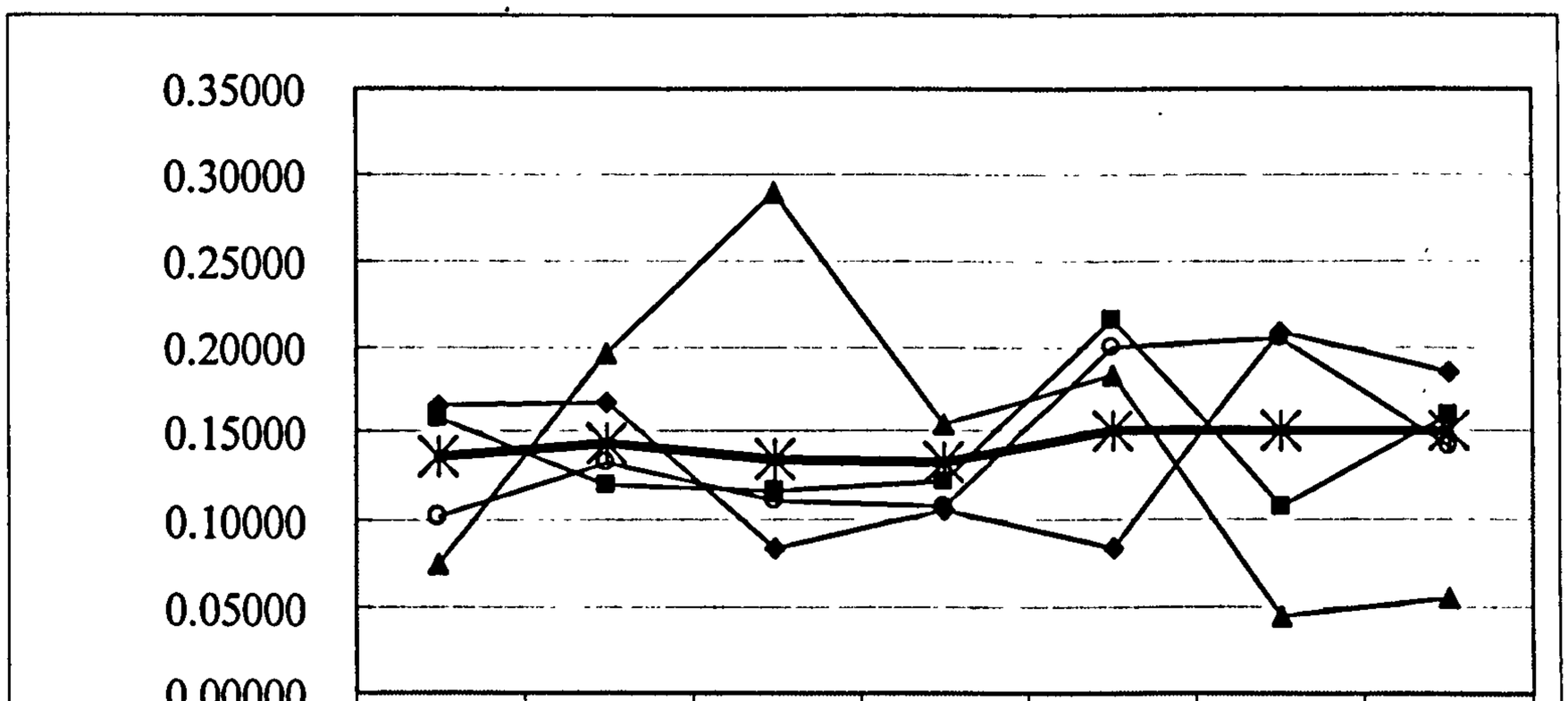


Figure 3. CWs for Port Competitiveness Factors



	X1	X2	X3	X4	X5	X6	X7
Researcher	0.16580	0.16661	0.08497	0.10564	0.08376	0.20840	0.18481
Forwarder	0.15809	0.11981	0.11704	0.12285	0.21524	0.10698	0.15999
Shipping Co.	0.07549	0.19582	0.28962	0.15364	0.18325	0.04571	0.05647
Logistics Co.	0.10249	0.13323	0.11165	0.10706	0.19963	0.20466	0.14127
CWs	0.13568	0.14401	0.13383	0.13305	0.15165	0.15157	0.15023

Table 1. Respondent Profiles

			Number of respondents		
Occupational status			Senior 27	Middle 48	Junior 17
Years work experience	Under 5 20	5-10 29	11-15 17	16-20 12	Over 20 13
Sea routes used	America 19	Europe 12	Korea/China 33	SE Asia 18	Other 9
Using ships of TEU	Under 500 18	500-1000 29	1000-3000 20	3000-5000 17	Over 5000 7
Number of employees		Under 100 54	100-500 23	501-1000 5	Over 1000 10
Annual sales (US$)		Under 0.1 48	0.1-1.0 16	1.0-5.0 17	Over 5.0 12

Table 2. Weights of Each Factor by Each Group

	Researchers Group	Forwarders Group	Shipping Companies Group	Logistics Companies Group
x_1	0.176	0.177	0.144	0.156
x_2	0.167	0.151	0.185	0.143
x_3	0.135	0.135	0.179	0.138
x_4	0.133	0.147	0.140	0.132
x_5	0.122	0.152	0.150	0.165
x_6	0.131	0.107	0.099	0.147
x_7	0.135	0.130	0.103	0.119
C.I.	0.008	0.025	0.016	0.020
C.R.	0.006	0.019	0.012	0.015

Table 3. Results of Weight Values under the UDMG

	Researchers Group	Forwarders Group	Shipping Companies Group	Logistics Companies Group
x_1	0.16580	0.15809	0.07549	0.10249
x_2	0.16661	0.11981	0.19582	0.13323
x_3	0.08497	0.11704	0.28962	0.11165
x_4	0.10564	0.12285	0.15364	0.10706
x_5	0.08376	0.21524	0.18325	0.19963
x_6	0.20840	0.10698	0.04571	0.20466
x_7	0.18481	0.15999	0.05647	0.14127