Erasmus University Rotterdam

MSc in Maritime Economics and Logistics

2012/2013

An Analysis of Port Competitiveness through User's Perception Measurement

by

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Acknowledgements

The memories of learning experience during the past few months in MEL are happy and even tough, nevertheless, always be the greatest achievement in my life. It builds a bridge for me to enter into the academic world to equip myself with more knowledge so as to promote me to higher level; it brought me a kind of energetic perseverance, persistence and courage to overcome difficulties; it even made me reap a precious friendship and gain a chance to experience multinational cultures. The completion of this thesis devotes my commitment and endeavor, while giving me this opportunity to express my sincere gratitude to the people who has contributed their time and efforts in this paper.

Firstly, the deepest gratitude is to my parents, who gave me life and taught me the truth and told me the treasure of knowledge, it is their endless love and thoughtful concerns that give me family warmth in a country far away from my hometown; it is their encouragement and support that give me confidence in tiding over the difficulties and inspire me to pursue dream.

My eternal appreciation goes to Dr. Michaël Dooms, who supervised me with this paper. Without his prestigious supervision, the accomplishment of this research would never be possible. It is his precious suggestions and ideas which show me the bright direction of the thesis writing. I would like to express my sincere thankfulness to his generosity and kindness. I am also greatly indebted to the professors and scholars in the shipping industry and the staffs of MEL who often send us a variety of information and news and always accompany us with every company visits.

Last thanks would go to the staffs and professionals from CMA CGM, Hapag-Lloyd, Sinotrans (Germany) GmbH, Sinotrans (Netherlands) and other shipping liners, freight forwarders in response to the survey, they indeed offer me great supports during this period of time. I also would like to express my thankfulness to my friends who always bring me bright sense and encourage me when I am in difficulties.

Abstract

The purpose of this research is to explore and distinguish the importance of relative factors which determine ports competitiveness from ports users' perspective. Port users were defined into three groups, that is, shipping liners, freight forwarders and shippers, and they will be investigated in this study. The results regarding to the importance of various factors relied on the questionnaire from professionals and staffs in this industry based on their different angles by using AHP (Analytic Hierarchy Process) model. Then, the results of survey were used for measuring European Top 4 ports, port of Rotterdam, Hamburg, Antwerp and Bremerhaven were listed to be considered as the target ports. The potential influential factors are geographical location, physical infrastructure, hinterland connection, technological infrastructure, port management and administration and terminal cost. The importance of these factors are various from different users' requirements and expectations on port services. Hinterland connection is a common focus of all parties' concerns, port efficiency and infrastructure construction are still the main targets that ports are struggling for and the exploration and usage of information technology is beneficial for improving operational efficiency of ports to some extent. Conclusions finally were drawn based on the analysis which can be used as benchmark to measure ports performance and their competitors as well, in order to realize which aspects should be put much attention for further improvement.

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List of Abbreviations

AHP	Analytic Hierarchy Process
AGV	Automated Guided Vehicle
KPI	Key Performance Indicator
THC	Terminal Handling Charge
TEU	Twenty foot Equivalent Unit
UNCTAD	United Nations Conference on Trade and Development

Chapter 1 Introduction

Worldwide container ports are facing unprecedented challenges under the context of increasing competition and growing pressure from their stakeholder's requirements (Van de Voorde and Winkelmans, 2002). Container seaports are functioning as logistics centers. This phenomenon not only reflects that their user's demand has changed for deeper and diversified services, but also reflects that ports themselves have been greatly integrated into the global supply chain (Bichou and Gray, 2005). Carbone and De Martino (2003) also commented on the port's status that "*port competitiveness is becoming increasingly dependent on external co-ordination and control of the whole supply chain. We can, therefore, interpret a port as a member of a supply chain*." In order to improve their positions in the global economy, it is necessary for them to cooperate with their users to provide satisfactory services. As users who have interaction with ports are more likely to choose those have optimal performance in efficient operation and better quality services offering. Ports are increasingly paying much attention to the quality of service delivered to their customers (Gi-Tae Yeo, *et al*., 2011). Take the port of Melbourne for example, "customer focus" has been included into the current strategic plan (port of Melbourne, 2013). Ports users' perceptions, therefore, have a vital role in measuring port competitiveness. Due to container ports are of unique, complex and dynamic and lack of standardization (UNCTAD, 2012), the way for its measurement is difficult. There are geography, economy, policies and trade practice that determine the answer.

1.1 Background of the research

Many international metropolises are also the world's largest ports, such as New York, Singapore, Hong Kong, Shanghai, Hamburg and Rotterdam and so on. With the development of ports, these cities gradually formed the center of the world economy; meanwhile modern port has become an important part of the economic system. As the importance of port enhances, the level of its development has become a main symbol of measuring international or regional economic development. The fierce competition exists not only within ports, but also between coastal cities and countries. Ports have unprecedented influence on supporting regional economic development, which are playing the traditional function as transfer stations and commanding level of regional economic development as well.

Moreover, ports' development strategies are closely related to world seaborne trade development. After the 1990s, companied by changes in the international political situation, the process of the global economy has been speeding up and international trade is developing rapidly as well. Current trend for shipping industry is that ocean transport occupies majority of the global transportation. Multiplication of international trade volume depends on fast movement of cargo to a large extent, which means that it needs a much more effective and efficient transport network. Figure 1-1 shows international maritime routes have extended to a deeper degree. Carriers are continuously improving their service so as to keep pace with the requirements of traders. The more shipping routes ship owners operate, the more ports vessels may call. Nowadays, shipping companies recognized the importance of both competition and integration. Currently, they adopt the way of merging into an alliance to exchange slots with their partners to reduce the costs or through cooperating with logistics providers to offer various intermodal modes, such as road, rail transport and

barge to grasp more potential customers. Ports under such circumstance are necessary to fully cooperate with their stakeholders to achieve joint benefits.

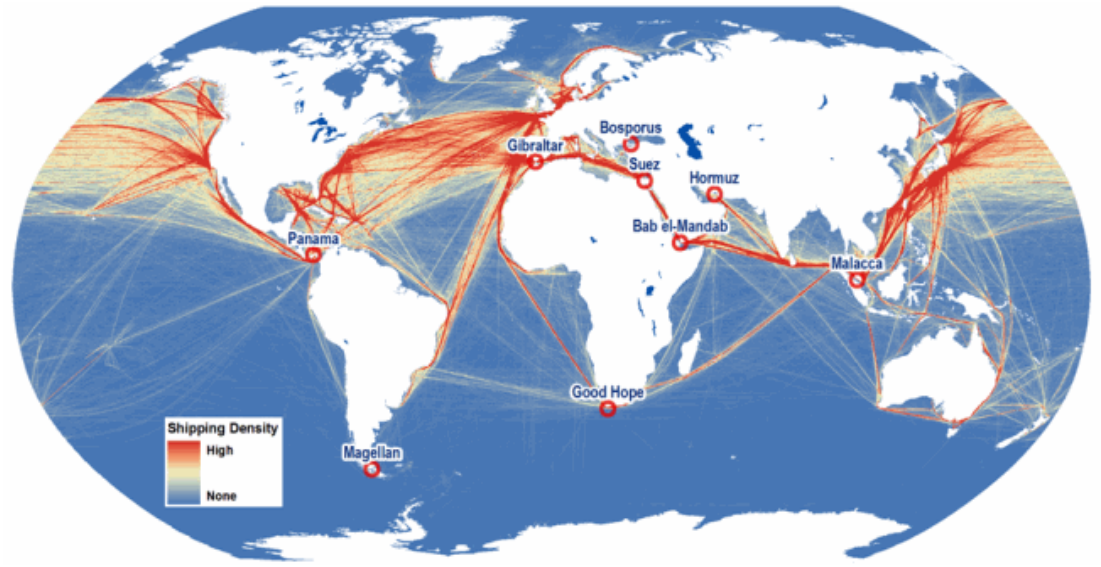

Figure 1-1 International maritime route
Source: http://origin-ars.els-cdn.com/content/image/1-s2.0-S0964569112000555-gr9.jpg

Generally, modern seaports have become global hubs for allocation of resource, the production process of ports are no longer in a relative simple way which only provide basic physical infrastructures for vessels to call, but offer more deeper comprehensive logistics services, such as, container storage, intermodal transport, customs clearance and transshipment etc. (Van Asperen, 2013). In addition, they have been revealed several trends in terms of cost reduction by large scale, offering intermodal 'door to door' services, adopting high efficient technology in the process of production, utilizing information technology and then transforming them into the comprehensive global logistics centers. In particular, transshipment ports like Singapore and Rotterdam, their transshipment cargo volume accounts for most of their throughputs annually. Singapore has the advantage of its geographical location in the Asian area, which has led it to be the largest transshipment hub in the Asia-European route. Similarly, Rotterdam, as the gateway of Europe, is also beneficial for its location with sufficient water depth, approachable channels and accessible berth for large container vessels. And its established crude oil storage and refinery facilities achieve oil procedures facilitation. Besides, in Hamburg, as for its advanced hinterland transport connection, cargo can be loaded on the train upon discharging from the vessel, as railway services offered by port of Hamburg speed up containers moving within port areas.

In the past decades, owing to technological and organizational innovations as well as the emergence of international powerful players, e.g. carriers and terminal operators, ports have witnessed substantial increase in competition globally. (Fleming & Baird, 2010; Notteboom & Winkelmans, 2001; Parola & Musso, 2007) Nowadays, in order to further deeply expand the scope of their business and continue to raise international reputation, ports are experiencing large challenges and pressures from their users and are pursuing aggressive developmental and innovative strategies through increasingly reinforcing their relationship with users so as to strengthen their

positions and achieve ultimate success.

Requirements for further deeply exploiting the services for global supply chains and their users' satisfaction on that will more or less affect ports reputation so that impact the competitiveness of ports on the international stage. By engaging in the research on the factors that determined ports competitiveness, port operators could know what are their users exactly needs so as to draw up future target to keep pace with the growth of the global logistics and innovations for technology and information. This research will analyze on this topic in more detail.

1.2 Problem Definition

Measuring ports competitiveness involves various kinds of factors to be considered by their users, for example, when shipping company would operate a new shipping route, if ports could provide satisfied supply logistics services with favorable charges; if construction of port infrastructure has bright prospect which can recover the initial investment and even make profits upon the project completes; if port is equipped with high efficient facilities, technologies and updated information system to provide their users with more effective supports; if the hinterland transport network is perfect enough so as to arrange and quickly deliver the cargo in order to meet user's need. These questions are general issues which port users often take into account and impact their judgments on port competitiveness.

Previous study (Gi-Tae Yeo, 2011) presented findings that port handling efficiency and port charges, etc. are important factors to be considered. In this era of supply chain, ports have been more and more contributed themselves into developing the integrated global logistics industry and trying to find a better way to upgrade their innovations in terms of technology and information. Therefore, the widely used computerized electronic transmission of cargo manifest and detailed stowage plan can largely shorten the time spent in the port area (M. Kia, *et al*., 2000). The more information technologies introduced in terminal operation, the more efficiency of boxes handling and moving in the port and thus the more competitiveness the port has.

It cannot be denied that port authority do change their future development target to some extent in the global logistics era. Most of published studies have done on port competition. However, few of them focus on the situation nowadays. The author has the ambition and is trying best to go deep into the current situation of ports competitiveness based on their users' perception to make a comprehensive analysis.

1.3 Aim of the Study

As continued world economic growth and an increasing amount of trade flows, new trade routes and new players are continuously emerging, all of these will directly influence performance of the ports. It is believed that this study can investigate the role of qualitative factors in measuring port competitiveness, shed some light on the current competitiveness of main European ports and provide an appropriate platform for further research on port competitiveness and prospective development.

1.4 Research Questions

As K. Cullinane and Y. Wang argued in their research, "*inter-port competition occurs when the user of port infrastructure or a particular port service has an economically feasible substitute for those facilities in another location*." (K. Cullinane and Y. Yang, 2009), as transportation and logistics infrastructure has increasingly improved ports hinterland connectivity and overlap, this prevalent phenomenon has never occurred before. For strengthening competitiveness, worldwide port authorities and controller are focusing on significant infrastructure investments with the aim at lowering operational costs and improving integral service quality. In order to analyze the current ports competition and do further research on the measurement of their competitiveness, it is important to tackle these questions. This research is going to do an analysis and measurement of port competitiveness based on the ports users' perceptions. In the meantime, four sub-questions to be answered in order to better analyze and resolve the main research question:

a. Do ports have any change since persistent development in global trade has significantly increased the demand for ports' users nowadays?
b. If so, how has globalization influenced the factors of competitiveness for ports?
c. Do ports respond to these significant changes or what's the new situation of ports when facing up to the changes?
d. If so, how do ports formulate their prospective plans to maintain their competitive position in the global logistics market?

1.5 Research Methodology

The author adopts the approach of literature review, which is used to conclude results from previous research. Factors associated with port competitiveness were summarized in the literature about 30 and mainly fall in 6 categories, including geographical location, physical infrastructure, logistic chain and connectivity to the hinterlands, technological infrastructure, port management and administration and terminal charges. From the previous literature review, some empirical findings can be used to support the research and also can motivate inspirations.

In addition, the research applies the Analytic Hierarchy Process (AHP) to present and analyze the factors that influenced measuring port competitiveness by their users. Statistical data are acquired by a designed questionnaire, which is distributed to 20 relevant port users, including port authority, shipping lines, freight forwarders and experts in this field. The investigated results will be used in the AHP model, through some basic statistical techniques and simple mathematical calculations. Final results will be given and applied to analyze the current situation of port competitiveness.

Finally, lots of ports annual reports, updated data and relevant information on ports website or from other sources will be presented for illustration.

1.6 Structure and outline of the Study

The research consists of seven chapters, the following contents are brief description for each chapter.

In chapter 1, a general introduction of the research is given at the very beginning. Moreover, the research background and aim of the study then represented and

explained in more detail. Furthermore, four sub-questions were defined so as to better resolve the main problem more deeply and roundly. Lastly, AHP approach as a methodology which will be applied to pave the way for the following research.

In chapter 2, plenty of literature reviews are in this section, as a whole, targeted literature mainly related to port and terminal; shipping lines, freight forwarders and other logistics providers; global logistics chain in terms of port competition. When reviewing these, the author will also gather and conclude the information.

In chapter 3, current situation of port competition will be revealed, it highlights the importance of cost and time in the phases of port stay and sometimes the marketing of port services, such as professional and financial activities, innovations on information and techniques and telecommunication areas are being paid much attention by the port authority. Furthermore, factors that influenced measuring port competition will be explained and analyzed within main European ports on both seaside and landside.

In chapter 4, it will have an introduction of AHP model and its principles of assessment, followed by an integrative framework design for port performance and then apply AHP approach into the assessment of port competitiveness. This approach is tested by a survey from port users focusing on the given performance indicators.

In chapter 5, select and extract useful responses from questionnaire then identify more prominent impact indicators to build the hierarchies. Based on the statistical data from chapter 4, the results of the calculation will be presented and interpreted.

In chapter 6, empirical findings on shipping lines, terminals, logistics companies as well as ports will be discussed, the current situation from seaside (container terminal and port infrastructure etc.) and landside (hinterland connection and intermodal transportation). Through reviewing and analyzing ports strategic plans and some annual reports, in order to maintain their competitive advantages under the context of global supply chain, the author find that the focus on future development for ports may be the hinterland connection, port operational efficiency, infrastructure construction and innovations on information and technology.

In chapter 7, besides the limitation of the research will be given, this study concludes with a series of recommendations for further improvement.

Chapter 2 Literature Review

2.1 Introduction

This section focuses on reviewing the relevant studies in the field of ports, terminals, logistics, supply chain, shipping lines, shippers, consignees and freight forwarders. Through extensive reading of literature, on the basis of understanding the concept of relevant terms and relations between different parties involved, the author may get a preliminary overview of previous findings and create a valuable thesis from ports users' perception theoretically.

Figure 2-1 Research framework of this paper
Source: compiled by the author

As continued worldwide economic growth and increased trade flows, new trade routes and new players emerged currently, all of these would directly influence the performance of ports. This study provides guidance for port authorities to identify their users' needs and consideration when making transportation decisions. It is also an insightful guidance for their optimal resources allocation and it has significance for their reorganization so as to meet future developmental requirement as well. Ports are not just for fulfilling the complex requirements from their users, including shipping liners, freight forwarders and shippers etc., the most important is that they have shifted their attention to improve their competitiveness for gaining greater market share through deeper services to satisfy their customers' needs. It is believed that this study can investigate the role of qualitative factors in port measurement, shed some light on the current competitiveness of main European ports (Antwerp, Rotterdam, Hamburg and Bremerhaven), which are acting as transshipment hubs through measuring their performance of each factor that affect their users' final decisions and it also provides appropriate platform for further research on port competitiveness and prospective development. Figure 2-1 below shows the logical structure of the paper.

2.2 Definition of logistics, supply chain and supply chain management

In order to better understand what and how the study will conduct in the following chapters, it is necessary to get a clear idea beforehand about the concept, terms and etc. which will be involved in the following research.

The definition of logistics is "*the function responsible for the flow of materials from suppliers into an organization, through operations within the organization, and then out to customers*." (Van Asperen, 2013), in other words, logistics can be regarded as effective objects movement amongst various parties. As far as port is concerned, it is indeed such an organization with a function of the medium of the whole process.

The concept of supply chain was proposed in 1980s, it does not have unified definition. However, many scholars have been given their explanations for it, for

example, La Londe and Masters defined it as:

"*A supply chain is a set of firms that pass materials forward. Normally, several independent firms are involved in manufacturing a product and placing it in the hands of the end user in a supply chain-raw material and component producers, product assemblers, wholesalers, retailer merchants and transportation companies are all members of a supply chain.*" (La Londe and Masters, 1994)

Another meaning was defined by Christopher that "*a supply chain is the network of organizations that are involved, through upstream and downstream linkages, in the different processes and activities that produce value in the form of products and services delivered to the ultimate consumer*." (Christopher, 1992)

Indeed, supply chain is a complicated process, which consists of multiple parties to participate and multiple segments. An example of cargo flow from China to Australia is given in Figure 2-2, it is easily illustrated that a supply chain consists of multiple parties on both sides: upstream (i.e. supply) and downstream (i.e. distribution) and the ultimate customer as well. Below process of the supply chain can be divided into several segments. After finishing production, cargo will be transported by truck to stack in the distribution center which to be prepared for export. When receiving shipper's instruction, all the cargo will then be covered into the container and sent to the port, according to the transport contract or agreement between trading parties, container or cargo will continue to be loaded on the vessel or airplane. Having arrived at the destination, the cargo will be delivered by a truck to a distribution center and wait for retailers' order, upon such order send to the distribution center, the required cargo will be transported by several vans to different retailers so as to deliver to final customers. The practical operation and process are much more complex.

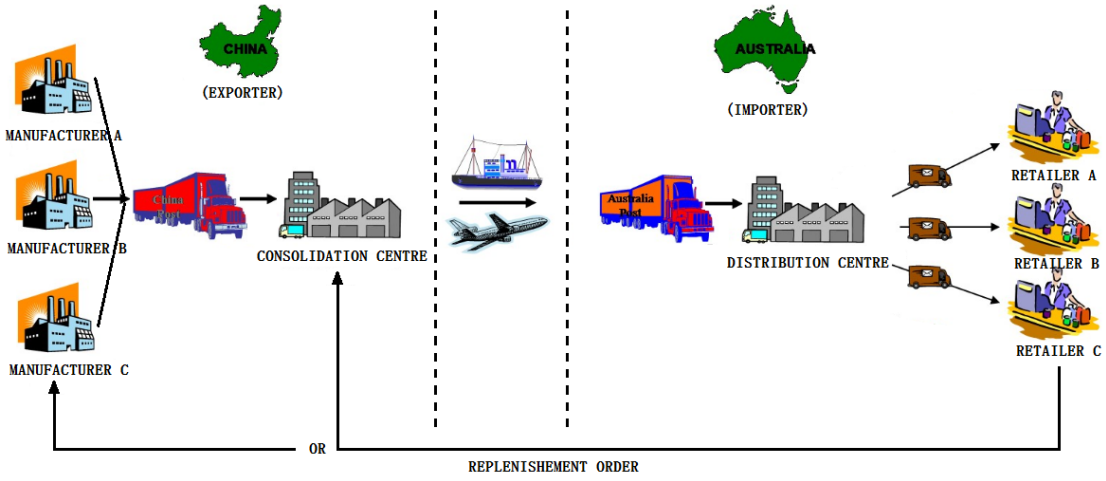

Figure 2-2 The process of supply chain
Source: compiled by the author

Several years later, Song and Lee defined Logistics and Supply Chain Management in their research and noted that:

"*Logistics and Supply Chain Management generally relates to the coordinated management of the various functions responsible for the flow of materials from*

suppliers into an organization through a number of operations within the organization, and then reaching out to its customers." (Song and Lee, 2009)

This introduced concept has a series of activities involved in the whole network, in most cases, it integrates with logistics and maritime transport. Owing to global containerization and heterogeneous services required by customers, the process involves the optimal physical integration of transport modes and logistics concept fused with the use of these modes as well.

2.3 Definition of port, terminal and port competitiveness

Several terminals form a port, a port can be described as "*a group of facilities and movable equipment used to provide different types of services which, in economic terms, are highly heterogeneous*."(Beatriz Tovar, *et al.*, 2003)

Bichou (2007) evaluated ports in three types of channels in terms of logistics, trade and supply with role of an intermodal transport intersection and as well as a logistics centre for cargo movement, he mentioned that a port is a location where identifies the ownership and control of traded goods or a place where creates production patterns and processes shipments on their own way.

Port competitiveness refers to the abilities that ports have which differentiate themselves from their competitors in the process of achieving their competitive objectives, such as, manufacturers' abilities of acquiring customers, possessing and controlling the market. This kind of competitiveness inevitably changes as the market structure changes and the power of competitors increase. When ports are regarded as main competitors, the term of competitiveness has two meanings: one is port's economic nature with purpose of gaining profits; the other is port social nature, which means that port is port city and as the gateway of foreign trade in surrounding areas where can reallocate resources, such as cargo, transport vehicles, information, funds and labor force and etc. in a proper and reasonable way through connections between ports. Hence, ports are playing an active role in terms of collocation of a variety of resources in the community and increasingly becoming the main part of harbor city. In this respect, port competitiveness refers to the ability to attract a variety of resources and a kind of competitive advantage compared to other ports by integrating and optimizing key elements and interacting with external environment in terms of occupying the market and creating value and sustainable development in the process of market competition.

Ports usually tend to focus on pursuing profits and added value generated by diversified services and more trade volumes. As for the purpose of port competition, some former researchers have given their ideas about it. Slack (1985) once mentioned that the port competition can be regarded as a process of ports that struggling for customers, market share, hinterland control and some further much more control in the global supply chain.

A couple of years later, Fleming and Baird followed Slack's point of view and argued that "... *competitors of greatest consequence in the fortunes of the port industry are the ports' main customers, the transportation carriers and the commodity shippers, because these decision-makers will determine transport itineraries and choose the ports to be used*." (Fleming and Baird, 2010)

This point of view also commented in Kevin Cullinane and Yuhong Wang's research that international trade has so fast growth that it has gradually become the bottleneck for further progressing of container shipping liners' available capacities and it also continuously influencing port competitiveness as well. As a fact of this complicated situation, the competition amongst ports, under the context of economic globalization and electronic commerce, is not an isolated phenomenon any more. Any changes in response in improving of port competitiveness may affect the structure of sea transportation system and even may potentially influence the trade patterns it served (Kevin Cullinane and Yuhong Wang, 2009).

2.4 Ports stakeholders and main users

Ports serve stakeholders' needs to ensure their expectations could be realized. The first task is to identify port users in order to further analyze and develop their perceptions. Notteboom and Winkelmans suggested four stakeholder groups in Port community: *(1) internal stakeholders (2) external stakeholders (3) legislation and public policy stakeholders and (4) community stakeholders* (Notteboom and Winkelmans, 2012).

Notteboom and Winkelmans also mentioned the parties involved in the external stakeholders group include trading companies (shipper and consignee), forwarders, shipping companies, etc. (Notteboom and Winkelmans, 2012), whom would be investigated as main users of port in the following research:

(1) Shippers

Shippers refer to those "*Individuals or businesses who tender goods or cargo for transportation - usually the cargo owners or their representatives and not to be confused with the party issuing the bills of lading or the ship's operator who is the carrier*…" (Glossary of maritime terms, 2013). As the owner of cargo – shipper – has a vital role in determining where their cargo will be shipped, this kind of decision more or less will be effected by port performance, this point of view also supported by Jose Tongzon and Wu Heng (2005), they argued that port performance based on their operations would have great effects on shippers and carriers' choice, even if ports can provide much more attractive price than their competitors, shippers and carriers are still able to bypass those ports with worse performance, which implicitly expressed that shippers and carriers' preferences have a little bit change that they do not only care about price factor any more.

(2) Consignees

Consignee is "*the person to whom cargo is consigned as stated on the bills of lading*" (Glossary of maritime terms, 2013). They are the final receivers of cargo delivered by carriers through presenting the bill of lading sent by shippers. In most cases, owing to different trade terms in the contract with shippers, consignees also have responsibility in choosing carriers and ports, e.g. under the incoterm of FOB, they have to book space and arrange for cargo transportation, at this point, their opinions are as important as shippers.

(3) Freight forwarders

Freight forwarder is "*a person or persons who represents the cargo owner and who arranges shipments for that owner*." (Glossary of maritime terms, 2013). Their functions are booking vessels, preparing the requisite documents for ocean carriage and trade on behalf of shippers (Van Asperen, 2013). In other words, they play the role as a medium of linking carriers with shippers to earn agency charges. De Langen analyzed the difference between shipper and freight forwarder was that shippers were less sensitive to the price change although both of them almost have a similar choice on assessing the port (De Langen, 2007). In practice, freight forwarders will generally arrange the most economical transportation route to meet shippers' needs after considering all available transport modes and comparing all possible charges. Some shippers may prefer to choose lower shipping cost for longer shipping time, while other shippers may in favor of quick delivery with higher transport cost.

(4) Carriers

Carriers are "*owners or operators of vessels providing transportation to shippers. The term is also sometimes used to refer to the vessels, i.e. ore carriers*." (Glossary of maritime terms, 2013) In all port users involved, carriers are regarded as the final decision-makers, as commented by Fleming and Baird that "*The carriers that are successful in booking the cargoes often determine the ports to be used, and these are decisions that are beyond the short-term influence of the ports themselves*." (Fleming and Baird, 2010)

2.5 Methodology on assessing port competitiveness

Research on port competitiveness includes measurement of port competitiveness, since the strongest correlation with port competitiveness and biggest contribution to the relative factors can be found and developed through measurement, it can turn to promote port competitiveness and provide city planner and government with quantitive and scientific decision-making basis. Previous studies contributed to analyze influential factors and assessment for port competitiveness, which usually adopted the following methods:

(1) Method of analyzing annualized slot capacity
Two studies introduced this analytical approach as a methodology on the Asian ports competitiveness under the context of the supply chain (Yap *et al*., 2006). The author argued that the data can be used to evaluate the changes of port calls by carriers. It presented an important reference in measuring the ports competitiveness and the relations among them as well through using this systematic and quantifiable method.

(2) Worldwide trade model
Barry Zondag used worldwide trade model in analyzing port competition on a basis of multinomial logit model, they mentioned that this approach provides "*an integrated value for cost, time and quality factors, the responses are consistent with economic theory and it can be applied to disaggregated market segments addressing the variation between these segments.*"(Barry Zondag *et al*, 2010).

(3) Multinomial Logit model

This type of model was led by Gambel (Mcfadden, 2009), it required that the random components of the assumption should be independent and distributed identically, otherwise, it cannot express the probabilities closely. Veldman and Buckmann applied this model to analyze European container port competition (Simme J. Veldman & Ewout H. Buckmann, 2003). Like all other econometric model, it also has some limitations, for example, the biggest limitation is that each classification must be equal, so in the alterative categories, the situation of mixing primary category with secondary categories cannot exist.

(4) Discrete choice modelling

Discrete choice model originated from Fechner's research on animal conditional reflections in 1860. Warner first used it in the field of economy in 1962. From 1970s and 1980s, discrete choice model was widely used to solve the problems in the studies relating to economic layout, transportation, employment, purchase decisions and other issues in terms of making economic decisions. In its definition, since the dependent variable is discrete value, such regression model called discrete choice model. Magala and Sammons suggested this new approach as the modeling framework in their studies of the port choice. As the explanation of the approach, making a decision on port choice is a complicated process which led by various issues, benefits would be filtrated in the mean time of assessing the economic costs (Mateus Magala and Adrian Sammons, 2008).

(5) DEA (Data Envelopment Analysis)

Currently, a kind of developed technique which can be used to compare the efficiency between multiple units that can offer similar services by explicitly considering the use of multiple inputs (e.g. resources) and the generation of multiple outputs (e.g. services), which called data envelope analysis (DEA). Because it can transform multiple inputs and multiple outputs into numerator and denominator of the efficiency ratio without converting to the same unit of currency, it avoids the calculation of the standard cost of each service. Therefore, with the DEA to measure efficiency, it can clearly illustrate the combination of inputs and outputs, and thus, it is more comprehensive and more trustworthy than a set of operating ratio or profit targets. This method was also advocated by Kevin and Tengfei who adopted it as a very important approach to be used for measuring efficiency (Kevin Cullinane and Tengfei Wang, 2010).

(6) Multi-criteria decision analysis

Multi-criteria analysis is a method of considering multiple factors in making a decision on a complicated issue. The biggest advantage of this method is that it can examine a number of factors that affect port competitiveness within a wider coverage so as to reflect the competitive aspects in a comprehensive and systematic way. Hence, there are not only multiple criteria involved in the measurement of complex issues, but also multiple parties who have a vitol role on the result of consequence. Emmanuel Guy and Bruno Urli introduced this method into their research on port selection and pointed that decision makers usually need to consider many factors before action rather than an individual objective and the importance of these criteria may change with the situation changes (Emmanuel Guy and Bruno Urli, 2006).

(7) AHP (Analytic Hierarchy Process)

In previous research, AHP as a multi-criteria decision-making method was firstly

proposed by Saaty in the late 1970s, it has been widely used in transport area (Saaty 1977). Many scholars in their studies introduced the AHP approach thus successfully solved transport problems. For example, in Poh, KL and Ang, BW (1999), Chang, YH and Yeh, CH. (2001), Vreeker et al (2002), Lirn et al (2003). The merit of the AHP method is that it is easy to accommodate the model's modification and simulation through a sensitive analysis. Saaty listed 10 advantages of the AHP method are: "*Unity; Complexity; Interdependence; Hierarchy Structure; Measurement; Consistency; Synthesis; Tradeoffs; Judgement and Consensus; and Process Repetition*" (Saaty, 2001). Indeed, when an organization is going to conduct several projects at the same time, it is better to use this approach to distinguish different levels of the importance of each project and to allocate the resources in an effective way in order to maximize profits and minimize the costs on some less-important projects. Nevertheless, the disadvantage is that as requested judgment matrix elements are exact numbers, which require respondents have a very clear understanding of the relative importance of each choice, in reality, it is more difficult to achieve. Moreover, investigator sometimes has to spend too much time on explanation of the model but less quality response.

In short, all the above seven analytical approaches have their own characteristics, advantages and various kinds of disadvantages as well. Therefore, choosing a suitable mathematical evaluation method highly depends on the purpose of the study and selection on indicators of different objects.

In order to highlight the meanings and characteristics of port performance indicators, this research introduces a relative mature approach – AHP for factor analysis so as to analyze major European ports competitiveness.

2.6 Conclusions

In this chapter, literatures related to ports and background of global supply chain they are living in were mainly presented. Different from other studies, analysis on Northern European ports in this research is based on their users' perception: shipping liners, freight forwarders and shippers, owing to multiple parties involved in the process of measurement, which lead to a more complicated situation that ports have to face and tackle. With regards to choosing the criteria and how the users score each factor and as well as the importance weights of each factor, the following chapter will give the discussion in more detail.

Chapter 3 Measurement for Port Competitive Performance

3.1 Introduction

Port competitiveness is determined by many factors, such as, port location, level of development of mainland integrated transport network, mainland and the city's economic strength, natural conditions, policy environment, customs clearance procedure, infrastructure, consolidation and distribution system, operating conditions, potential opportunities and challenges, port charges, management level and service quality. The author will give more analysis on the main factors in the following paragraph.

3.2 Determinants of port competitiveness and factor analysis

Many scholars had chose relevant factors that they thought were important ones. For example, Jose Tongzon and Wu Heng raised eight elements in their research on port efficiency and competitiveness: "*(1) port (terminal) operation efficiency level; (2) port cargo handling charges; (3) reliability; (4) port selection preferences of carriers and shippers; (5) the depth of the navigation channel; (6) adaptability to the changing market environment; (7) landside accessibility; (8) product differentiation"* (Jose Tongzon and Wu Heng, 2005).

Douglas K. Fleming and Alfred J. Baird also summarized some reflections on port competition as "*(1) port tradition and organization; (2) port accessibility, by land and sea; (3) state aids and their influence on port costs; (4) port productivity; (5) port selection preferences of carriers and shippers; (6) comparative locational advantage"* (Fleming and Baird, 2010).

Similarly, Khalid Bichou divided port performance factors into three categories, namely "*(1) input measures (e.g., time, cost and resource), (2) output measures (e.g., production/throughput, profit) and (3) composite measures (productivity, efficiency, profitability, utilisation, effectiveness, etc.)"* (Khalid Bichou, 2007).

Also, Kevin Cullinane and Yuhong Wang introduced some important factors categorized into three groups mentioned in previous research, that is, "*route factors (which include frequency, capacity, convenience/directness, flexibility and transit time), cost factors (freight rate and other costs) and service factors (delays, reliability and urgency, avoidance of damage, loss and theft, fast response to problems, cooperation between shipper and carrier, documentation and tracing capability)*" (Kevin Cullinane and Yuhong Wang, 2009)

The factors mentioned in the literature on port competitiveness involved above 30, combined with the factors mentioned with high frequencies in previous literatures, the selection of these factors is based on Chi-lok Andrew Yuen's research (2012) and explanation for each factor will be given as follows,

(1) Geographical location and natural conditions

This factor includes several sub-factors. Standards for pros and cons of natural conditions vary with progress of history. For example, as more and more world's large-scale ships exist, those ports (mainly in some estuary ports and river ports) with original advantages are gradually losing their edges. In order to survive and develop, some estuary ports looked for new sites and adopted a development

strategy of shifting the port area on the ships requirements.

As far as port competitiveness is concerned, it is for sure important that whether it is a natural harbour or located in the international trunk routes, but it can not be looked at in isolation in the aspect of the role of natural conditions on formatting port competitiveness, instead, it must be considered together with global transport network system, inland and overseas conditions and other factors involved.

As far as its proximity to import and export areas (adaptability to the changing market environment etc.) is concerned, whether or not the ports can be accessible to the inland trade market usually depend on the level of hinterland economy development and whether ports can quickly adjust their strategies as changes of pattern of international trade to offer corresponding services in terms of hinterland connection as a logistics provider.

Furthermore, proximity to feeder ports and to main navigation routes requires port to be a transport intermediator between sea carriers and other transport mode carriers in the supply chain. Under such circumstance, ports have the responsibility to arrange the containers to connect to the next transport more effectively and efficiently. For those ports with higher quality service, they always can fulfill the task to well meet their customers' needs and gain the advantages of competition.

(2) Port distribution and transport conditions, connection to hinterlands

The focal point of port competition is containers. Adequate cargo relies on fast development of the hinterland economy and enormous increase of foreign trade volume, hence, the function and main characteristic of ports also depends on economic and trade boom of inland areas. Port distribution and transport condition continue to be developed as technology advances. From the current perspective, port distribution transport condition includes mainland developed inland sea and air consolidation and distribution, teleconmunications, global interactive network of regional or industry-base interactive network. To achieve the goal of function of logistics center, ports should be equipped with logistics distribution, cargo storage, consolidation and distribution, international logistics services, market transactions, information management, consulting services and value-added service and other functions, which break through original conventional design of port as a single transport hub. According to the functional requirements of the modern logistics concept, it is necessary for ports to re-integrate the resources through functional diversification standards internationalization, layout regionalization, modernization of management and operational efficiency of the transformation so as to enhance the ports competitiveness.

Furthermore, accessibility of hinterland by rail, highway and barge is important factors. Raimonds Aronietis corroborated that the evaluation of different ports are strongly different in terms of hinterland connectivity, since lots of elements related to hinterland connection are strong divergent between targeted ports, such as, reliability, frequency of services, etc. (Raimonds Aronietis *et al*, 2010). Barry Zondag, *et al*. explained the function of hinterland connection, they believed that

hinterland transport cost is an important part of cost of logistics, therefore, port authority and local government are contributing to the activities in improving land transport conditions so as to reduce the costs (Barry Zondag, et al. ,2010). Gi-Tae Yeo suggested that port operators should focus on improving productivity and investments and mentioned that port competitiveness increases when inland condition are improving. He divided hinterland condition into three respects: *"professionals and skilled labour in port operations", "size and activity of Free Trade Zone in port hinterland" and "volume of total container cargoes" of which the latter is the most important attribute* (Gi-Tae Yeo, 2011). Similarly, greater connectivity means higher competitive advantage.

(3) Technical and information conditions (IT and online services etc.)
Ports technical condition mainly refers to the technical conditions of the efficient operation of supporting centre and spread the high-tech and innovative management skills to the services. The technology of intermediary function is very important in forming port competitiveness. The degree of modernization of the port and the level of development largely depends on information management. Digitalization and information on port operations realized rational allocation of resources, it also directly improved port production capacity and economic efficiency dramatically. Unified port logistic information platform is a necessary condition for building a modern "Digital Port". "Digital Port" is a comprehensive digital port logistics system, it is based on "information" and "digital" foundation. Production, distribution and services and all other aspects are linked on the basis of "digital flow", which broke the original port logistics model, it is no doubt for ports to improve service quality and thus provide an important mean of strengthening the overall competitiveness of ports.

(4) Regime and policy conditions
Rediating distribution of port is at least a regional direct mainland market, so it should meet two basic requirements in the aspects of its market system, legal system environment and policy conditions, that is, liberalization and stability. Liberalization of port competitiveness is an important condition for the formation of which is a key factor to ensure and pursue port efficiency of distribution. Such stability means a stable policy, a stable economy, stable legal norms and stable economic situation. From the point of view of port development nowadays, there is a distinct trend that natrual-condition dependence is gradually changing to regime-progress dependence. The formation of the earliest ports only depended on their geographical locations, such as, natural conditions of ports and level of industrialization of inland areas along the port and shipping center. Take two global shipping centers, Hongkong and Singapore, for example, their perfect market system and free port policy and measures which emphasized soft environment effectively remedied their disadvantages of inadequate of its small internal markets and other hard conditions. Currently, the competition on policy and institutional factors will be the key point, especially the security and stability of policy mechanism having being attracted much more attentions.

(5) Port productivity and operational efficiency level (berth availability, waiting time, etc.)
Port productivity refers to the maximum volume of containers or moves that the cranes can handle during a certain period of time within the port area. The more containers be handled, the higher efficiency of the port operation, the higher

berth availability and the shorter waiting time for vessel to call. To some extent, this element is one of the most important KPIs for measuring port competitiveness nowadays. Normally, carriers prefer to choose port with higher berth availability so as to ensure fast turn-around time and cost savings; however, for the ports, they conversely prefer lower berth availability since they may gain profits from vessels' long-time occupancy of their facilities and long-time utilization of port infrastructures (Saanen, 2013).

(6) Port charges

The terminal handling charges (THC) and storage charges are the main source of port income. THC is the terminal authorities charged for using the handling equipment and maintenance at each port, which varies from port to port due to different operational handling facilities and port conditions. Normally, THC is collected from the shipper when issuing the bill of lading by the carrier at the port of origin and it is also can be collected from the consignee when the carrier issuing delivery notice at the port of destination. So, it is clear to see that the undertaker of this charge shifts from carriers to shippers or consignees. For the storage cost of containers, carriers also have careful consideration and comparation between ports. Furthermore, Jose L. Tongzon made a summary on port charges that:

"*Except for landlord ports, which derive their revenues from rents, port charges are generally levied on the basis of port visits and / or cargoes. Examples of ship-based types include port navigation fees, berthage, berth hire, harbour dues and tonnage while cargo-based types include wharfage and demurrage.*" (Jose L. Tongzon, 2009)

(7) Port charges

As coming of global integrated logistics era, port authorities are attaching importance to the basic infrastructure construction. Owing to economies of scale, larger vessels increasingly emerged, these types of ships usually require deeper water accessibility and dedicated navigation channel for them to call. Port authorities have noticed this issue and expect to implement much more constructions on its facilities and sites in the future.

(8) Service reliability

The element of service reliability can be judged by three indicators, accessibility, continuity and performance. Services are expected to be delivered quickly upon customer's need; process of serving needs to be on a continuous basis and maximally satisfy ports customer's expectations would enable a port to be more competitive and attractive compare to its competitors.

3.3 Conclusions

In this chapter, through lots of literature review, the most frequent factors and information mentioned in the literature on port competitiveness were discussed and analyzed in more detail. Ports are still playing an important role in the supply chain from their users' point of view. Along with more in-depth port services, it has been revealed that ports also paid much attention on the exploration and improvement of innovative information and technology currently.

Chapter 4 Research Design and Methodology

4.1 Introduction

This sector describes research methodology, which can be shown how the study is going to conduct and get a clear overview of its direction and further development, and also provides a scientific basis for subsequent analysis. The benefit of designing analytical step is making the research framework more clearer for allowing the research question in each step more specific.

4.2 Research Design

This research is going to conduct an analysis on the port competitiveness under the context of supply chain nowadays, the selected ports are within North-European range, owing to lack of unified criterion, it is more or less subject to their users' perception. In order to make the structure more clearly, the author splits the research into several steps and tries to solve the previously defined research question and sub-questions in the end.

(1) In the first phrase, lots of literature review are strongly recommended, which is a benefit to the author to get a wider horizon of new thoughts through drawing on the experience from previous studies. Literature could be books, journal articles, newspapers, thesis and annual reports of port authorities.

(2) Next is the selection of the main factors that have effects on port competitiveness, which can be referred on the literature review as the scientific base. After that, a design on the questionnaire which is used as a statistical database to support the AHP can properly start.

(3) After finishing questionnaire design, it is necessary to distribute it to the parties concerned at an early date since this process is of time-consuming and low efficiency. For this research, the target groups are port authorities (terminals), shipping lines, freight forwarders, shippers, consignees and other experts.

(4) Screen out the questionnaire responses and create AHP model, then apply AHP model to the research, conduct all steps of calculation to get the final results of importance of relative elements.

(5) Analyze and explain the final results from AHP calculation combined with the current port developmental focus and interest and empirical findings will involve as well. Meanwhile, the main question and sub-questions for the research will be given.

(6) Draw the conclusion of the whole research, some recommendations, drawbacks and further research on the specific topic and etc. will be given lastly.

4.3 Research Methodology

4.3.1 Introduction of Analytic Hierarchy Process (AHP)

AHP (Analytic Hierarchy Process) was formally proposed by Thomas L. Saaty in

1980, and was described and explained in his book *The analytic hierarchy process: planning, priority setting, and resource allocation*. It is an analytical approach systematically combining quantitative method together with a qualitative method. He also remarked in his book that:

"*We must stop making simplifying assumptions to suit our quantitative models and deal with complex situations as they are. To be realistic our models must include and measure all important tangible and intangible, quantitatively measurable, and qualitative factors*." (Saaty, 1980)

Because of its complex and effective decision-making process on practical issues, it soon got much attention worldwide and its application has been spread economic planning and management, distribution of energy policy, behavioral science, military command, transportation, agricultural industry, education, health care, environment and other fields.

4.3.2 The principle of the Analytic Hierarchy Process

The principle of AHP is that through the analysis of factors contained in the complex issues and their interactive relations distributes the problem into different elements. These elements are incorporated into different hierarchies to create a multi-hierarchy structure. According to a standard in each level, this layer element is established by the comparative judgment matrix. Combined weights for each level of an element are gained on the basis of calculation of the maximum eigenvalue and corresponding orthogonal eigenvectors. Thus, it comes to different scenarios of weights to provide the basis for the selection of the optimal solution.

In order to clearly clarify the AHP basic principles of decision analytical methods, the following simple examples can be used to analyze. Suppose there are n objects as $A_1, A_2, \ldots, A_n$, the weight of each object is compared with the other variable in the pairwise group (see Table 4-1).

Table 4-1 AHP judgment matrix

	A_1	A_2	...	A_n
A_1	W_1/W_1	W_1/W_2	...	W_1/W_n
A_2	W_2/W_1	W_2/W_2	...	W_2/W_n
⋮	⋮	⋮		⋮
A_n	W_n/W_1	W_n/W_2	...	W_n/W_n

Source: compiled by the author (based on Saaty, 1980)

If matrix is used to indicate the above mutual relations between variables, it can be presented as the following formula, A is called judgment matrix.

$$A=\begin{bmatrix} W_1/W_1 & W_1/W_2 & \ldots & W_1/W_n \\ W_2/W_1 & W_2/W_2 & \ldots & W_2/W_n \\ \vdots & \vdots & \ddots & \vdots \\ W_n/W_1 & W_n/W_2 & \cdots & W_n/W_n \end{bmatrix}$$

When weight vector is defined as: $W = [W_1, W_2, \dots, W_n]^T$, then,

$$AW = n \cdot W$$

That is, W is eigenvector of judgment matrix A, n is an eigenvalue of matrix A. It can be proved according to the linear algebra that n is the only non-zero and also the largest eigenvalues of matrix A.

The above fact presents that if there is a set of objects, the weights of them are needed to know, then they can be got through pairwise comparison of their mutual weight, after the judgment of weight ratio of each pair of the objects, a judgment matrix was constituted. Next, through solving the maximum eigenvalue λ_{max} and its corresponding eigenvector of the judgment matrix, the relative weight of this group would be got.

4.4 Research Framework

According to explanation from Saaty, the Analytic Hierarchy Process includes three processes, that is,

"*identifying and organizing decision objectives, criteria, constraints and alternatives into a hierarchy; evaluating pairwise comparisons between the relevant elements at each level of the hierarchy; and the synthesis using the solution algorithm of the results of the pairwise comparisons over all the levels*." (Saaty, 1980)

As the process discloses, the AHP model can be divided into five steps specifically, (Saaty, 1980, 1994; Cheng and Li, 2002)

(1) Clarify the problem and set up the target.
Firstly, people need to identify the problems they have and determine how is the goal he/she is going to achieve.

(2) Establish a multi-level hierarchical structure
Second, a hierarchical decision problem can be decomposed into a number of elements. The level of problem can be regarded as the first hierarchy or the zero hierarchy, the first decomposed level is regarded as the second hierarchy or the first hierarchy, each element of these levels can continue to decompose to another set of elements and so on till it no need to be decomposed. If decomposition continues, it will generate the third hierarchy, the fourth hierarchy and so on till the targeted problem can be finally resolved. Such decomposition constitutes at least three hierarchies.

With regards to the hierarchical structure, it has two types widely used in reality as follows,

a. A completely independent hierarchical structure
The character of this structure is that all the elements in the higher layer are independent and the lower elements are totally different. Figure 4-1 is an example of this structure.

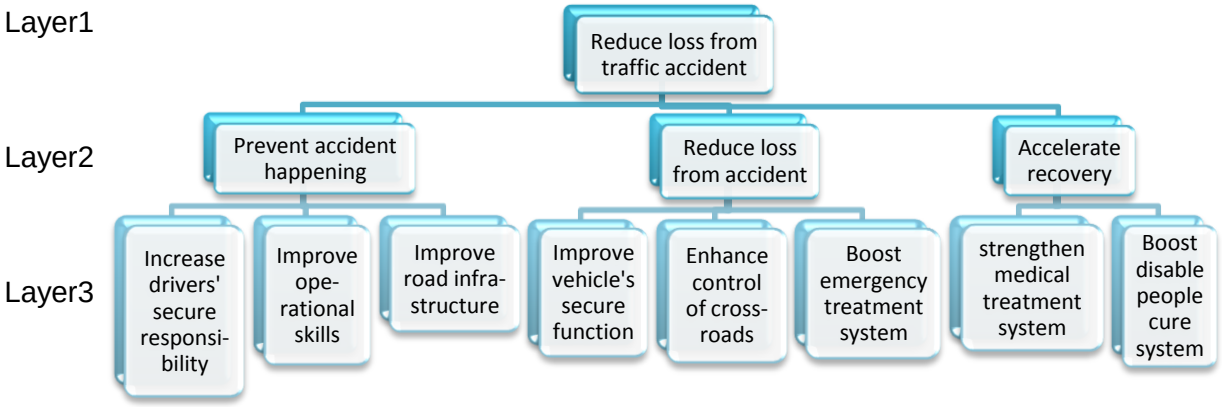

Figure 4-1 Hierarchy structure for reduce loss from traffic accident
Source: compiled by the author based on (Saaty, 1980)

b. Perfectly correlated structure
The character of this structure is that each element in the higher level is fully correlated with the element in the lower level. Figure 4-2 is an example of this structure.

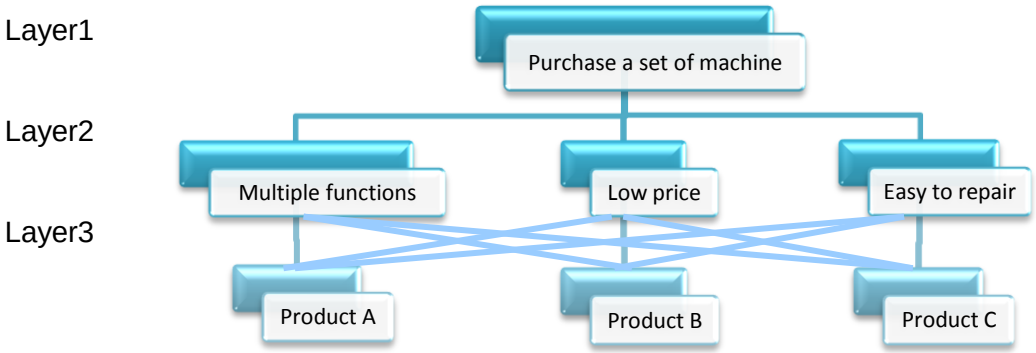

Figure 4-2 Hierarchy structure for purchase a set of machine
Source: compiled by the author based on (Saaty, 1980)

(3) Set up the judgment matrix by using the pairwise comparison method
The elements of the corresponding level are determined by setting a certain element C in the higher layer as the criteria of evaluation and using the method of pairwise comparison. Decision-makers will make a comparison of the paired elements that used in the questionnaire. For example, C as the evaluation criteria has n elements, the judgment matrix form can be presented as follows (Table 4-2),

Table 4-2 AHP judgment matrix

C	B_1	B_2	...	B_j	...	B_n
B_1	b_{11}	b_{12}	...	b_{1j}	...	b_{1n}
B_2	b_{21}	b_{22}	...	b_{2j}	...	b_{2n}
⋮	⋮	⋮		⋮		⋮
B_i	b_{i1}	b_{i2}	...	b_{ij}	...	b_{in}
⋮	⋮	⋮		⋮		⋮
B_n	b_{n1}	b_{n2}	...	b_{nj}	...	b_{nn}

Source: complied by the author

The element b_{ij} in the judgment matrix presents the relative importance of element b_i to element b_j according to evaluation criteria C. The value of b_{ij} is identified based on the data, expert's opinions, investigator's experience and lots of studies about it.

Saaty recommended a nine-point scale comparison as follows (Figure 4-3),

Intensity of importance	**Definition**
1	Equal importance
3	Weak importance
5	Essential or strong importance
7	Very strong or demonstrated importance
9	Absolute importance
2,4,6,8	Intermediate value between adjacent scale values

Figure 4-3 Nine-point scale comparison
Source: Saaty, 1980

Based on the above explanation, the criterions which usually used for assessing a targeted problem are as follows,

(1) As far as C is concerned, b_i is as extremely more important than b_j, then $b_{ij}=9$.
(2) As far as C is concerned, b_i is as very strongly more important than b_j, then $b_{ij}=7$.
(3) As far as C is concerned, b_i is as strongly more important than b_j, then $b_{ij}=5$.
(4) As far as C is concerned, b_i is as moderately more important than b_j, then $b_{ij}=3$.
(5) As far as C is concerned, b_i is as equally important than b_j, then $b_{ij}=1$.
(6) As far as C is concerned, b_i is as moderately less important than b_j, then $b_{ij}=1/3$.
(7) As far as C is concerned, b_i is as strongly less important than b_j, then $b_{ij}=1/5$.
(8) As far as C is concerned, b_i is as very strongly less important than b_j, then $b_{ij}=1/7$.
(9) As far as C is concerned, b_i is as extremely less important than b_j, then

b_{ij}=1/9.

Compared to make decisions by the board within the company, in the field of academic research, when using this method to apply to a target problem, it is recommended to acquire a larger sample to generalize the outcome to the investigated population.

(4) Test the consistency of pairwise comparisons

The reason why consistency should be tested is that the elements of the pairwise comparison matrix are got by pairwise comparison based on subjective judgment and personal opinions, if a large amount of elements involved in the questionnaire, it most likely draws inconsistent conclusions. Take an inconsistent situation for example, as seen in Figure 4-4,

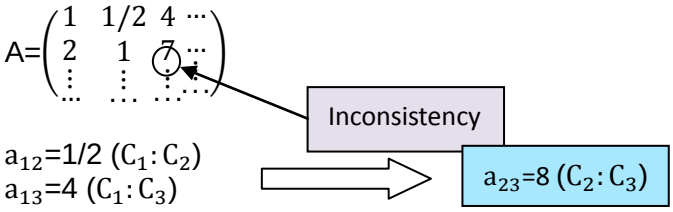

Figure 4-4 Consistent comparison
Source: Complied by the author based on (Saaty, 1980)

As matrix A shown above, a_{12} is less important than a_{11} with score is 1/2, a_{13} is more important than a_{11} with score is 4, then when comparing a_{23} to a_{11}, logically, the score for a_{23} should be 8 (1 divided by 1/2 times 4), however, in reality, when people is trying to give the score of each pairwise elements, they usually focus on the which point much matches to what they thought about the importance of the elements when doing the comparing, but don't have much consideration on the internal logical relations within the judgment matrix. Under such situation, insistency occurs.

Saaty gave his comment on the consistency issue that "*Inconsistency is a violation of proportionality which may or may not entail violation of transitivity. Our study consistency demonstrates that it is not whether we are inconsistent on particular comparisons that matters, but how strongly consistency is violated in the numerical sense for the overall problem under study.*" (Saaty, 1980)

He also raised an effective method Consistency Index (C.I.) to measure the consistency, its can be formulated as follows,

$$C.I. = \frac{\lambda_{max} - n}{n - 1}$$

When $\lambda_{max} = n$, $C.I. = 0$, it is of consistency. The larger the value of $C.I.$, the lower degree the consistency of the judgment matrix. Normally, as long as $C.I. \leq 0.1$, consistency is acceptable, that is, we accept W; otherwise, in order to improve the consistency, a further pairwise comparison on the judgment is needed. (Saaty, 1980)

The larger the sample n, the worse the consistency of the judgment, then a modifier $R.I.$ to $C.I.$ is introduced, the formula for it as follows (Figure 4-5),

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

Where $C.R.$ is Consistency Ratio, $R.I.$ is Random Index.

n	1	2	3	4	5	6	7
$R.I.$	0.00	0.00	0.58	0.90	1.12	1.24	1.32
n	8	9	10	11	12	13	14
$R.I.$	1.41	1.45	1.49	1.51	1.48	1.56	1.57

Figure 4-5 Value of R.I.
Source: Saaty, 1980

(5) Calculate the comprehensive importance
As for making decisions on the elements, the weighted criteria are scored by relative parties so that the comprehensive score will be calculated. Through calculation, the weight of each element is going to be given, those with higher weights mean key elements and more important. It is the aim of the AHP that determine the key elements for succeeding in achieving the final goal.

4.5 Conclusions

This sector mainly introduced the research methodology, explained its application principle and the design of AHP model used in measuring port competitiveness, besides, the author also presented the suggested steps for calculation of AHP model which will be shown in the next part.

Chapter 5 Research Results

5.1 Introduction

This chapter will show the whole process of using AHP to calculate and measure port competitiveness from the selection of criteria and targeted ports, filtering the questionnaire to calculate the AHP model and getting the results. and will finally present them in more detail. It is good to see how the principle of AHP works in this research, it also paves the way for further analysis of empirical findings on a theoretical base.

5.2 Apply AHP into measuring port competitiveness

5.2.1 Selection of criterion for measuring port competitiveness

Factors that affect port competitiveness have already been summarized in chapter 3 based on the literature. Following is the list for those 8 factors.

(1) Geographical location and natural conditions
(2) Port distribution and transport conditions, connection to hinterlands
(3) Technical and information conditions (IT and online services etc.)
(4) Regime and policy conditions
(5) Port productivity and operational efficiency level (berth availability, waiting time, etc.)
(6) Port charges
(7) Physical infrastructure
(8) Service reliability

However, once all of these 8 main factors are chosen as criteria, the process of measurement and analysis is getting cumbersome, hence, in order to gain a more clear and easy understanding picture, several categorized factors are screened out to become the criteria. Meanwhile, the overlap and approximate factors are removed as well. The advantage from this classification is that each category can be extended as new factors are considered but that this does not change the process of calculation on AHP at all. Moreover, these factors will be judged by respondents through questionnaires, so it is indeed a challenge for the respondents to score such a long list for measuring. Usually, they may lose their patience under such circumstances, resulting in bad outcomes. Considering these elements, it is necessary to narrow the range of alternatives for potential decision makers to improve efficiency. Eventually, below 6 most important criteria are chosen for further study.

(1) Geographical location (eg. proximity to I/E areas, to feeder ports and to main navigation routes etc.)
(2) Physical infrastructure (eg. water access etc.)
(3) Logistic chain and connection to the hinterland (eg. intermodal links: rail, highway and barge etc.)
(4) Technical infrastructure (eg. IT etc.)
(5) Port management & administration (eg. port efficiency of berth occupancy, ship turn-around time, ship waiting time, port security and safety, service reliability etc.)

(6) Carriers' terminal cost (eg. handling cost of containers, storage cost of containers and terminal ownership/exclusive container policy etc.)

5.2.2 Selection of target ports

Figure 5-1 shows the map of main ports in European areas, those marked with red five-pointed stars are target ports in this research. Port of Rotterdam is well known as the gateway to the European market, because of its excellent geographical location, the port of Rotterdam has dominated most of the European container throughtput market for many years.

Figure 5-1 Top European ports (Rotterdam, Hamburg, Antwerp and Bremerhaven)
Source: Port statistics, Port of Rotterdam, 2012.

The statistical data from Rotterdam port authority show that the top four ports are Rotterdam, Hamburg, Antwerp and Bremerhaven in 2012 (Figure 5-1). Clearly, in terms of cargo volume, Rotterdam is larger than the other three ports with 11,866,000 TEUs, port of Hamburg and Antwerp are more or less the same ranked the third and the fourth respectively; as the last one, port of Bremerhaven does not indicate much advantages of it, which only equals almost half of that of Rotterdam with a volume of 6,115,000 TEUs in 2012.

Table 5-1 Top 4 European container ports, 2012-2010

Ports	2012	2011	2010
Rotterdam	11,866	11,877	11,148
Hamburg	8,864	9,014	7,896
Antwerp	8,635	8,664	8,468
Breherhaven	6,115	5,916	4,888

(Note: Number x 1,000 TEU (Twenty-Feet Equibalent Units)
1. Estimated based on Units, incl. Ro-Ro (Department of Transport);
2. 2012 Provisional figures)

Source: Port statistics, Port of Rotterdam, 2012.

Evidently, there always has been fierce competition among the top container ports. It is interesting to find the difference between them, Rotterdam, Hamburg, Bremerhaven and Antwerp are therefore being selected.

5.2.3 Building the hierarchy

Through introducing AHP model, the design for the hierarchy is needed to follow its analytical structure. For this research, its goal has determined as the first layer as shown in Figure 5-2, that is, to measure the port competitiveness; the second layer is the criteria that have great influence to the target ports and the lowest layer is the selected target ports.

5.3 Designing the questionnaire and selecting the feedback

After determining criteria and target ports, with the aim of getting the priorities of selected elements, then designing the questionnaire can be started.

In the very beginning, a brief introduction of the thesis will be shown to the investigated parties, then a series of simple questions will be asked followed by a applied rating system of AHP, as questions are getting deeper, respondents have to give each element a score ranged from 1 to 9 in their own opinions. This process is too much time consumed and inefficient for the feedback. Since most people are not quite similar with AHP model, thus cannot do it in a logical way, under such circumstance, the second round so called explanation for the principle of AHP model is needed. Hence, it is recommended that distribution of these questionnaires is better start at an early date. Moreover, the target parties are from different departments, shipping lines, such as COSCO, Hapag-Lloyd and CMA-CGM; freight forwarders, such as, Sinotrans Netherlands, Sinotrans Germany and several trading companies in China, etc.

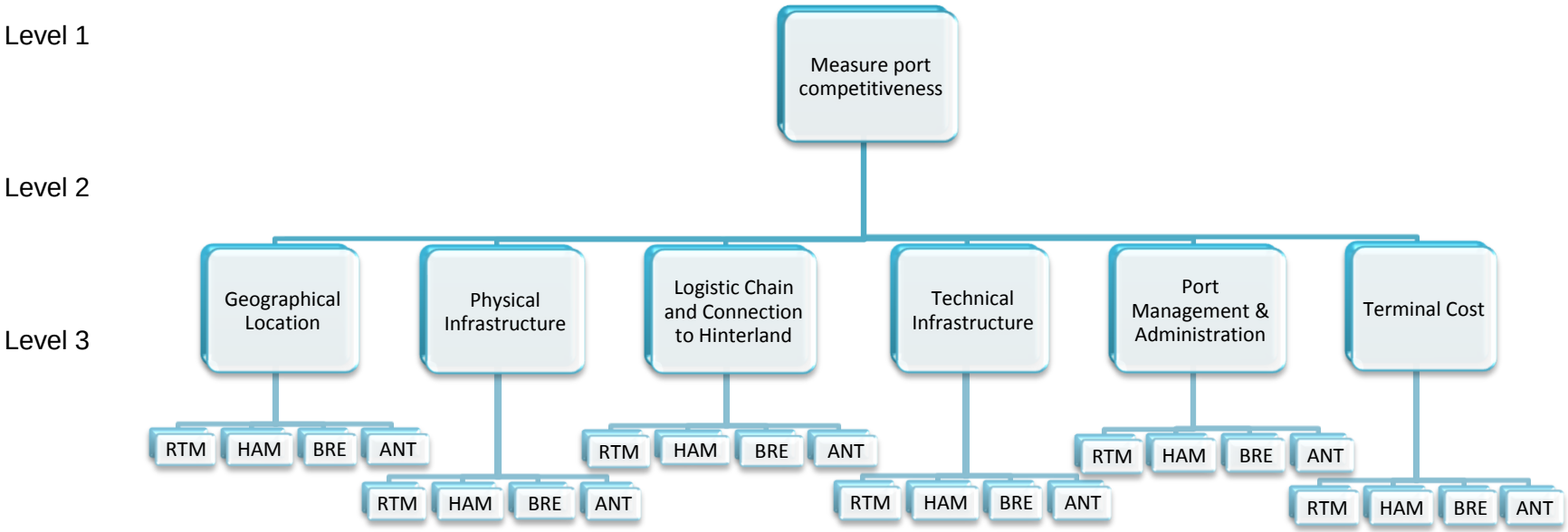

Figure 5-2 AHP model for measuring Port Competitiveness
Source: compiled by author

With regards to the selection of the feedback from the respondents, the larger group, the more responses, the better quality of the survey results. At the end, 12 effective responses received from the target parties can be used (4 responses from shipping liners, 3 from freight forwarders and 3 from shippers), it is indeed not a large amount of feedback as this period of time because of the holiday season and some of them did not express a kind of positive attitude and interest to do such a survey, but having studied some previous thesis found that Liguo Wang (2010) collected 11 responses and Yan Xiong (2007) received only 5, from practical experience, as far as effectivity is concerned, the survey results are not entirely dependent on the amount of feedback received, but the quality of the responses have whether which can reflect current trend to a large extent. 12 responses are also feasible for conducting the research. During this period, since respondents have less knowledge about AHP model, many illogical errors involved. Following are two typical examples about it (Table 5-2 and 5-3).

Table 5-2 An example of AHP model with high inconsistency

	Rotterdam	Hamburg	Bremenhaven	Antwerp
Rotterdam	1	3	5	7
Hamburg	6	1	2	6
Bremerhaven	2	3	1	2
Antwerp	7	8	5	1

Source: compiled by author from the questionnaire

Inconsistency usually happens because the individual does not use AHP correctly, like the problem shown in table 5-2, a few respondents have such feedback. If Rotterdam is more important than Hamburg with degree of 3, which means that Hamburg should be less important than Rotterdam with degree of 1/3; nevertheless, the result given is 6, this score means Hamburg is 6 degree more important than Rotterdam, it is rather unrealistic and irrational since it contradicted degree 3 in previous scoring. Hence, respondents should understand pairwise comparison method correctly before doing the survey.

Table 5-3 An example of AHP model with high inconsistency

	Rotterdam	Hamburg	Bremenhaven	Antwerp
Rotterdam	1	2	5	7
Hamburg	1/2	1	1/6	1/2
Bremerhaven	1/5	6	1	3
Antwerp	1/7	2	1/3	1

Source: compiled by author from the questionnaire

The other example in Table 5-3 also presents an illogical problem, the respondent understands the pairwise comparison method, he judged Rotterdam is 2 degree important than Hamburg and 5 degree important than Bremerhaven, error appeared again when he judging Hamburg as less important than Bremerhaven with 1/6. Normally, one can infer that Hamburg is more important than Bremerhaven based on the first level of judgment (Rotterdam/Hamburg=2, Rotterdam/Bremerhaven=5, then, Hamburg/Bremerhaven should be 1/2*5=2.5). Evidently, the score of 1/6 is irrational. In order to avoid such kind of inconsistency, the author will present how to score these criteria and revise mistakes. Furthermore, owing to three parties involved in the questionnaire, shippers, freight forwarders and shipping liners, the research results are expected to show options from three groups.

5.4 Calculating the AHP model

In this section, 15 pairwise comparisons ($6 \times 5 \div 2 = 15$) needed to be made by the respondents. According to Saaty, $C_1, C_2, \dots C_6$ can be defined as criteria that will be measured, the quantified judgments on pairs of criteria C_i, C_j are presented by a 6 by 6 matrix in this study

$$A = (a_{ij}), \qquad (i, j = 1,2, \dots ,6)$$

Thus the matrix A has the form as follows,

$$A = \begin{bmatrix} 1 & a_{12} & \dots & a_{16} \\ 1/a_{12} & 1 & \dots & a_{26} \\ \dots & \dots & \dots & \dots \\ 1/a_{16} & 1/a_{26} & \dots & 1 \end{bmatrix}$$

Next step is to assign to the 6 contingencies $C_1, C_2, \dots C_6$ a set of numerical weights $w_1, w_2, \dots w_6$ that would "reflect the judgments."

To compare C_1 with C_2, respondent put C_1 as a standard scale and its weight, say, $w_1 = 3$, and he weighs C_2 and finds $w_2 = 5$. Next, he divides w_1 by w_2, which is 0.6, which means that C_1 is 0.6 times as important as C_2, and can be presented as $a_{12} = 0.6$. It is an exact measurement of ideal case, that is, the judgment a_{ij} is formularized as:

$$\frac{w_i}{w_j} = a_{ij} \qquad (\text{for } i, j = 1,2, \dots ,6)$$

And

$$A = \begin{bmatrix} w_1/w_1 & w_1/w_2 & \dots & w_1/w_6 \\ w_2/w_1 & w_2/w_2 & \dots & w_2/w_6 \\ \dots & \dots & \dots & \dots \\ w_6/w_1 & w_6/w_2 & \dots & w_6/w_6 \end{bmatrix}$$

However, Saaty commented on the deviation of the judgments that "…*physical judgments are never exact in a mathematical sense, and allowance must be made for deviations; and because in human judgments, these deviations are considerably larger*." (Saaty, 1980)

The author intends to set a series of formulae in Microsoft office Excel to conduct the AHP model as Excel is easy to understand and use. Take one of the questionnaires for example, the calculation process is shown below.

Table 5-4 An example of Mathematical calculations on the alternatives for criteria (Shipping liner)

		Aij				Wij				Eigenvector		Aij * Wij		
Criterions		Rotterdam	Hamburg	Bremerhaven	Antwerp	Rotterdam	Hamburg	Bremerhaven	Antwerp	Avg.	Aij * Wij	Avg.	CI	CR
Geographical Location	Rotterdam	1	1	3	2	0.3529	0.3529	0.3333	0.3636	0.3507	1.4079	4.0144	0.00	0.00
	Hamburg	1	1	3	2	0.3529	0.3529	0.3333	0.3636	0.3507	1.4079	4.0144		
	Bremerhaven	1/3	1/3	1	1/2	0.1176	0.1176	0.1111	0.0909	0.1093	0.4378	4.0041		
	Antwerp	1/2	1/2	2	1	0.1765	0.1765	0.2222	0.1818	0.1892	0.7586	4.0086		
	Total score	2.83	2.83	9	5.5						λmax	4.0104		
Physical Infrastructure	Rotterdam	1	5	7	5	0.6481	0.6667	0.5000	0.6897	0.6261	2.6281	4.1975	0.04	0.04
	Hamburg	1/5	1	2	1	0.1296	0.1333	0.1429	0.1379	0.1359	0.5654	4.1592		
	Bremerhaven	1/7	1/2	1	1/4	0.0926	0.0667	0.0714	0.0345	0.0663	0.2666	4.0219		
	Antwerp	1/5	1	4	1	0.1296	0.1333	0.2857	0.1379	0.1717	0.6980	4.0663		
	Total score	1.54	7.5	14	7.25						λmax	4.1112		
Connection to hinterland	Rotterdam	1	7	9	8	0.7252	0.8203	0.5000	0.6486	0.6735	3.1465	4.6715	0.09	0.09
	Hamburg	1/7	1	5	3	0.1036	0.1172	0.2778	0.2432	0.1855	0.7980	4.3031		
	Bremerhaven	1/9	1/5	1	1/3	0.0806	0.0234	0.0556	0.0270	0.0466	0.1900	4.0736		
	Antwerp	1/8	1/3	3	1	0.0906	0.0391	0.1667	0.0811	0.0944	0.3803	4.0303		
	Total score	1.38	8.53	18	12.33						λmax	4.2696		
Technical Infrastructure	Rotterdam	1	1	5	3	0.3947	0.3947	0.3846	0.4000	0.3935	1.5767	4.0065	0.00	0.00
	Hamburg	1	1	5	3	0.3947	0.3947	0.3846	0.4000	0.3935	1.5767	4.0065		
	Bremerhaven	1/5	1/5	1	1/2	0.0789	0.0789	0.0769	0.0667	0.0754	0.3016	4.0012		
	Antwerp	1/3	1/3	2	1	0.1316	0.1316	0.1538	0.1333	0.1376	0.5507	4.0025		
	Total score	2.53	2.53	13	7.50						λmax	4.0042		
Port management & administration	Rotterdam	1	1	7	5	0.4268	0.4091	0.3500	0.5357	0.4304	1.7671	4.1056	0.02	0.02
	Hamburg	1	1	9	3	0.4268	0.4091	0.4500	0.3214	0.4018	1.6237	4.0408		
	Bremerhaven	1/7	1/9	1	1/3	0.0610	0.0455	0.0500	0.0357	0.0480	0.1941	4.0402		
	Antwerp	1/5	1/3	3	1	0.0854	0.1364	0.1500	0.1071	0.1197	0.4839	4.0416		
	Total score	2.34	2.44	20	9.33						λmax	4.0571		
Terminal Cost	Rotterdam	1	1	1	1	0.2500	0.2500	0.2500	0.2500	0.2500	1.0000	4.0000	0.00	0.00
	Hamburg	1	1	1	1	0.2500	0.2500	0.2500	0.2500	0.2500	1.0000	4.0000		
	Bremerhaven	1	1	1	1	0.2500	0.2500	0.2500	0.2500	0.2500	1.0000	4.0000		
	Antwerp	1	1	1	1	0.2500	0.2500	0.2500	0.2500	0.2500	1.0000	4.0000		
	Total score	4	4	4	4						λmax	4.0000		

Source: compiled by author

Table 5-5 An example of Mathematical calculations on the priorities for alternatives (Shipping liner)

Response 1: Aij

	Geographical Location	Physical Infrastructure	Connection to hinterland	Technical Infrastructure	Port management & administration	Terminal Cost
Geographical Location	1	2	1/4	1/3	1/4	2
Physical Infrastructure	1/2	1	1/7	1/2	1/3	1
Connection to hinterland	4	7	1	5	1	9
Technical Infrastructure	3	2	1/5	1	1/5	2
Port management & administration	4	3	1	5	1	8
Terminal Cost	1/2	1	1/9	1/2	1/8	1
Total Score	13	16	3	12 1/3	2 10/11	23

Wij

Geographical Location	Physical Infrastructure	Connection to hinterland	Technical Infrastructure	Port management & administration	Terminal Cost	Eigenvector Avg.	Aij * Wij	Aij * Wij / Avg.	CI	CR
0.0769	0.1250	0.0925	0.0270	0.0860	0.0870	0.0824	0.5023	6.0970	0.06	0.05
0.0385	0.0625	0.0528	0.0405	0.1146	0.0435	0.0587	0.5996	10.2085		
0.3077	0.4375	0.3698	0.4054	0.3438	0.3913	0.3759	2.8326	7.5349		
0.2308	0.1250	0.0740	0.0811	0.0688	0.0870	0.1111	0.9963	8.9681		
0.3077	0.1875	0.3698	0.4054	0.3438	0.3478	0.3270	1.4426	4.4114		
0.0385	0.0625	0.0411	0.0405	0.0430	0.0435	0.0448	0.0224	0.5000		
							λ-max	6.2866		

Performance:	
Rotterdam	0.5686
Hamburg	0.2609
Bremerhaven	0.0814
Antwerp	0.0874

Source: compiled by author

As shown in Table 5-4 in previous page, in the "Geographical Location", the sum of the columns of the matrix is a row vector $(2.83, 2.83, 9, 5.5)$, which is used to investigate the weight of each port of the sum in its corresponding column. The weights of each row are then added to get an entire proportion of each port's overall performance compared to other ports. The sum of each row when averaged by the number of target ports, that is, 4 yields the column vector of priorities as: $(0.3507, 0.3507, 0.1093, 0.1892)$, which is also the eigenvector for each port. To illustrate the approximate calculations of $C.I.$ and $C.R.$, next step is to multiply the matrix by the column of eigenvector, this process can be presented as follows,

$$\mathrm{A} = \begin{bmatrix} 1 & 1 & 3 & 2 \\ 1 & 1 & 3 & 2 \\ 1/3 & 1/3 & 1 & 1/2 \\ 1/2 & 1/2 & 2 & 1 \end{bmatrix} \rightarrow \text{ can be simplified as: } \begin{bmatrix} 0.354 & 0.354 & 0.333 & 0.364 \\ 0.354 & 0.354 & 0.333 & 0.364 \\ 0.118 & 0.118 & 0.111 & 0.091 \\ 0.177 & 0.177 & 0.222 & 0.182 \end{bmatrix} \rightarrow$$

$$\rightarrow \text{averaging each row as: } \begin{bmatrix} 0.351 \\ 0.351 \\ 0.109 \\ 0.189 \end{bmatrix} = \mathrm{w},$$

$$\text{since } \mathrm{Aw} = \begin{bmatrix} 1.407 \\ 1.407 \\ 0.438 \\ 0.758 \end{bmatrix} \text{ and } Aw = \lambda w.$$

$$\text{then, } \lambda_{\max} = \frac{1}{4}\left(\frac{1.407}{0.351} + \frac{1.407}{0.351} + \frac{0.438}{0.109} + \frac{0.758}{0.189}\right) = 4.01$$

The product of the above calculation for 4 ports divided by eigenvector produces maximum weight for each port, summing over those components and taking the average gives $\lambda_{\max} = 4.0104$. This gives $(4.0104 - 4)/3 = 0.0035$ for the C.I. To determine how good the result is, it should be divided by the corresponding value $\mathrm{R.I.} = 0.90$. The consistency ratio $(C.R.)$ is $0.0035/0.9 = 0.00$ $(0.00 < 0.10)$, it is acceptable and liability. Regarding to the result of testing with $C.I.$, if $C.I.$ is close to 0, there is a satisfactory consistency; conversely, the larger the value of $C.I.$, the more serious inconsistencies it has.

By using the same method, priorities of criteria for measuring port competitiveness also can be calculated (Table 5-5). Take port of Rotterdam for example, the total score for performance is calculated as, $0.3507 \times 0.0824 + 0.6261 \times 0.0587 + 0.6735 \times 0.3759 + 0.3935 \times 0.1111 + 0.4304 \times 0.3270 + 0.2500 \times 0.0448 = 0.5686$.

Finally, the research results are shown in the following Table 5-6 and 5-7. These statistical data all calculated based on the feedback from respondents. The blue highlighted parts are inconsistencies occurred,

Table 5-6 Priorities for the criteria of measuring port competitiveness

Criteria	S.L.1	S.L.2	S.L.3	S.L.4
Geographical Location	0.0529	0.0513	0.0553	0.0508
Physical Infrastructure	0.2855	0.2373	0.1881	0.1001
Connection to hinterland	0.1625	0.1937	0.2357	0.2844

Technical Infrastructure	0.0652	0.1837	0.1835	0.1590
Port management and administration	0.3953	0.3066	0.3089	0.3411
Terminal cost	0.0387	0.0275	0.0286	0.0510
C.R.	0.02	0.02	0.09	0.11

Criteria	**F.F.1**	**F.F.2**	**F.F.3**	**F.F.4**
Geographical Location	0.1948	0.2958	0.1913	0.2677
Physical Infrastructure	0.0388	0.0609	0.0345	0.0496
Connection to hinterland	0.3919	0.2775	0.4331	0.3949
Technical Infrastructure	0.1032	0.0830	0.1081	0.0877
Port management and administration	0.2166	0.1867	0.1627	0.1225
Terminal cost	0.0547	0.0961	0.0703	0.0776
C.R.	0.05	0.05	0.04	0.06

Criteria	**SHR.1**	**SHR.2**	**SHR.3**	**SHR.4**
Geographical Location	0.1267	0.1433	0.1286	0.1264
Physical Infrastructure	0.0295	0.0363	0.0357	0.0314
Connection to hinterland	0.3704	0.3750	0.4748	0.3428
Technical Infrastructure	0.0473	0.0556	0.0531	0.0350
Port management and administration	0.0709	0.0629	0.0554	0.0762
Terminal cost	0.3552	0.3270	0.2524	0.3881
C.R.	0.04	0.01	0.08	0.04

(Note: S.L.:Shipping liner; F.F.:Freight Forwarder; SHR: Shipper)
Source: Compiled by author

Table 5-7 Priorities for alternatives and final results

	Ports	**S.L.1**	**S.L.2**	**S.L.3**	**S.L.4**
Geographical Location	Rotterdam	0.3507	0.4838	0.4831	0.4451
	Hamburg	0.3507	0.2688	0.2081	0.3095
	Bremerhaven	0.1093	0.1422	0.0803	0.1214
	Antwerp	0.1892	0.1052	0.2285	0.1240
	C.R.	0.00	0.05	0.01	0.24
Physical Infrastructure	Rotterdam	0.6261	0.2878	0.6412	0.6412
	Hamburg	0.1359	0.4259	0.1407	0.1407
	Bremerhaven	0.0663	0.0483	0.0773	0.0773
	Antwerp	0.1717	0.1057	0.1407	0.1407
	C.R.	0.04	0.04	0.01	0.01
Connection to Hinterland	Rotterdam	0.6735	0.4805	0.2430	0.4056
	Hamburg	0.1855	0.3479	0.3465	0.3133
	Bremerhaven	0.0466	0.0579	0.3497	0.2143
	Antwerp	0.0944	0.1138	0.0608	0.0668
	C.R.	0.09	0.07	0.09	0.19
Technical Infrastructure	Rotterdam	0.3935	0.3284	0.2800	0.5243
	Hamburg	0.3935	0.4606	0.3453	0.1581
	Bremerhaven	0.0754	0.0746	0.0550	0.0960
	Antwerp	0.1376	0.1364	0.1197	0.2216
	C.R.	0.00	0.02	0.08	0.02
	Rotterdam	0.4304	0.5470	0.5986	0.4049

Port Management and Administration	Hamburg	0.4018	0.2256	0.2078	0.4049
	Bremerhaven	0.0480	0.0864	0.0745	0.1301
	Antwerp	0.1197	0.1411	0.1191	0.0602
	C.R.	0.02	0.09	0.08	0.00
Terminal Cost	Rotterdam	0.2500	0.2500	0.2500	0.2500
	Hamburg	0.2500	0.2500	0.2500	0.2500
	Bremerhaven	0.2500	0.2500	0.2500	0.2500
	Antwerp	0.2500	0.2500	0.2500	0.2500
	C.R.	0.00	0.00	0.00	0.00

	Ports	**F.F.1**	**F.F.2**	**F.F.3**	**F.F.4**
Geographical Location	Rotterdam	0.5633	0.3722	0.4883	0.4786
	Hamburg	0.2304	0.3722	0.1607	0.2166
	Bremerhaven	0.1075	0.0790	0.1001	0.1083
	Antwerp	0.0989	0.1765	0.2509	0.1966
	C.R.	0.01	0.00	0.01	0.01
Physical Infrastructure	Rotterdam	0.4786	0.3727	0.4786	0.5191
	Hamburg	0.2166	0.2014	0.2166	0.2201
	Bremerhaven	0.1083	0.0995	0.1083	0.0734
	Antwerp	0.1966	0.3727	0.1966	0.1875
	C.R.	0.01	0.06	0.01	0.02
Connection to Hinterland	Rotterdam	0.5527	0.5726	0.4632	0.4771
	Hamburg	0.2703	0.2477	0.3441	0.1382
	Bremerhaven	0.0723	0.0776	0.0794	0.2564
	Antwerp	0.1048	0.1021	0.1133	0.1282
	C.R.	0.03	0.03	0.04	0.00
Technical Infrastructure	Rotterdam	0.4955	0.3935	0.2948	0.3536
	Hamburg	0.2955	0.3955	0.5266	0.3536
	Bremerhaven	0.0737	0.0754	0.0534	0.1317
	Antwerp	0.1348	0.1376	0.1251	0.1612
	C.R.	0.06	0.00	0.05	0.01
Port Management and Administration	Rotterdam	0.3000	0.4669	0.2518	0.3507
	Hamburg	0.3000	0.2127	0.4148	0.3507
	Bremerhaven	0.1000	0.0876	0.0614	0.1093
	Antwerp	0.3000	0.2327	0.2719	0.1892
	C.R.	0.00	0.02	0.04	0.00
Terminal Cost	Rotterdam	0.2500	0.2500	0.2500	0.2500
	Hamburg	0.2500	0.2500	0.2500	0.2500
	Bremerhaven	0.2500	0.2500	0.2500	0.2500
	Antwerp	0.2500	0.2500	0.2500	0.2500
	C.R.	0.00	0.00	0.00	0.00

	Ports	**SHR.1**	**SHR.2**	**SHR.3**	**SHR.4**
Geographical Location	Rotterdam	0.3682	0.5920	0.2694	0.3536
	Hamburg	0.3682	0.2002	0.4763	0.3536
	Bremerhaven	0.0705	0.0818	0.1009	0.1317
	Antwerp	0.1930	0.1259	0.1534	0.1612
	C.R.	0.02	0.01	0.05	0.01

Physical Infrastructure	Rotterdam	0.4444	0.4883	0.5852	0.4170
	Hamburg	0.2222	0.1896	0.1843	0.2224
	Bremerhaven	0.1111	0.0893	0.0662	0.1105
	Antwerp	0.2222	0.2328	0.1644	0.2505
	C.R.	0.00	0.01	0.02	0.02
Connection to Hinterland	Rotterdam	0.5272	0.5851	0.5463	0.5463
	Hamburg	0.3053	0.2003	0.2317	0.2317
	Bremerhaven	0.0829	0.0900	0.0935	0.0935
	Antwerp	0.0846	0.1246	0.1285	0.1285
	C.R.	0.02	0.07	0.03	0.03
Technical Infrastructure	Rotterdam	0.3363	0.3301	0.3847	0.3940
	Hamburg	0.5055	0.5109	0.4644	0.3555
	Bremerhaven	0.0485	0.5270	0.0492	0.0889
	Antwerp	0.1098	0.1062	0.1018	0.1616
	C.R.	0.09	0.12	0.07	0.01
Port Management and Administration	Rotterdam	0.4811	0.5342	0.3636	0.4811
	Hamburg	0.2197	0.1873	0.3636	0.2197
	Bremerhaven	0.1307	0.1190	0.0909	0.1307
	Antwerp	0.1685	0.1595	0.1818	0.1685
	C.R.	0.02	0.02	0.00	0.02
Terminal Cost	Rotterdam	0.2500	0.2500	0.2027	0.2500
	Hamburg	0.2500	0.2500	0.2964	0.2500
	Bremerhaven	0.2500	0.2500	0.2982	0.2500
	Antwerp	0.2500	0.2500	0.2027	0.2500
	C.R.	0.00	0.00	0.09	0.00

Source: compiled by author

As seen in Table 5-6 and 5-7, a few of eigenvectors do not comply for the principle of consistency, which need the investigator to reconsider the model or reconstruct those pairwise comparison matrices with a high rate of consistency. In this case, the reason has been revealed that those errors mainly came from respondents' illogical scoring, which needs a certain amount of time to adjust. The author tends to normalize all the priorities to keep all the value of $C.R.$ falls within the allowable range of less than 0.1 through modification. The normalized consistencies are shown in the following Table 5-8 and Table 5-9. These modified data will be used in the following analysis.

Table 5-8 Normalized priorities for the criteria of measuring port competitiveness

Criteria	**S.L.1**	**S.L.2**	**S.L.3**	**S.L.4**
Geographical Location	0.0529	0.0513	0.0553	0.0508
Physical Infrastructure	0.2855	0.2373	0.1881	0.1162
Connection to hinterland	0.1625	0.1937	0.2357	0.2981
Technical Infrastructure	0.0652	0.1837	0.1835	0.1429
Port management and administration	0.3953	0.3066	0.3089	0.3411
Terminal cost	0.0387	0.0275	0.0286	0.0510
C.R.	0.02	0.02	0.09	0.10

Criteria	**F.F.1**	**F.F.2**	**F.F.3**	**F.F.4**

Geographical Location	0.1948	0.2958	0.1913	0.2677
Physical Infrastructure	0.0388	0.0609	0.0345	0.0496
Connection to hinterland	0.3919	0.2775	0.4331	0.3949
Technical Infrastructure	0.1032	0.0830	0.1081	0.0877
Port management and administration	0.2166	0.1867	0.1627	0.1225
Terminal cost	0.0547	0.0961	0.0703	0.0776
C.R.	0.05	0.05	0.04	0.06

Criteria	**SHR.1**	**SHR.2**	**SHR.3**	**SHR.4**
Geographical Location	0.1267	0.1433	0.1286	0.1264
Physical Infrastructure	0.0295	0.0363	0.0357	0.0314
Connection to hinterland	0.3704	0.3750	0.4748	0.3428
Technical Infrastructure	0.0473	0.0556	0.0531	0.0350
Port management and administration	0.0709	0.0629	0.0554	0.0762
Terminal cost	0.3552	0.3270	0.2524	0.3881
C.R.	0.04	0.01	0.08	0.04

(Note: S.L.:Shipping liner; F.F.:Freight Forwarder; SHR: Shipper)
Source: Compiled by author

Table 5-9 Normalized priorities for alternatives and final results

	Ports	**S.L.1**	**S.L.2**	**S.L.3**	**S.L.4**
Geographical Location	Rotterdam	0.3507	0.4838	0.4831	0.4883
	Hamburg	0.3507	0.2688	0.2081	0.2116
	Bremerhaven	0.1093	0.1422	0.0803	0.1532
	Antwerp	0.1892	0.1052	0.2285	0.1470
	C.R.	0.00	0.05	0.01	0.08
Physical Infrastructure	Rotterdam	0.6261	0.2878	0.6412	0.6412
	Hamburg	0.1359	0.4259	0.1407	0.1407
	Bremerhaven	0.0663	0.0483	0.0773	0.0773
	Antwerp	0.1717	0.1057	0.1407	0.1407
	C.R.	0.04	0.04	0.01	0.01
Connection to Hinterland	Rotterdam	0.6735	0.4805	0.2430	0.4082
	Hamburg	0.1855	0.3479	0.3465	0.4082
	Bremerhaven	0.0466	0.0579	0.3497	0.0866
	Antwerp	0.0944	0.1138	0.0608	0.0969
	C.R.	0.09	0.07	0.09	0.00
Technical Infrastructure	Rotterdam	0.3935	0.3284	0.2800	0.5243
	Hamburg	0.3935	0.4606	0.3453	0.1581
	Bremerhaven	0.0754	0.0746	0.0550	0.0960
	Antwerp	0.1376	0.1364	0.1197	0.2216
	C.R.	0.00	0.02	0.08	0.02
Port Management and Administration	Rotterdam	0.4304	0.5470	0.5986	0.4049
	Hamburg	0.4018	0.2256	0.2078	0.4049
	Bremerhaven	0.0480	0.0864	0.0745	0.1301
	Antwerp	0.1197	0.1411	0.1191	0.0602
	C.R.	0.02	0.09	0.08	0.00
	Rotterdam	0.2500	0.2500	0.2500	0.2500
	Hamburg	0.2500	0.2500	0.2500	0.2500

Terminal Cost	Bremerhaven	0.2500	0.2500	0.2500	0.2500
	Antwerp	0.2500	0.2500	0.2500	0.2500
	C.R.	0.00	0.00	0.00	0.00

	Ports	**F.F.1**	**F.F.2**	**F.F.3**	**F.F.4**
Geographical Location	Rotterdam	0.5633	0.3722	0.4883	0.4786
	Hamburg	0.2304	0.3722	0.1607	0.2166
	Bremerhaven	0.1075	0.0790	0.1001	0.1083
	Antwerp	0.0989	0.1765	0.2509	0.1966
	C.R.	0.01	0.00	0.01	0.01
Physical Infrastructure	Rotterdam	0.4786	0.3727	0.4786	0.5191
	Hamburg	0.2166	0.2014	0.2166	0.2201
	Bremerhaven	0.1083	0.0995	0.1083	0.0734
	Antwerp	0.1966	0.3727	0.1966	0.1875
	C.R.	0.01	0.06	0.01	0.02
Connection to Hinterland	Rotterdam	0.5527	0.5726	0.4632	0.4771
	Hamburg	0.2703	0.2477	0.3441	0.1382
	Bremerhaven	0.0723	0.0776	0.0794	0.2564
	Antwerp	0.1048	0.1021	0.1133	0.1282
	C.R.	0.03	0.03	0.04	0.00
Technical Infrastructure	Rotterdam	0.4955	0.3935	0.2948	0.3536
	Hamburg	0.2955	0.3955	0.5266	0.3536
	Bremerhaven	0.0737	0.0754	0.0534	0.1317
	Antwerp	0.1348	0.1376	0.1251	0.1612
	C.R.	0.06	0.00	0.05	0.01
Port Management and Administration	Rotterdam	0.3000	0.4669	0.2518	0.3507
	Hamburg	0.3000	0.2127	0.4148	0.3507
	Bremerhaven	0.1000	0.0876	0.0614	0.1093
	Antwerp	0.3000	0.2327	0.2719	0.1892
	C.R.	0.00	0.02	0.04	0.00
Terminal Cost	Rotterdam	0.2500	0.2500	0.2500	0.2500
	Hamburg	0.2500	0.2500	0.2500	0.2500
	Bremerhaven	0.2500	0.2500	0.2500	0.2500
	Antwerp	0.2500	0.2500	0.2500	0.2500
	C.R.	0.00	0.00	0.00	0.00

	Ports	**SHR.1**	**SHR.2**	**SHR.3**	**SHR.4**
Geographical Location	Rotterdam	0.3682	0.5920	0.2694	0.3536
	Hamburg	0.3682	0.2002	0.4763	0.3536
	Bremerhaven	0.0705	0.0818	0.1009	0.1317
	Antwerp	0.1930	0.1259	0.1534	0.1612
	C.R.	0.02	0.01	0.05	0.01
Physical Infrastructure	Rotterdam	0.4444	0.4883	0.5852	0.4170
	Hamburg	0.2222	0.1896	0.1843	0.2224
	Bremerhaven	0.1111	0.0893	0.0662	0.1105
	Antwerp	0.2222	0.2328	0.1644	0.2505
	C.R.	0.00	0.01	0.02	0.02
	Rotterdam	0.5272	0.5851	0.5463	0.5463

Connection to Hinterland	Hamburg	0.3053	0.2003	0.2317	0.2317
	Bremerhaven	0.0829	0.0900	0.0935	0.0935
	Antwerp	0.0846	0.1246	0.1285	0.1285
	C.R.	0.02	0.07	0.03	0.03
Technical Infrastructure	Rotterdam	0.3363	0.2847	0.3847	0.3940
	Hamburg	0.5055	0.5943	0.4644	0.3555
	Bremerhaven	0.0485	0.0512	0.0492	0.0889
	Antwerp	0.1098	0.0698	0.1018	0.1616
	C.R.	0.09	0.06	0.07	0.01
Port Management and Administration	Rotterdam	0.4811	0.5342	0.3636	0.4811
	Hamburg	0.2197	0.1873	0.3636	0.2197
	Bremerhaven	0.1307	0.1190	0.0909	0.1307
	Antwerp	0.1685	0.1595	0.1818	0.1685
	C.R.	0.02	0.02	0.00	0.02
Terminal Cost	Rotterdam	0.2500	0.2500	0.2027	0.2500
	Hamburg	0.2500	0.2500	0.2964	0.2500
	Bremerhaven	0.2500	0.2500	0.2982	0.2500
	Antwerp	0.2500	0.2500	0.2027	0.2500
	C.R.	0.00	0.00	0.09	0.00

Source: compiled by author

5.5 Analyzing and interpreting the results

In 1992, Murphy identified all port users with an attempt to investigate the difference of opinions held by different parties involved with regards to the importance of factors in affecting port selection, he concluded that the focus of different users on the quality of service was different, he also recommended that ports should strengthen communication with their customers in order to provide more satisfactory services (Murphy *et al*, 1992). The following sections consists of more analysis on it.

5.5.1 Importance weights for factors in competitiveness

Table 5-10 Importance weightings for criteria scored by ports users

	Importance weighting		
	Shipping liners	Freight Forwarders	Shippers
Geographical Location	5%	24%	13%
Physical Infrastructure	21%	5%	2%
Connection to hinterland	22%	37%	40%
Technical Infrastructure	14%	10%	5%
Port management & administration	34%	17%	7%
Terminal Cost	4%	7%	33%

Source: compiled by author

The outcome came from the pairwise comparisons conducted by the ports users presented in Table 5-10, suggesting that the most important factor in shipping liner's opinion is "Port management and administration" with a rate of 34%, slightly less than hinterland connection. Sub-factors determined in the previous chapter which highlights port efficiency, i.e. berth occupancy, ship turn-around time and ship waiting time, etc. in shipping liners' perception, this factor is evidently important in determining and measuring service quality for both terminal operators and ports. It

has been emphasized in some academic papers, e.g. Saanen stated that efficiency is still a major factor used to indicate port or terminal capacity and performance and their logistics services as well, this is a comprehensive evaluation index that combines berth capacity, yard handling capacity, yard storage capacity and gate capacity, in addition to the above mentioned capacities (Saanen, 2013). “The longer a ship stays at berth, the higher is the cost that a ship will have to pay (Chinonye Ugboma, et al., 2007)”. Realized this, shipping lines attach much attention to it, as higher efficiency means much time and costs savings. “Connection to hinterland” is considered as the next important elements at 22%, it seems that the result is in line with current industry practice. Hinterland accessibility is considered as one of the main elements in determining ports competitiveness, it has been verified by Martijn R. and Larissa M., they argued that such connection requires a cooperative mechanism over price mechanism between parties, he continued to express his opinion that shipping liners were merging into coordination arrangement together with terminal operators and transport companies for hinterland business (Martijn R. van der Horst and Larissa M. van der Lugt, 2011). This integration of shipping liners was discussed in the international transport forum with regards to organization for economic co-operation and development in 2009, which raised the increasing concentration of shipping lines and their enhanced coordination with terminal operators may offer more beneficial conditions to the development of barge and railway transportation; similarly, it also strengthens shipping liners’ hinterland connectivity. Furthermore, for the third important factor, it is “physical infrastructure”, physical infrastructure, like water accessibility, is still an important factor for shipping lines nowadays although such natural condition is not easy to change, ports are contributing themselves into the activities of extending their sites to satisfy more shipping liners’ larger vessels to access. The construction project of Maasvlakte 2 in Port of Rotterdam is a good example of it, as the establishment of new site, it would offer their users with much more connection to European hinterlands and the port can also benefit a lot from increased cargo volume. “Technical infrastructure” was evaluated as the fourth important element, which seems to be a new trend nowadays that shipping liners have increasing demands for IT and other innovative technologies, which can be better used for improving service delivery. It is well known that the importance of information and innovative technology in this informative era, Notteboom and Rodrigue commented in their paper emphasized its function in logistics operation and information flow as a key factor together with cash flow and cargo flow constitute the important segments of supply chain. Utilization of IT in terminal can speed up the whole logistics operation so as to keep their management efficiency on a stable and continuous basis (Notteboom and Rodrigue, 2005). Next, “geographical location” ranked the fifth, with only 5%. Individual may admit that geographical location is always the first consideration when measuring a port and such kind of natural advantages or disadvantages cannot be easily removed. Garcia-Alonso and Sanchez-Soriano introduced Sargent’s point of view 1938 and argued that cargo transportation always chose those shortest shipping route (Garcia-Alonso and Sanchez-Soriano, 2009). Nevertheless, nowadays, location is no longer the most important factor in accessing a port or the first main consideration as before. The less important one is “terminal cost”, one may think that it is also very important, yet, if take consideration on the practical operations, the importance of terminal cost is decreasing since scale of economies and fierce competition on price between ports. This situation leads the terminal cost is getting more and more transparent and little different from that of other ports so that carriers do not need to worry too much whether terminal cost would bring them much burden any more. Koi Yu noted that

shipping lines do not always choose a port on the basis of price only (Koi Yu (Adolf) Ng., 2006). Also, in practice, carriers usually shift those charges to shippers and consignees and they only share a very small part of that cost.

The evaluation on port selection factors is different from shippers and freight forwarders who control and share a large part of cargo transportation (Murphy et al., 1992 and De Langen, 2007). The above result does present such difference that freight forwarders scored the highest for "hinterland connection" at 37% and the second important element is "geographical location" at 24%. As the agents of shippers and consignees, freight forwarders are usually responsible for arranging following road or rail transportation after cargo discharged from a vessel. Hence, it is reasonable to assume that hinterland accessibility, intermodal network and port geographical location are main considerations when measuring port competitiveness. As for the port charges, Jose L. Tongzon (2009) commented that "*the costs which shippers or freight forwarders eventually pay include ancillary charges such as costs of pilotage, towage, lines, mooring/unmooring, electricity, water and garbage disposal."* And he also cited Murphy et al.'s findings in 1991 and 1992 and pointed out that they would like to pay higher port charges in exchange for superior services. This result is in line with the discussion with freight forwarders and shippers. Compared to "physical and technical infrastructure", "port management & administration" was evaluated as the third important factor, which expressed their attitude and focus on port's cargo-handling capacity and efficiency in this category, because if the cargo volume exceeds a terminal and port's maximum capacity, it will unavoidably lead to traffic congestion and inefficiency within port area and logistic costs will also increase as waiting time increases. As the main logistic providers, freight forwarders believe that improvement for port productivity and efficiency can be achieved by introducing adequate infrastructure, which includes the introduction of motivated employees and adoption of high-efficient cargo handling equipments. Furthermore, Jose L. Tongzon also proposed that lacking of information system has negative impact on documentation processing and will further influence the function of ports, i.e. owing to limited information accessibility, port users may not readily grasp the movements of the cargo to schedule cargo delivery, thus may cause traffic congestion within a certain period of time or container overdue delivery issues (Jose L. Tongzon, 2009). Port user's increased attention on information technology presents a trend of port's current focus.

Finally, "connection to hinterland" (40%) was regarded as the most important factor in shippers' opinion. Owing to the development of international trade and optimization of transport network, which makes higher frequency of the transactions between ports as well as inland networks, thus ultimately leads to larger demand for door-to-door service so as to ask for deeper ports services. As mentioned earlier, shippers are the ultimate bearers of terminal costs charged by shipping liners and port authorities, therefore it is not difficult to understand why they are always sensitive to the costs compared to other users. Moreover, since "geographical location" (13%) always determines the route of cargo flow, it is also important for shippers for consideration. As shown in the results, its scoring is close to that of "hinterland connection" and "terminal cost" (33%). "Terminal cost" has much important sense to shippers, compared to shipping liners and freight forwarders, Ugboma, et al., (2007) gave their explanations on that: "*This higher cost can be passed on to shippers in terms of higher freight charges and longer cargo dwelling time*." Besides, port efficiency (7%) often refers to speed and reliability of the port

service (Jose Tongzon, 2002). UNCTAD (1992) also cited "'on-time delivery' was *a major concern by most shippers*."

The above ranking results conducted by different port users provide port operators some findings when making a multiple decision. For example, the result presents that "hinterland connection" is the most important factor to all port users. In reality, the importance of this factor has already been recognized by port operators (Chi-lok Andrew Yuen, 2012). Owing to different expectations, port operators have taken different measures to satisfy different requirements. Port of Rotterdam, Antwerp and Hamburg set up intermodal system to strengthen the connection between ports and inland areas. In addition, unlike "hinterland connection", the three groups have common sense on its importance, some factors are considered important to one group, but other groups may not think so. For example, "port charges" is considered more important by shippers than shipping liners, Guy and Urli considered that port charges are not as important as total transaction costs, transaction costs consists of terminal handling charges, port dues or other kind of logistics costs related to port, which almost holds 38% of importance weights in port determination (Guy and Urli, 2006). Port users usually try to minimize the total costs along the supply chain.

Having different results judged by different groups of users, it offers an useful resource to decision-makers who may use it as a basis to balance different factors in his decisions, thus put more efforts on those desirable and profitable factors for them.

5.5.2 Ports ranking in competitiveness

Results of ranking for port of Rotterdam, Hamburg, Bremerhaven and Antwerp were concluded in Table 5-11-13 regarding to competitiveness, which were grouped by port users' perceptions. From the questionnaire, the performance score evaluated by port users was given, and then the average score for each group of users can be calculated. Next, total score for each port can be computed by multiplying the score of port performance by its important weightings of each factor.

Table 5-11 Rankings on ports competitiveness scored by shipping liners

	Importance weighting	Rotterdam	Hamburg	Bremerhaven	Antwerp
Geographical Location	5%	2.3	1.3	0.75	0.17
Physical Infrastructure	21%	11.55	4.4	1.47	2.94
Connection to hinterland	22%	9.9	7.04	3.08	1.98
Technical Infrastructure	14%	5.3	4.76	1.12	2.1
Port management & administration	34%	1.7	0.11	2.72	3.74
Terminal Cost	4%	0.01	0.01	0.01	0.01
Total score (full point:100)		30.76	12.49	9.15	10.94

Table 5-12 Rankings on ports competitiveness scored by freight forwarders

	Important weighting	Rotterdam	Hamburg	Bremerhaven	Antwerp
Geographical Location	24%	11.52	5.76	2.4	4.32
Physical Infrastructure	5%	2.3	1.05	0.5	1.2
Connection to hinterland	37%	19.24	9.25	4.44	4.07
Technical Infrastructure	10%	3.8	3.9	0.8	1.4
Port management & administration	17%	5.78	5.44	1.53	4.25
Terminal Cost	7%	1.75	1.75	1.75	1.75
Total score (full point:100)		44.39	27.15	11.35	16.99

Table 5-13 Rankings on ports competitiveness scored by shippers

	Important weighting	Rotterdam	Hamburg	Bremerhaven	Antwerp
Geographical Location	13%	5.2	4.55	1.3	2.08
Physical Infrastructure	2%	0.96	0.4	0.18	0.44
Connection to hinterland	40%	22	9.6	3.6	4.8
Technical Infrastructure	5%	1.75	2.4	3	0.55
Port management & administration	7%	3.29	2.24	0.84	1.19
Terminal Cost	33%	8.25	8.25	8.25	8.25
Total score (full point:100)		41.25	27.44	17.17	17.31

Source (Table 5-11-13): compiled by author

The results in Table 5-11 reflect shipping liners' point of view, port of Rotterdam was ranked the most competitive port among the target ports, which mainly due to its excellent performance in terms of "hinterland connection" and "port efficiency". Without considering the common sense of hinterland factor, "short time in port", in other words, "port efficiency" is indeed a major factor for shipping liners for consideration. On the other hand, it is also well known that the port of Rotterdam also ranked the first with regards to "physical infrastructure" and "technical information", the advantages in sufficient water accessibility and its successful application of automated guided vehicles in port operation benefit Rotterdam to become the leader in European port cluster. The results show that the port of Antwerp and Bremerhaven were ranked in the third and the fourth in comparison.

Table 5-12 shows the ranking result given by freight forwarders. Port of Rotterdam once again gains the first place, although Rotterdam was not good as that of Hamburg and Bremerhaven in terms of "Terminal cost", the difference amongst the four ports are not too large in fact, it performed well in all other factors, such as "connection to hinterland", "geographical location", "port management and administration" and etc., which are important for freight forwarders.

Finally, Table 5-13 shows the result of shippers' selection. Port of Rotterdam evidently shows its advantages in respect of "hinterland connection", "port management" and "geographical location". Hamburg and Antwerp are placed in the second and the third. Bremerhaven was only ranked the fourth, which mainly due to its unsatisfactory performance in "hinterland connection" and "geographical location".

5.6 Conclusions

The author investigated the factors that determined ports competitiveness and the relative importance through AHP calculation in this chapter. The port users were divided into three groups: shipping lines, freight forwarders and shippers so that the difference of opinions on port competitiveness within each group can be identified. Besides, "connection to hinterland" has already recognized by users as the most important determinant nowadays, the factor "port management" has direct influence on cargo handling and its efficiency is the main focus of shipping liners; while, as freight forwarders are the shipper's agents who always undertake much of the logistics services and consider "geographical location" as the most important factor followed by "port management"; shippers expressed their interests and focus on "terminal charges" and "geographical location", in their opinion, these two factors together with "hinterland connection" almost have similar position in measuring port competitiveness.

The four ports were also ranked on competitiveness based on the AHP results which collected from port users. In general, the difference in terms of "terminal costs" is not significant within the four ports, but in all other respects, port of Rotterdam performed best, then followed by Hamburg and Antwerp and Bremerhaven was ranked the last.

Chapter 6 Empirical Findings

6.1 Introduction

It is important to realize that the real condition and the practical operation of ports so as to find out the different competitiveness amongst the target ports. In this chapter, the author read lots of current articles, annual reports, database from a professional organization and other useful resources as well with the aim at searching for ports' current situation both in terms of competition and measurement currently. The following part will be divided into several segments from geographical location to the new focus and interest regarding to information, innovative network technology, while, base on the data comparison, some analysis will also be given. These empirical findings are expected to contribute much, combining with the previous findings on the questionnaire, in drawing conclusions in the next chapter.

6.2 Empirical findings on ports

6.2.1 About geographical location

According to the report from SCI Verkehr, an independent consultancy company, the top ten container ports in Europe account for about 60% of cargo handling along the North Sea (SCI, 2010). Rotterdam is the largest European port in handling containers and bulk cargo as well. Hamburg, Antwerp and Bremerhaven constitute the four busiest ports in European areas.

As for the mentioned four ports, they all located within Hamburg-Le Havre range. Port of Rotterdam is close to the North Sea. It benefits from its largest geographical advantage of allowing the biggest vessel to access and easily stretching to hinterland areas. For the port of Antwerp, it is located in the estuary, has the dominant position with only 80 kilometers from the open sea, but on the other hand, it also means that Antwerp cannot accept those largest vessels to berth. Huybrechts concluded through conducting a survey of evaluating port attractiveness that the main reason for the port of Antwerp that cannot match the other European ports was port accessibility, particularly the restrictions of River Schldt (Huybrechts *et al,* 2002). Port of Hamburg has a longer distance of 100 kilometers from the open sea, which located in the river of Elba. Bremerhaven is 32 kilometers away from the Northern Sea. In terms of geographical location, all these Northern European ports were surrounded by the industrial hinterlands and linked up with each other, given them lots of advantages.

Nevertheless, measuring a port competitiveness, geographical location is probably the first factor that one may consider, the advantage that a port may has is not absolute. Koi Yu (Adolf) Ng also mentioned that those ports with geographical advantage cannot be measured separately. Containers discharged from the same vessel always have different destinations, a port which has geographical advantage to a specified region is usually compensated by its disadvantage to another region. For example, Rotterdam can be regarded as the most attractive transshipment port serving Hamburg-Le Havre region while not a good choice when serving customers in Portugal (Koi Yu Ng, 2006).

6.2.2 About market share and throughput

Market share is the main focus that ports are competing for. Figure 6-1 depicts the distribution of market share in the Hamburg-Le Harve range in 2012. As seen in the following pie, port of Rotterdam took up the largest part of the volume of containers handled in this region with 37.5%, followed by port of Antwerp at a percentage of 15.7, only equals approximately one second of that of Rotterdam, Hamburg ranked the third with a market share of 11.1%, almost one third of the market share gained by Rotterdam. Bremerhaven only gained the fourth place in the target four port rankings and the fifth in the mentioned region with a little share of 7.3%. Hence, there is no doubt that port of Rotterdam is the giant in the European market.

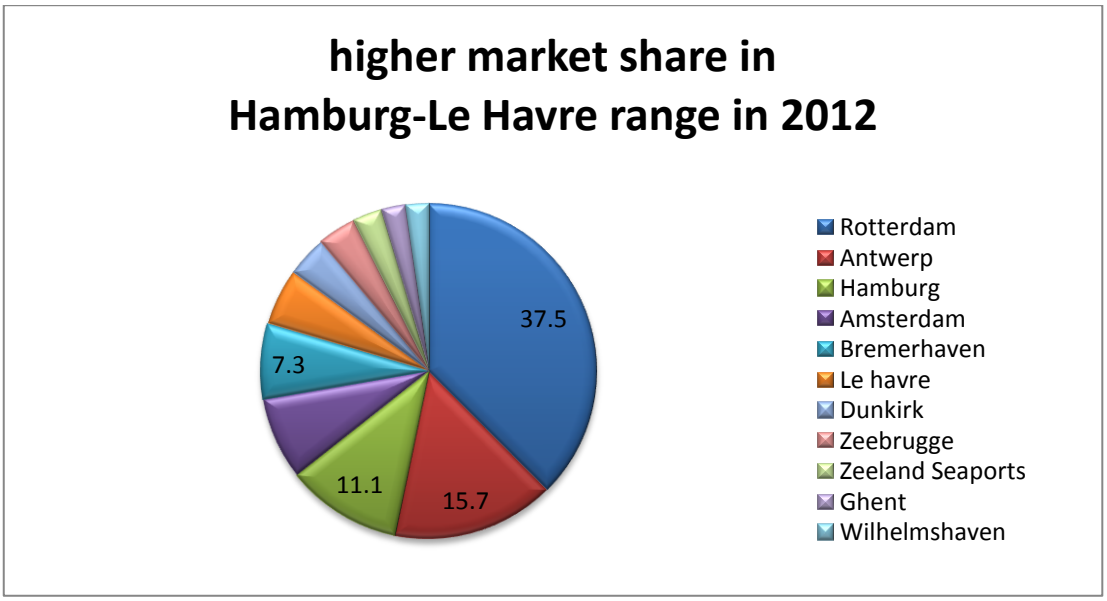

Figure 6-1 Market share in Hamburg-Le Havre range
Source: Annual report, Port of Rotterdam, 2012

Another similar measuring index is throughput, which is the maximum amount of TEUs that a port or a terminal can handle during a certain period or it can also presented as all productive moves made by quay cranes on sea going vessels, per TEU equals two moves. Although throughput is not the only factor measuring the capacity of a port and the determinant whether a port has a competitive advantage or not, it indeed a reference and a comprehensive index that reflects performance and development trend of ports during a period of time.

Table 6-1 Throughput of the four ports between 2010 and 2012

	2010 (Million TEUs)	2011 (Million TEUs)	2012 (Million TEUs)	Rank
Rotterdam	11.15	11.88	11.87	1
Hamburg	7.90	9.01	8.90	2
Antwerp	8.47	8.66	8.64	3
Bremerhaven	4.89	5.92	6.28	4

Source: compiled by author based on the statistics from port authorities

Table 6-1 presents the throughputs of the target ports during 2010 to 2012. During the successive three years, port of Rotterdam keeps a highest record of container throughput and leaves the other three ports far behind. It handled 11.15 million TEUs in 2010, which almost amounts 3 times of that of Bremerhaven, comparing to the volume of containers in 2011, it has a continuous increase to up to 11.88 million

TEUs, while Hamburg went up to become the second biggest port with a volume of 9.01 million TEUs and followed by Antwerp which was ranked the second place in 2010 but the third in 2011 with a little bit less volume than Hamburg, the last place was still the port of Bremerhaven with only 5.92 million TEUs in 2011. Having reviewed the throughputs in 2012, Rotterdam still dominated the market along the Northern Sea and the other three ports had no change in ranking compared with the throughput of 2011. However, it is interesting to see that except the port of Bremerhaven experienced a slight increase, other three ports all decreased than that of the previous year. Found the reason of the decline is that since November 2011, world merchandise trade has lost momentum.

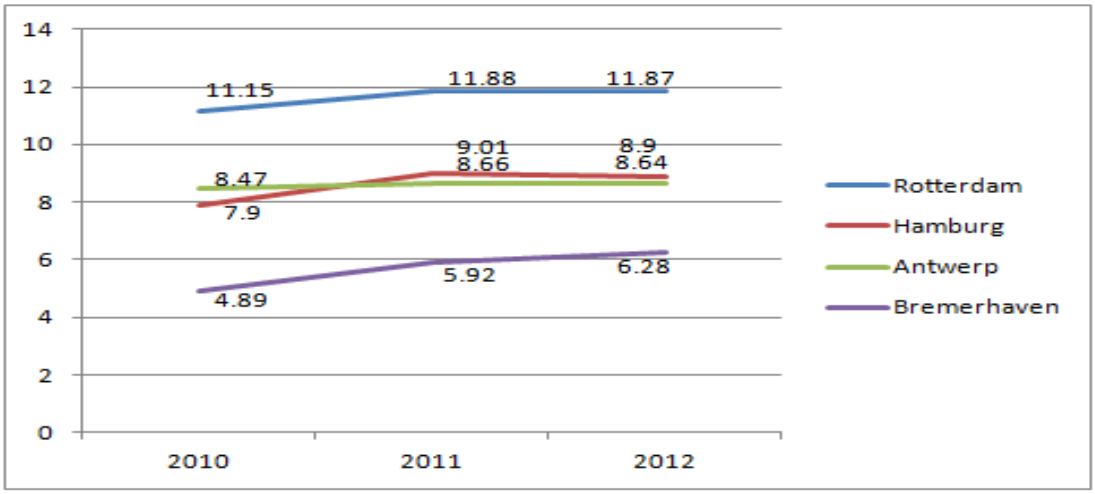

Figure 6-2 Throughput of the four ports between 2010 and 2012
Source: compiled by author based on the statistics from port authorities

The curves in Figure 6-2 show the trend of throughput of four ports between 2010 and 2012 based on the table, by doing so, it is much clear to see the tendency of changes in each port. Different from other three ports, Antwerp did not change a lot as the curve is almost flat, other ports had more or less increase in the past three years. In addition, only port of Bremerhaven indicated a remarkable upward tendency in 2012, although it still cannot match with other three ports in the area. As seen above, port of Rotterdam ranked the first, Hamburg and Antwerp are the second and the third respectively and Bremerhaven was in the last place in 2012.

6.2.3 About container terminal and port infrastructure

Container terminal is a significant component of a port. Terminal handling efficiency largely determines performance of a port. A terminal can be defined as:

"An *organization offering a total package of activities and services to handle, store and control cargo to and from transportation modes with a balance in handling and services to the transportation modes against minimized costs*." (Saanen, 2013)

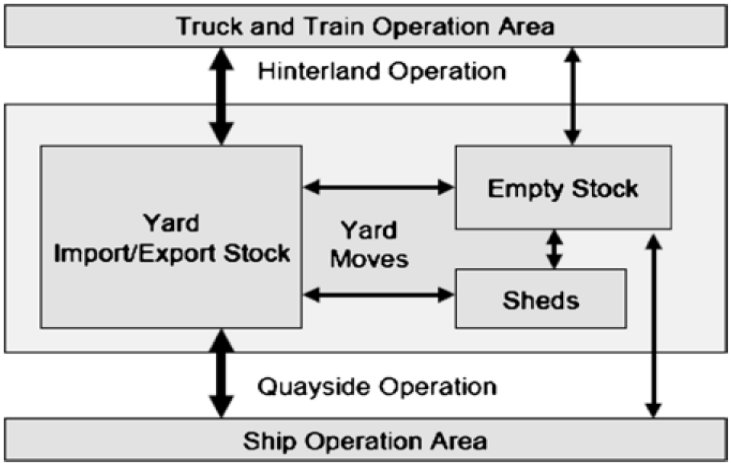

Figure 6-3 Operation areas of a seaport container terminal and flow of transports
Source: Hans, 2006

The systems that seaport container terminals have are more or less the same although they may distinguish in size, layout or functions (Figure 6-3). Main equipments for ships in operation are quay cranes. Time spent on loading and unloading containers largely rests on the quay cane's productive capacity. Import and export area is divided into different blocks. A special stack area equipped with electrical supply is usually reserved for reefer containers or tanks for dangerous cargo. Empty containers are required to store in another separate area where they can be changed or relocated whenever necessary. Shed area is employed for containers stripping or stuffing for other logistics activities. The truck and train operation areas link the terminal with outside transportation system which can deliver containers directly to inland areas. In order to accelerate the operational process, terminals adopted fully automated container handling system or transportation vehicles moving within a port area. Container terminal is an important link in the supply chain (Saanen, 2013), improvement in vessel handling efficiency not only reduces the costs generated by the normal production, but also produces added value for shipping liners because the time spent at terminal for vessel is saved, which is an important indicator for port performance measurement. World ports or terminals nowadays are continuously contributing to foster operational efficiency to fulfill their users' demands.

Throughout the development of the harbor container terminals in these years, the number and capacity of them has considerably increased, meanwhile, container terminal configurations show an ongoing improvement in terms of utilization of automated transportation vehicles and container handling technology, especially in countries which has high expenditure in labor costs. Therefore, manual operator of quay cranes is gradually being replaced by automated equipments. AGV is a successful example of being used instead of manual operation of carts in the port of Rotterdam.

The competition between global seaports and between container terminals has dramatically increased propelled by fast growth of container volume in major shipping routes. It is not only terminal capacity has got larger than before, but also considerable gains on productivity and efficiency were achieved by means of optimizing terminal layouts, introducing more efficient information technology,

improving logistics control and operation systems, and using automated handling and transportation equipments. For example, according to the statistics of Port of Rotterdam, the added value created per employee in the Rotterdam-Rijnmond area increased from 108,750 euro to 114,250 euro between 2009 and 2011 due to the adoption of new technology (port of Rotterdam, 2012).

A port infrastructure includes: *all the terminals, all the equipment on the terminals, the area where the terminals are located and its surroundings. Linking infrastructure includes all the physical parts of an infrastructure: roads, railway lines, river canals, airports, pipelines etc*. (Saanen, 2013)

According to the information and data regarding the infrastructure of the four ports from port authorities, port of Hamburg have 4 large container terminals; Rotterdam has 3; Antwerp and Bremerhaven has 16 and 4 respectively. In terms of total length of terminals, port of Antwerp owns the terminal with 18,345 meters, and Rotterdam has total 11650-meter long terminals with a quay length of 64 kilometers. Bremerhaven has quay length with 3.9 kilometers, operating area with 90 hectares and terminal length of 4920 meters. Hamburg possesses the terminal length with 7250 meters. Hamburg has 34.6-kilometer long quay walls for ocean-going vessels in operation. For the maximum water depth, Hamburg, Rotterdam, Antwerp and Bremerhaven are 16.5 meters, 24 meters, 18.1 meters and 15 meters respectively. Decision-makers are continuously contributing to expanding the capacities to satisfy their users' requirements in terms of inland market connection and larger scale of vessels' call (port of Rotterdam, Hamburg, Antwerp and Bremerhaven, 2013).

It is noteworthy that in shipper's opinion, port infrastructure is the least important factor. Slack conducted a research in 1985 and found that despite improvements of port facilities were often be considered as a necessary and basic task for ports, however, it did not impact goods flow to divert to other places since shippers were conservative decision-makers who were not willing to choose other alternatives in most cases (Slack, 1985).

6.2.4 About hinterland connection

Seaport is acting as a main logistics center which connects the inland transportation by road, rail and barge and contributes themselves into inland economic activities. SCI Verkehr GmbH published in 2009 that approximately 14% of the ports throughputs were transported from or to the ports by railway (SCI, 2010). Although, railway has been widely used in the dry bulk transportation, road is still the main supporter for container transportation. Rail transportation network has already been established and well connected within the main European ports area, such as Rotterdam, Hamburg, Antwerp, Bremerhaven ports. The stretching in the hinterland markets makes one port's hinterland overlap another, thus leads to fierce competition among ports. Since more and more ports realized environmental issues continuously, railway as the most environment-friendly mode, which has become a more attractive and great potential means of transport.

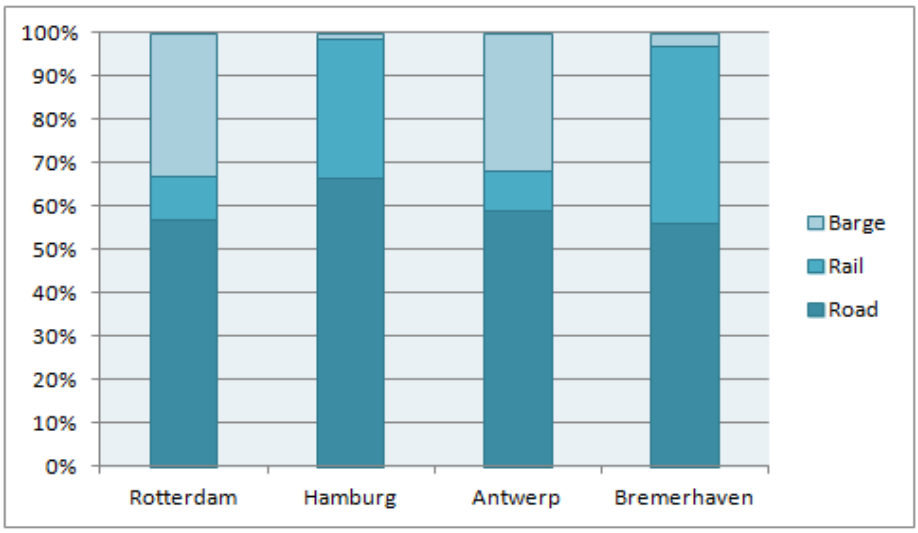

Figure 6-4 Modal split for container traffic for the four ports (2011)
Source: compiled by the author

Inland transportation includes barge, rail and road. Figure 6-4 illustrates the distribution of the three modes utilized in the target ports. It is evident to see that road undertook most of the inland cargo transportation in all ports. However, barge and rail transport present a big difference amongst four ports. Having benefit from the geographical advantages, Rotterdam and Antwerp have relatively mature water transport networks that can deliver the cargo in a more efficient and effective way. However, Hamburg and Bremerhaven do not have much more advantages in operating barge as the other two ports, specially, only around 1% barge transport in Hamburg so that it may lose customers who are used to transport cargo by the river. Although the disadvantage they have, Hamburg and Bremerhaven almost have the same dominant position in the rail transport operation. Rotterdam lags behind Hamburg and experiences a great number of congestion by trucking. Realized the shortage in rail transport, port of Rotterdam is struggling for rail infrastructure construction, it has successfully operated over 340 rail shuttles which connect the port with main inland destinations in Europe so far, in addition, the so called “Betuwe Route” is a direct rail line with 160-likometer long connecting to Germany, just operated in July without any restrictions and solely served rail freight department (port of Rotterdam, 2013). Furthermore, in order to reduce the greenhouse effects so as to maintain sustainable development, many ports formulate their strategic plan of shifting road transport towards railway or feeder transport. T. Heaver, et al. argued in their research that port not only struggle for competitiveness on its own way, it also needs to pay certain concerns about the development status of its competitors. He highlighted the importance of improving intermodal transport services nowadays “*The effects of improved intermodal services are to increase the competitiveness of alternate port routings*” (T. Heaver, et al., 2001)

Although it has been argued by T. Heaver that “*among the hinterland transport modes, the highly competitive road transport is the most important.*” (T. Heaver, et al., 2001), railway transport is considered as the one of the most environment-friendly modes of transport in the era of advocating environmental protection. Short-distance road transportation indeed can well satisfy customer’s more and more door-to-door service, however, it will increase much more costs by using truck to transport more

small volumes of cargo and will also generate much pollution (Rommert Dekker, 2013). Hence, most of the ports nowadays are in an effort to develop infrastructure and capabilities of rail transport and gradually expand the scope of use. For example, in order to expand its connection to hinterlands, currently, port of Antwerp approved a railway operator, called Railport, to develop its distribution transportation network with the purpose of ensuring its competitive position in the logistics and industrial area through this approach. The establishment of professional operator will gain port of Antwerp fast development in the railway system. The port authority also realized the strategic importance of logistics activities between the Antwerp-Duisburg-Vienna routes that linking Antwerp with central and Eastern Europe, they offered a positive support in upgrading their railway links in inland area. Furthermore, based on the rail link, they are planning to further strengthen the intermodal transport in the two regions. These inputs will benefit the port of Antwerp with more competitiveness in Northern Europe region. (Port of Antwerp, 2013)

With regards to the port of Bremerhaven, owing to their traditional railway network, the railway infrastructure covers 229 km of the total length. High quality and efficient railway service are the key factor for attracting more cargo to distribute and transport from there, which increases more function of Bremerhaven as a port and also a logistics center. As port authority's much attention on upgrading track infrastructure to meet the requirement of continuous increasing cargo volume in the coming years. They worked out a strategic plan that they will focus on expanding their abilities in terms of vehicle and container terminals till the year of 2020. (Port of Bremerhaven)

6.2.5 About information and innovative technology

Offering reliable services to relative partners involved in the logistic chain is the main purpose of any container port in the world. Effective information flow within port area is considered to be an important variable. In recent years, ports have included the exploitation of information networks and innovative technology into their agenda. Since this factor may affect port's operational efficiency thus results in improvement of service quality, it has attracted the attention of port operators.

According to Trujillo and Tovar, as the first person who proposed and studied on technical supporting in port efficiency, they emphasized the importance of technical efficiency and cited the limitation of information and technology may limit European ports' efficiency. In terms of supply chain management, the efficiency of information flow is significant to the integral efficiency of the supply chain. Port authorities have already realized its role in improving the quality of their service. By doing so, ports may use logistics efficiency to measure the efficiency of each factor in logistics activities (Trujillo and Tovar, 2007).

For example, in June of 2013, port of Hamburg started to use a new online system aiming to better match future supply with demand and even effectively. This Portlog website offers a marking platform for manufacturers, logistics companies, importer and exporter as well as potential customers and warehousing, transportation and logistics providers. Hence, German or international port customers may find a warehousing company to operate the business on his own. For example, after logging in the Portlog system, he can choose his own language as the service provided is user-friendly input. After completing the input for the procedure, the system uses a program which can match the existing pool to the selected matching

requirements then lists these alternatives on screen for the user to select (port of Hamburg, 2013).

In early 2009, Rotterdam owned an online 'portbase' system established jointly by port of Rotterdam and Amsterdam to set up a network supporting system in the Rotterdam-Amsterdam area. Through one-stop-shop service, information sharing and exchange, logistic chain in port is getting more attractive. This information exchange platform allows their users to optimize their logistic procedures so as to strengthen their competitive position on quality services. The 'portbase'-Rotterdam port community system links all chain partners, such as harbor authorities/companies, customs, shipping lines, forwarding agents to each other in the field of documentation (port of Rotterdam, 2013).

Port of Antwerp also mentioned that a roll-out of APICS2 (Antwerp Port Information & Control System, generation 2) was being used in practical operation (port of Antwerp, 2013).

In this respect, M. Kia, *et al.* (2000) also emphasized that advancement of information technology provided more choices for terminal operators to manipulate an automated information system. Manual labor and paper flow have been replaced by electronic devices nowadays, which facilitated the information flow and improved the control of service quality. The application of the computer has become a standard method for measuring cargo handling equipments. Information technology, containing internet, facilitated information exchange between ports and ports, and ports and their users in the supply chain. Hence, the importance of information technology is improving.

6.2 Empirical findings on port users' perception

As continuous growing of containerization and globalization, carriers as well as shippers are showing less loyalty in choosing a port. For shippers, they usually prefer to move their cargo over the shipping routes which could offer best performance with regards to ports service provision and for those carriers, who only express a loyalty to a specific port during the period of their lease arrangement (Fleming and Baird, 1999). Port authorities and operators require finding a solution to enhance their attractiveness of the ports when facing up to the growth of competition between ports.

Port users emphasize on upgrading the level of service quality. Ugboma, et al., (2004) argued that delivering high quality service to customers was the thing what ports must do either for success or for survival in today's competitive environment. Parasuraman et al. (1985) stated that excellent service is a strategy of earning additional profits, since it may attract more customers and could bring more business opportunities from current customers. It even can compensate the disadvantages in price competition. Nevertheless, fewer mistakes in the service will no doubt lower the performance of ports. Normally, users' satisfaction is an essential element in determining the success of port service (Moore, 1998). Another comment is from Tongzon (2002). He argued that service quality was indeed an important factor that impact port user's measurement on port competitiveness. Port authority of Antwerp clarified in their strategic plan, as for their customers, they expect to continue to offer reliable and dependable delivery service, and they though it is as important as cost

efficiency. Hence, port of Antwerp is struggling for the improvement of hinterland connection service for their customers.

In addition, it has been reported in 2009 by port of Jakarta that congestion at ports has become the major obstacle to shippers and consignees who tend to get the goods quickly so as to seize the market. Besides, logistics providers also recognized that congestion continued to be a major problem and would like to accelerate the cargo flow. Hence, from their opinions, port efficiency is their main concern and at least could be an important factor in measuring port's competitiveness. However, this finding is inconsistent with the result of the research, the reason is that in Jakarta, manual handling operation is still their main approach, which is completely different from an automated processing system in Rotterdam. Human handling will inevitably lead to a serious decline in efficiency and attract port users' more attentions on it. European ports indeed have excellent performance than that of Jakarta.

6.3 Conclusions

This chapter mainly clarifies some empirical findings related to ports' competitive situation nowadays combined with the result of the previous AHP model. The advantages in geographical location have gradually been replaced by developing hinterland connection and transportation network, and to become the main focus in determining port competitiveness. It is worthy of knowing that port efficiency is still a significant factor in terms of competitiveness.

Chapter 7 Conclusions

7.1 Introduction

For the research questions raised in chapter one, the author will give corresponding answers in this section, due to some limitations in real and specific conditions, the research more or less indicates imperfection, which will be recommended to improve for further study. Following parts will be split into conclusions and recommendations with detailed explanations.

7.2 Conclusions

The main aim of this research is to present the possible determinants of ports competitiveness measurement from port users' perception, focusing on four selected Northern European ports. In order to successfully accomplish this, the author has provided that the activities offered by ports were somewhat dynamic as ports deepening into the supply chain activities in recent years. The fundamental reason for port's function changes is that the requirements for logistic services in ascension along with containerized trade in expansion. In order to survive and succeed in the global competitive environment, seaports have to optimize their infrastructures and extended services to adapt to the changes.

Some basic terminologies and notations which are necessary for understanding of subsequent results have been presented at the very beginning. Different from other studies, respondents in the survey were divided into three groups: shipping liners, freight forwarders and shippers, whose judgments for port competitiveness are distinct due to their different expectations on ports. By using AHP model, those determined factors' importance weights were investigated. It was found that shipping liners intend to focus on vessel's time at ports, requiring for a high efficiency of container handling, while "hinterland connection" is the most important factor for both shippers and freight forwarders, unlike shipping liners, they have little interests in port's "physical infrastructure".

Based on the results given by the questionnaire, the target four ports were also tested and ranked with regards to their competitiveness. On the whole, port of Rotterdam was ranked the first; port of Hamburg and Antwerp earned the second and third place respectively; the last was Bremerhaven, albeit a little difference between each factor scored by three groups.

In conclusion to the sub-questions in the chapter one, it becomes obvious that the answers of them in the fact that fast growing of container trade volume brought port not only a place for vessel to call, instead, a diversified service provider with high degree of hinterland connection. Under the changeable global economic environment, ports have to and have already adjusted themselves to accept such challenges. This result also has been recognized by all the respondents involved in the survey. As a result of ports competition is gradually extending to hinterland, the criteria for competitiveness measurement are not limited to "geographical location" any more. On the contrary, the importance of hinterland connectivity is increasingly enhanced in terms of port's competitiveness. It is interesting to find that a new trend of information and innovative technology has drawn port's users' attentions as well. Empirical findings shown that information transfer indeed brought advantages of

port's efficiency and port's users also enjoyed accessing to the updated information of their cargo personally. Therefore, ports are contributing themselves to improve both their basic infrastructures and upgrade quality and scope of their services. However, ports are expected to follow the trend of integration of supply chain logistics and exert their unique features and advantages, rather than totally driven by their users' every requirement. The best approach is to make a strategic plan in a reasonable way, carefully considering various degrees of importance weights for each factor and combining current situation of competition to make the best strategic decision finally.

7.3 Recommendations for future research

Like other papers, this study also has some limitations, which could be improved by further research. First of all, the results of port competitiveness measurement are heavily rely on the quality of AHP model and data base, yet these data were gained from questionnaire which means that the respondents' knowledge and experience played a vital role in the whole process of survey. On one hand, even though the data used are rather new for the target four ports and the author would like to believe that the research results are cogent, a small size of samples may still lead to a narrow scope of study thus result in a relative low valid outcome. The gap of the results between ports is somewhat larger than expected and maybe port of Rotterdam in fact is not always the best for all cases. Since most of the responses are located in port of Rotterdam and Hamburg regions, shipping liners may have comprehensive knowledge of Northern European ports, while shippers or even freight forwarders have limited knowledge with that, one may choose the port with high reputation, and that is the reason why port of Rotterdam always has a highest score almost in all judgments. Therefore, for further research, it could expand the scope to other locations with a bigger difference and a broader selection of respondents.

Furthermore, some improvements to the scheduling aspect of the model may be brought through additional levels in the hierarchy for more detailed representation of the scheduling activity, which means that additional sub-hierarchies may make the results of research more rigorous.

Besides, this study did not make a distinction between shippers in terms of cargo type, customer source and trade term and so forth, thus it is interesting to investigate whether or not their different requirements for port's services in those cases will have different influence on the final results.

Finally, it is interesting to explore in future research that whether these factors would still be dominant in determining port's competitiveness. For example, after hinterland connection network amongst ports are developed to be so mature enough that measuring port competitiveness would return to be a situation that a port which has an advantage of "low cost" is of competitiveness.

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Appendix Questionnaire format

Dear Sir/Madam,

Firstly I would like to express my gratitude for your participating my questionnaire regarding to my thesis research, the topic of my research is analysis on port future development based on measuring competitiveness of container ports from users' perspective within main European port area (it mainly focuses on Rotterdam, Hamburg, Antwerp and Bremen). The result of the questionnaire is very important to me since it determines the final conclusion of my thesis research. It will be highly appreciated if you could take some time to answer these questions with patience, then you may forward it to my mailbox: lh0304gl@hotmail.com after you finished it. Thank you for your kind help in advance.

Han Luo

Erasmus University Rotterdam

2013.7.2

Questionnaire

Name: _____
Company: _____
Email: _____
Date: _____

There are 7 questions in the whole questionnaire survey:

1. Which sector are you working in now? ( )
   a. Shipping line, b. Freight forwarder,
   c. Shippers/Consignees, d. Other: _____

2. Do you think we are living in an international trade and global logistics era and being influenced greatly? ( )
   a. Yes, b. Not.

3. Nowadays, do you think the function of port authority is changing more diversified in line with development of global trade? ( )
   a. Yes, b. Not.

4. We find that the following factors are key elements when assessing port competition and are highly dependent on port users' preferences, which factor do you think is the most important? ( )
   (1) Geographical location (eg. proximity to I/E areas, to feeder ports and to main navigation routes etc.)

(2) Physical infrastructure (eg. water access etc.)
(3) Logistic chain and connectivity to the hinterlands (eg. intermodal links: rail, highway and barge etc.)
(4) Technical infrastructure (eg. IT etc.)
(5) Port management & administration (eg. port efficiency on berth occupancy, ship turn-around time, ship waiting time, port security and safety etc.)
(6) Carriers' terminal cost (eg. handling cost of containers, storage cost of containers and terminal ownership/exclusive container policy etc.)

5. Following question 4, assume that a ship liner is planing to operate a new route from Asia to North Europe, the target ports are Rotterdam, Hamburg, Anwerp and Bremen. You have chance to decide a port where to load your cargo based on your preferences, in order to gain the determinant factors that measuring the ports' competitiveness through the comparation between different factors, you are asked to compare pairwises of criteria using the following 9-point scale shown as follows.

Pairwise comparison scale using AHP:

Verbal Judgment	Nurmerical Rating
Extremely more important	9
	8
Very strongly more important	7
	6
Strongly more important	5
	4
Moderately more important	3
	2
Equally important	1

Next, please score each factor according to the above rating list. For example, when you compare geographical location (main factor) to physical infrastructure (specific factor). and if you consider the main factor 'geographical location' is more important in the *pairwise* comparisons with 'strongly more important' degree, then just rate it as 5; conversely, if you think the main factor is less important, then just rate it as 1/5 in the blank as the example shown below. (Please just focus on every two factors that you rate when measuring, regardless other factors may involve.)

Examples:

(When you think Main Factor 'Geographical location' is MORE important and the degree for it is 'Strongly more important'. Your rating is positive integer from 1 to 9.)

Main factors	Specific factors	Your rating
Geographical location	Physical infrastructure	5

(When you think Specific Factor 'Physical infrastructure' is MORE important and the degree for it is 'Strongly more important'. Your rating is fraction with deminator from 1 to 9.)

Main factors	Specific factors	Your rating
Geographical location	Physical infrastructure	1/5

Main factors	Specific factors	Your rating
Geographical location	Physical infrastructure	
	Logistic chain and connectivity to the hinterlands	
	Technical infrastructure	
	Port management & administration	
	Carriers' terminal cost	
	Financial performance	
Physical infrastructure	Logistic chain and connectivity to the hinterlands	
	Technical infrastructure	
	Port management & administration	
	Carriers' terminal cost	
	Financial performance	
Logistic chain and connectivity to the hinterlands	Technical infrastructure	
	Port management & administration	
	Carriers' terminal cost	
	Financial performance	
Technical infrastructure	Port management & administration	
	Carriers' terminal cost	
	Financial performance	
Port management & administration	Carriers' terminal cost	
	Financial performance	
Carriers' terminal cost	Financial performance	

Then, we are going to use *pairwise* comparisons amongst four ports: Rotterdam, Hamburg, Bremen and Antwerp based on your above rating. The judgment is the same as the previous approach. For example, if you think Hamburg is more important than Rotterdam and the extent is 'Strongly more important', then you write down 5 in the blue blank; if you think Bremen is less important than Rotterdam, then write down 1/5 if you think it is of the same extent of importance as the comparisons between Hamburg and Rotterdam. (You only need to fill in the blue blanks in all tables below.)

Example:

	Rotterdam	Hamburg	Bremenhaven
Rotterdam	1	5	1/5

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i) Port geographical location

	Rotterdam	Hamburg	Bremenhaven	Antwerp
Rotterdam	1			
Hamburg		1		
Bremerhaven			1	

Antwerp				1

ii) Port physical infrastructure

	Rotterdam	Hamburg	Bremenhaven	Antwerp
Rotterdam	1			
Hamburg		1		
Bremerhaven			1	
Antwerp				1

iii) Port logistic chain and connectivity with the hinterlands

	Rotterdam	Hamburg	Bremenhaven	Antwerp
Rotterdam	1			
Hamburg		1		
Bremerhaven			1	
Antwerp				1

iv) Port technical infrastructure

	Rotterdam	Hamburg	Bremenhaven	Antwerp
Rotterdam	1			
Hamburg		1		
Bremerhaven			1	
Antwerp				1

v) Port management & administration

	Rotterdam	Hamburg	Bremenhaven	Antwerp
Rotterdam	1			
Hamburg		1		
Bremerhaven			1	
Antwerp				1

vi) Carriers' terminal cost

	Rotterdam	Hamburg	Bremenhaven	Antwerp
Rotterdam	1			
Hamburg		1		
Bremerhaven			1	
Antwerp				1

vii) Financial performance

	Rotterdam	Hamburg	Bremenhaven	Antwerp
Rotterdam	1			
Hamburg		1		
Bremerhaven			1	
Antwerp				1

6. Any other factors that you think are also important when measuring port competition under the context of global logistics nowadays?

_____

_____

_____

7. Do you have any other opinions or ideas on the future sustainable development of port? If so, please state it briefly.

_____
_____
_____
_____

Thank you so much for your feedback and kind cooperation!