The role of port infrastructure for economic development with an application to Belgium and the Port of Antwerp

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List of Abbreviations

ADF	Augmented Dickey-Fuller
AHP	Analytical Hierarchy Process
ANP	Analytic Network Process
CBA	Cost Benefit Analysis
CGE	Computable General Equilibrium
DF	Dickey-Fuller
DOLS	Dynamic Ordinary Least Square
ECM	Error Correction Model
FANP	Fuzzy Analytic Network Process
FDI	Foreign direct investment
FMOLS	Fully Modified Ordinary Least Square
FUR	Functional Urban Regions
GCTS	Global Container Transport System
GDP	Gross Domestic Product
GNP	Gross National Product
HO	Heckscher-Ohlin
IMF	International Monetary Fund
JIT	Just-In-Time
MID	Modern Industrial Dynamic
MRP	Material Requirements Planning
OECD	Organisation for Economic Co-operation and Development
OLS	Ordinary Least Square
PP	Phillips-Perron
R&D	Research and development
SAM	Social Accounting Matrix
SC	Supply Chain
SCBA	Social Cost-Benefit Analysis
SCM	supply chain management
ULCS	Ultra Large Container Ships
VAR	Vector Auto-Regression
VMI	vendor managed inventory

1. CHAPTER ONE: INTRODUCTION

1.1 Setting and Outline of the Research

Major international gateway and corridor infrastructures such as ports, airports and key road and rail routes are components of strategic transport infrastructure. Alongside other competitive criteria, such as educational system, communication sector, taxation and regulation, the strategic transport infrastructure is a pre-requisite for an economy's success and a major factor in determining national and regional competitiveness.

The relationship between business location decision and performance of strategic transport infrastructure is a main determinant of economic and port competitiveness. Port development as a component of local, regional, national and global economy is dependent on industrial evolution and related policies. Economic performance indicators for ports could serve to measure the effectiveness of these policies.

An enhancement in infrastructure can make a significant difference to the costs of trading. Furthermore, one of the important issues for the future development of the global economy is where economic activities will locate. Further issue in this respect is the role of the strategic transport infrastructures as an important supply chain element in the regional economic development. This research argues that efficient and effective transport infrastructure in the modern time plays an important and vital role in the related economic development.

Section 1.2 outlines the background to the research. Sections 1.3, 1.4 and 1.5 specify the new concepts in shipping port logistics studies. The rationale for the research is highlighted in section 1.6. Methodological approaches are explained in section 1.7 together with data collection techniques. The chapter concludes with the research design and structure in section 1.8.

1.2 Background: Economic geographic shift / business relocation

In contemporary thinking, there is a view that in developed economies, port developments could act as a threat to job creation and economic development because of the role such port developments can play in enabling outsourcing and the relocation of major national industries to emerging economies.

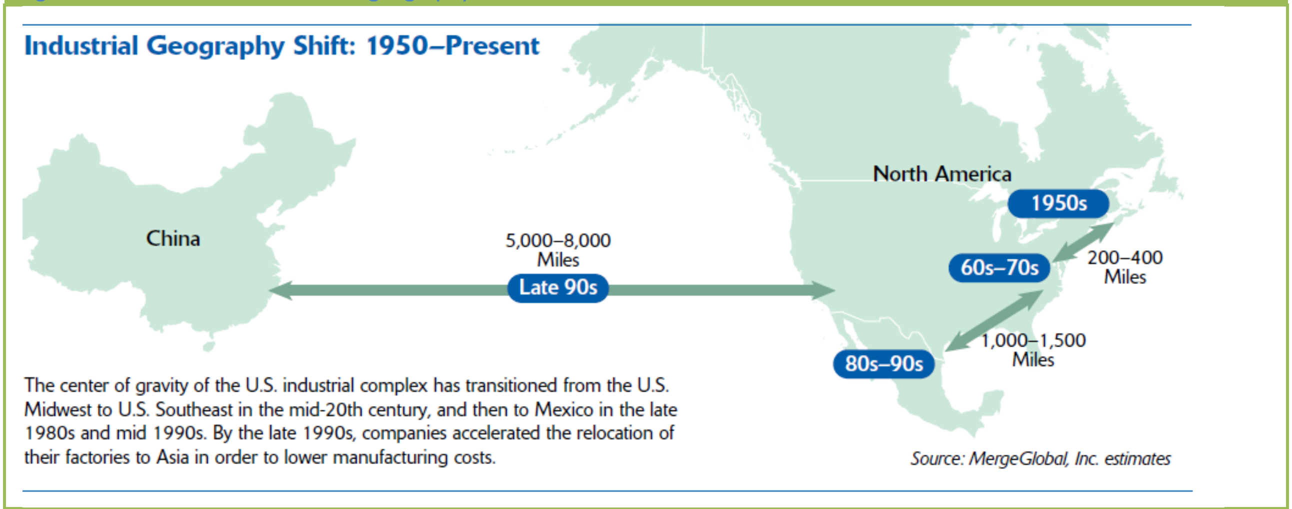
There are elements of truth in this argument (Scott, 2015; Kletzer, 2005; Allias, 1999; Frankel and Romer, 1999; World Bank 1993).

However, this study proposes that there could be a counter argument which port developments provide opportunities for national and regional economic development. This study argues that firms would split their main three activities (financial, manufacturing and commercial) to different locations and if a particular port acquires a competitive advantage as a commercial location by further developments, the domestic as well as the foreign firms will relocate to this particular port because of commercial competitiveness.

Several changes have occurred in container transport and its role in the supply chain in recent years. These include a shift in the forces driving demand, speed of delivery and a reduction in the level of operational defects. Arguably, these developments are associated with the processes of economic and industrial globalization which are creating a new global business environment. At the macroeconomic level, globalization has resulted in a new economic geography and the formation of new global economic hierarchies. There has been an ascendance of Asian economies, such as China and India as main industrial and economic centres, and a corresponding decline in the industrial strength of Northern-American and European economies. At microeconomic level, increased competitive pressures have led to an increase in outsourcing. This outsourcing strategy is pursued by businesses seeking to become more productive by successful exploration of the competitive and regional advantages of the firms in their network of suppliers and distributors.

Global competition puts pressure on firms to outsource for which the establishment of global supply chains is a necessary condition. In this context, managers are faced with making complicated decisions relating to the disaggregation of their firms' functional activities and identification of optimum locations for each predefined business function which intensifies the international division of labour as a modern market phenomenon. Additionally, ownership of firms is becoming more global and ownership strategies are also becoming more diverse and complex, ranging from wholly-owned units via FDI to outsourcing, subcontracting and joint ventures as options. A key characteristic of this phenomenon is the significant increase in the distance covered by global supply chains since the late 1980's, with a continued trend. This has increased by 5 to 10 times in length and may average anywhere between 5,000-8,000 miles (Merge Global, 2006). Figure 1.1 traces the industrial and economic geography shift between North America and Asia since the 1950's.

Figure 1-1. Industrial and economic geography shift between North America and Asia



Merge Global, (2006)

"Longer distance within supply chain means larger unit transport costs, larger in-transit inventory levels and associated inventory carrying costs" (Merge Global, 2006). To succeed in this global business environment in which production is separated by thousands of miles from consumer markets, firms' global supply chain strategies not only aim at reducing manufacturing costs, but also at achieving a smooth commodity flow at minimum cost (Marcus, 2010). Thus transport productivity has become more important and strategic than ever in the contemporary complex global economy as it connects players in the supply chain and enables the flow of goods between raw material suppliers, manufacturers and customers. For example, late delivery may paralyze entire production processes which can be rated as bad as early arrival resulting in higher inventory costs. Thus, the strategic decision to choose the suitable mode, carrier and trading network is crucial in order to guarantee minimum defects in supply chain management.

It is argued that the combination of characteristics highlighted above drives competition and has created a global business environment which is spatial and has dynamic links. The characteristics are as follows: (a) business functional activities are split between geographic locations, (b) outsourcing increases, and (c) global supply chains cover significantly longer distances, thereby making transport becoming a strategic decision variable.

For better understanding of this phenomenon, there is a need for this research to introduce a few concepts; these are “Modern Industrial Dynamic MID, “Global Container Transport System” GCTS and “Commercial Cluster”. These concepts will now be discussed.

1.3 Modern Industrial Dynamics (MID)

In one aspect, this study focuses on changes in the global industrial and business environment as drivers of changes in firms’ strategies, especially their supply chain and transport strategies and the implications for government transport policies. This is achieved by the introduction of the concept of “Modern Industrial Dynamics” (MID) environment.

MID highlights the relationship between globalization processes, changing geography of the world economy, the evolving firm’s strategies, and the implications of these for container transport and for government transport policy.

The MID attempts to capture the importance of dynamism, competition, and the role of transport operations in firms’ strategies. Underpinning the concept of MID is the idea of strategic fit which stems from the seminal works of Chandler (1962) and Andrews (1971) and refers to the alignment between a business’ resources and capabilities and the external environment. It means that all stages of strategic decision making from the level of corporate strategy down to the level of supply chain strategy and further down to the operational level where transport decisions are made should be aligned.

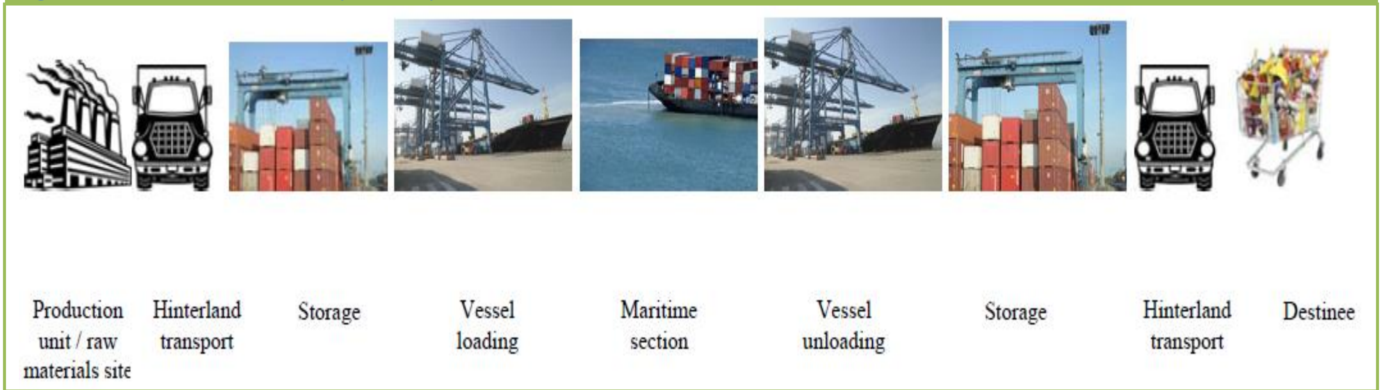
The author of this research argues that firms’ decision making on all different strategic levels should be aligned to the elements of the MID. By aligning all levels of decision making to the MID a firm will benefit from transport decision making that will add value to the product and achieve the competitive advantage in the global market. The evidence for this argument will be provided in chapter four, section 4.2.

A crucial consequence of the MID environment for transport is the full integration of container transport into the supply chain and global manufacturing process, which is comprised of outsourcing, assembling and distribution. This phenomenon helps achieve effective and efficient materials management. This bilateral relationship allows container transport to play an increasingly important role in the development of industrialization in global economies (further discussion on this also will be provided in chapter four, section 4.2).

1.4 Global Container Transport System (GCTS)

Within the proposed framework, attention now turns to arguing how GCTS contributes to materials management within supply chains and adds value to products. The supply chain strategies have affected the freight transport operations significantly. The role of transport in supply chains has changed from being a service provider to becoming more strategic in nature (Darling and Wise, 2010). The GCTS is a combination of multimodal, intermodal and transhipment operations, providing a systematic integration of ports, shipping, road, rail and barge transports. At the operational level the GCTS is a complex and extensive system which consists of different transport components as modes and nodes. The modes are "road, rail, and barge transport at origin and destination (land transport)" and "liner and feeder shipping", whereas the nodes are "sea port, dry port, warehouse, etc.". These components are interacting within an industrial process in a sequential phases, positioned somewhere in between the manufacturer and the end-consumer, distribution centre or retailer. The system under consideration is illustrated in Figure 1.2 below.

Figure 1-2 Global container transport components



Source: Van De Voorde and Vanelslander, 2009

The multiple system – GCTS - starts with manufacturing, land transport at origin, port handling at origin, maritime shipping, port handling at destination and finally land transport at destination. Using the container as a transport unit in this system provides heterogeneous transport systems, enabling efficient interaction between different modes of transport, particularly maritime and land. On the other hand, there are major dissimilarities among trading regions due to geographical and infrastructural factors. Nevertheless, the GCTS links these infrastructures and forms semi-homogenous global transport infrastructures.

1.5 Evolution of port to commercial location and commercial cluster formation

This section focuses on the role of the business functions[1] clusters in providing a competitive advantage to firms and extends the theory of clusters to explain the role of commercial clusters in regional economic development. Furthermore, this section explicitly incorporates the role of government policies in facilitating the formation of clusters and the concentration of business activities in a particular geographic location.

Changes in the relative importance of different ports since the early 1990s can be ascribed to the MID environment and the process of commercial cluster formation. For example, the port of Rotterdam, which was ranked the world's largest port in 2000, has been surpassed by Shanghai and Singapore, and almost all of the world's major ports are now in Asia Pacific. Also, the top 20 container ports account for 56% and 72% in 2005 and 2011 respectively of the global container traffic (Containerization International, 2012).

The changes highlight geographical shifts and the associations between ports in industrial regions (e.g. Far East: China, with Shanghai and Hong Kong), and ports in consumption regions (e.g. North

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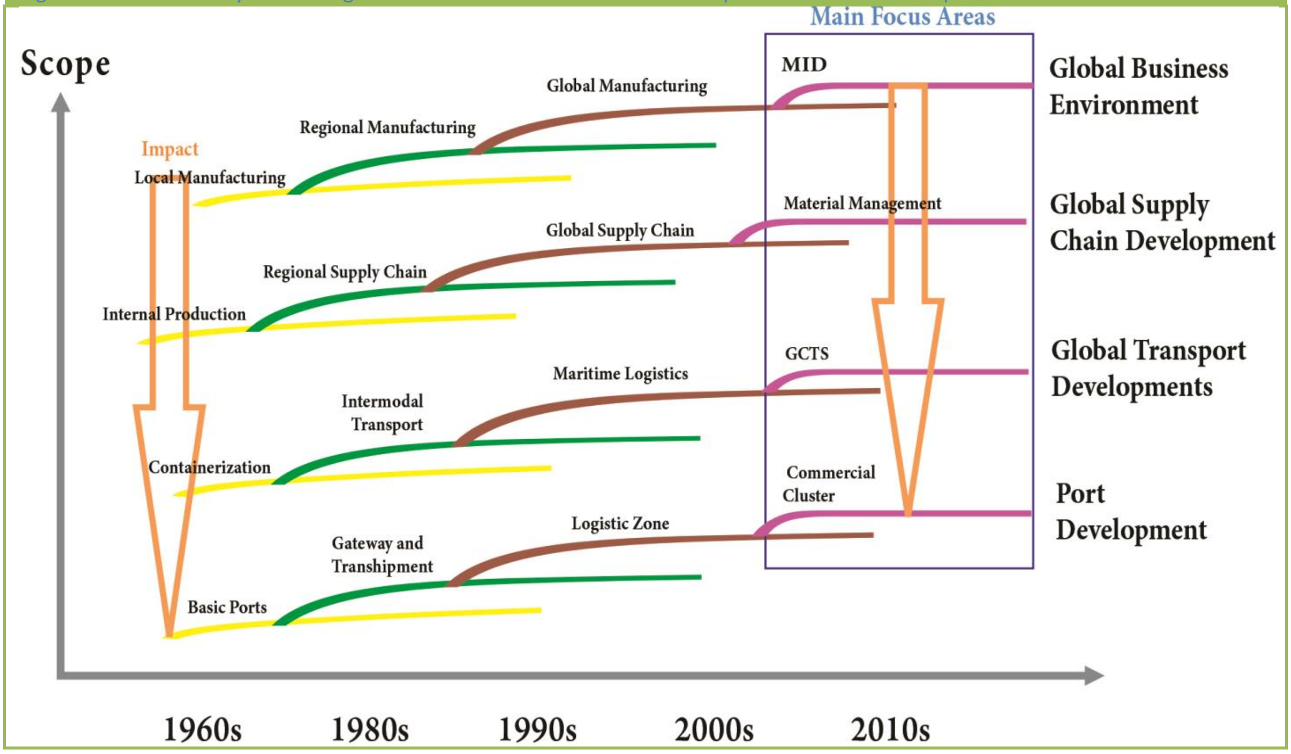
[1] It is discussed in this thesis that every business has three main functions; namely financial, manufacturing and commercial function. The financial function focuses on sources of funds, the manufacturing function on production and the commercial function on supply chain and distribution at a global level. Further discussion will be provided in chapter four, section 4.2.

America: Los Angeles; Europe: Rotterdam and Antwerp; Middle East: Dubai) and intermediary hubs (e.g. Singapore and Dubai).

Spatial economic geography, MID and global supply chain strategies have a profound effect on port functions. Since GCTS has introduced new global end-to-end services and pendulum services especially on the main east–west trade routes, there is a need for ports to reshape their function, operations and environment to become commercial locations which are a prime candidate for commercial clusters. This proposed restructuring needs to take place along three main dimensions, namely technical and operational characteristics, accessibility and commercial requirements. The formation of commercial clusters will in turn have cluster effects which have implications on a port's competitive position and hinterland expansion.

The proposed commercial cluster specifies that the port developments and competition in modern time is not only depending on port investment and hinterland connection but also on the commercial cluster (network) effects. To understand the globalization influences on port competition Figure 1.3 which constructed by the author for illustrative purposes shows the evolutionary trends in global business environment and its impact on Supply Chain Management and transport.

Figure 1-3 Evolutionary trends in global business environment and its impact on SCM and transport



The diagram traces evolutionary trends in global business environment and the operating and functional characteristics of ports, transport and supply chains from the 1960s to present day. It specifies four interconnected developments, namely, global business developments, global supply chain developments, global transport developments and port developments. The diagram illustrates the development in global business has impacts by triggering further developments on other sectors. In the current global business environment, the MID environment is shaped by increasing globalization, advances in technology, the combination of increasing product ranges and more demanding customer expectations. Global competitive pressures make the establishment of global supply chains by firms a necessary part of firms' operations. Transport productivity has become more important and strategic than ever as it connects players in the supply chain. Furthermore, there is a tendency towards a higher level of integration between global transport and commercial systems by the development of intermodal and multimodal systems together with liberal trade and transport policies that provide opportunities for a clustering of shipping, logistics and commercial activities around ports[1]. This emerging phenomenon emphasizes the prospective role of port in the regional economic development in the future. It necessitates more in-depth investigation in this area to improve and develop a port's function to cope with the modern global business environment requirements.

1.6 Rationale for study

The introduction of MID, GCTS, and commercial cluster identified a lacuna in the shipping, port, and logistics literature in which the nature of the relationship between the modern industrial and business environment and container transport is underexplored.

Global trade and the relevant data reveal the significance of Belgium's role in the global trade and new economic geography formation[2]. The significant role of Belgium despite its small extent in terms of geographical surface and population brought the question why a small country plays an important

[2] Based on literature review and studied statistics (e.g. World Shipping Council, 2016; WTO, 2015; KOF, 2015; Schwab, 2013; Ey, 2013).

role in the current global business and trade? Why do businesses locate in Belgium? Why does Belgium play a significant role in the global trade? These questions are narrowed down to the objectives (central questions) of this research to be answered.

These issues pose a challenging research agenda for transport and more specifically port economics as a main strategic transport infrastructure. In this respect the central question is:

How can ports contribute to the Belgian economic development??

Within this framework, the objectives of this research are:

- Quantifying the effect of transport infrastructure investment – focusing on ports - on national economic growth by estimation of a traditional aggregate growth model (quantitative analysis provided in chapter three).
- Evaluating whether container port development promotes regional developments by formation of a network of commercial players (Commercial cluster), (qualitative analysis in chapter four).
- Assessing and ranking the factors which increase port attraction for businesses (port users), with a view to inform government and business planning for developing infrastructure. This is achieved by using multi-criteria decision making models (quantitative analysis provided in chapter five).

Inadequate transport infrastructure increases costs for firms and subsequently reduces a nation's attractiveness for new investments. SMI (2012) suggests that "*transport infrastructure quality has a notable effect on cost levels: improvements in transport infrastructure can directly reduce operating costs in a number of different industries, ..., researchers have found that an improvement in infrastructure will decrease costs by 11 to 21%, depending on the industry under review*".

1.7 Methodologies

This section describes the methodologies and techniques relevant to the empirical analysis undertaken in this thesis to analyse the proposed framework. This thesis consists of two main analytical chapters (3 and 5), each chapter using a different methodology.

In chapter three, a growth model is used to estimate the interaction between Belgian GDP, the length of highways per capita, gross fixed capital formation, port infrastructure investment by government to total investment ratio, the openness ratio of the economy, and the ratio of relative transport sector deflator.

Chapter four addresses an existing gap in the literature by relating a mechanism that specifies the relationship between government transport policy, the MID environment, supply chain management and container transport functions and operations to decision factors priority models.

Following chapter three's results which quantified the impact of transport infrastructure on the Belgian economy and discussed the role of port development in the economy, chapter five specifies the main determinants of port selection by global supply chain players. Analytical Hierarchy Process (AHP) and Analytic Network Process (ANP) methods used in this chapter are important methods in the multi-criteria decision making approach in container shipping network decisions. A dual modelling approach in this chapter allows comparing and contrasting the results.

Further discussion on why these methodologies have been selected for this study is provided in chapters three and five.

1.8 Structure of the Thesis

To answer the central research question, an investigation is proposed in the following structure.

To explore whether the existing literature provides a suitable framework for this investigation, chapter two presents a comprehensive review of previous studies which model and analyse the container shipping and port investment. Furthermore, studies which focus on supply chain and logistics operations and concepts are also reviewed. The objective of reviewing this combination of literature is to present a general overview of past research, which has addressed relevant aspects of this thesis, and supports the research theme in this thesis.

Belgium is a small country with high degree of economic openness and a great dependency on transport infrastructure. Therefore, an investigation of transport sector contribution to regional economic development seems a crucial research area for Belgium. In this respect, chapter three quantifies the impact of transport infrastructure investment – focusing on ports - on economic growth of Belgium using a growth model.

To establish how port infrastructure and related services play a crucial role in the global supply chain, chapter four provides further discussion of how to make strategic transport infrastructure more efficient and effective. In this regard, the concept of “Modern Industrial Dynamics” as a contemporary trade, transport and business issue, is discussed. Moreover, statistical evidence on trade and transport developments together with a discussion regarding the formation and concept of a “Global Container Transport System”, and “Commercial cluster” are provided. This chapter discusses that evolution of a port to a commercial cluster raises the value added of supply chain and improves domestic employment and GDP.

Following chapter three’s analyses of the impact of port infrastructure on the regional economy and chapter four’s discussion on modern global business environment, port policymakers must continuously make an effort to understand what factors influence port users’ choice of port. Services provided by strategic transport infrastructure are, to a varying degree, subject to supply chain design and configuration and also require government regulation. However, MID over the past decade or so has changed the competitive environment of these services. Making infrastructural services more efficient involves government policy measures and possible regulatory reforms. Chapter five therefore identifies and ranks which factors assist to form a commercial cluster in and around a port. It does so for three alternative ports - Antwerp, Rotterdam, Hamburg - and three types of decision-makers - shippers, carriers, and freight forwarders, using the AHP and ANP methodologies.

Finally, chapter six presents a summary and conclusions to the thesis.

Table 1-1 Structure of thesis

Chapters	Questions	Aim	Methodology
2. Literature review		To explore whether the existing literature provides a suitable framework for this investigation	
3. Transport contribution to the economic development, case study of Belgium	What are the effects of transport infrastructure on national economic development?	To quantify the impact of transport infrastructure investment in Belgian economy	Aggregate production function
4.Characteristics and mechanism of the modern transport market environment	What is the role of port in national economy?	To explain the interaction of port function in global production process and the consequence for national economy.	
5.Port selection determinants and regional economic developments	What are the port requirements to respond to the modern global production process?	Identify and rank port selection criteria and rank the alternative ports from users' point of view.	AHP and ANP
6.Conclusion		To conclude and provide suggestions for future studies and policy implications.	

2. CHAPTER TWO: LITERATURE REVIEW

This chapter offers a critical and evaluative review of the related literature which is discussed in section 2.1 to identify how researchers have tackled similar problems and what they have learned. This chapter identifies the key factors, concepts and variables and the presumed relationship among them in order to provide a solid basis for answering the research questions.

2.1 Scope of the chapter

Chapter one indicated the emergence of a new economic geography as an important development in global economics with significant implications for the design and formation of the supply chain's infrastructural elements. The aim of this chapter is to review the literature, which will be utilized to understand the connection between transport infrastructure as an element of supply chain and its impact on regional and national economic development. In the light of this, it is necessary to draw insights from theoretical and empirical works which have modelled firms' outsourcing strategies, global relocation and new economic geography, the contemporary business environment, global supply chain design, and transport and port infrastructural developments and selection criteria. This multidisciplinary literature review allows identifying gaps in the literature and facilitating the development of an appropriate conceptual framework to address the market mechanism. Although these different literature streams (outsourcing, relocation, etc.) have various theoretical backgrounds and methodologies, in wider aspects they are explaining the same phenomenon from a different viewpoint. Therefore, this chapter is divided into three main sections.

Section 2.2 considers the formation of industrial clusters, which is the defining feature of the new economic geography and the result of firms′ outsourcing strategy. This section surveys the body of works regarding global relocation and new economic geography and concentration of economic activities (cluster formation). The pioneering works of Krugman (1998) and Porter (2000) are broadly considered as the initial academic works which introduced the concept of 'cluster formation in new economic geography'. These two studies generated a new wave of theorizing and empirical studies in these fields. This section reviews post-Krugman and -Porter studies to draw insights from modern developments in the field. This research defines a commercial cluster based on these studies.

Section 2.3 reviews the literature on supply chains with specific attention to the function and design of supply chains. This section looks at studies which have dealt with global supply chain design as a strategic response to the ‘new economic geography’. The literature in this discipline could be traced back to the seminal work by Moneta (1959), who estimated the costs of shipping goods as a proportion of the total cost of international trade. The twentieth century perceives a substantial expansion of supply chains into global locations, particularly in the automobile, computer, and apparel industries (Dornier *et al*., 1998; Taylor, 1997). This section considers supply chains not only in terms of their functions but also in terms of the way they are configured and by different players to achieve specific distribution objectives for existing and new product lines globally.

Section 2.4 surveys the literature on the transport infrastructure and its pricing, port selection criteria, port development and its relation to economic development. More specifically, this section reviews the studies concerning with transport infrastructure developments as an element of the supply chain, transport infrastructural pricing policy and their impacts on regional economics. This section also includes the works that have been done on how these factors determine regional economic activities and port selection criteria. For example, the impact of transport infrastructure on market access, economic concentration and comparative advantage has been studied by Davis and Weinstein (1998). Benefits of investment in transport have also been investigated by Lakshmanan (2007).

2.2 Industrial clusters and the New Economic Geography

Due to the significant increase in the covered distance by global supply chains, transport infrastructure investment and performance has turned into an important element of global production processes and industrial dynamics. The New Economic Geography theory helps explain this phenomenon. Consequently, this section surveys previous studies regarding firms’ decision to outsource and their location strategies as drivers of the industrial cluster formation, a phenomenon observed as a feature of the new economic geography and Modern Industrial Dynamic (MID) with which this thesis is concerned. These are the main streams which form the modern global production process and consequently determine the role of port and transport as the main components of this process.

2.2.1 Motivation of outsourcing

Most literature in the strategic outsourcing decision focused on the question whether to outsource or not, while researches on operational planning and control perspective address questions of the quantities to be ordered at the contract manufacturer or the planning implications of outsourcing. An extensive literature review is conducted by Kremic *et al*., (2006) which is used as a research foundation in this section. The main aim of this section is to provide insights on the implications of outsourcing on the operational planning, and how the global economy is made complex due to the outsourcing strategic decision.

Riker and Brainard, (1997) and OECD, (2005) specified that a firm’s decision on what and where to outsource is based on their individual decisions on which resources and capabilities are best to build internally and which to procure. Outsourcing will result in a company ceasing to perform an activity in-house and substituting it with a market transaction. Alternatively, the company may never engage in a particular activity and therefore stop doing it even though it is within the company’s ability to carry out the task in-house. By outsourcing, organizations reduce costs and specialize in core areas by entering a contractual agreement with logistic providers. The parties will exchange goods and services for payment (Windrum, *et al*, 2009).

The reasons for outsourcing need to be analysed in the view of a firm’s competitiveness. Cachon and Harker (2002) argue that the lower cost company has a higher market share therefore is more competitive. They further argue that firms favour outsourcing even if outsourcing provides no direct cost advantage in the short term: it will assist the competitive position in the long-term. Contradicting to this view, Tsai and Lai (2007) and Harrison and Van Mieghem (1999) studied the strategic outsourcing when a company faces a capacity expansion decision of whether to expand the own production capacity or to outsource. They conclude that the values of outsourcing option increase as markets are more volatile.

2.2.2 The New Economic Geography and cluster formation

Firms' outsourcing decisions have led to a highly dynamic business environment and a new economic geography - characterized by business function clusters which influenced competition at global level. In order to find a relationship between business environment and competitive strategy, Miller (1988) investigated undiversified firms. He found that strategies must be matched with environments to promote success. The seminal work of Skinner (1969) provides the basis for many conceptual and empirical studies on manufacturing strategy and describes the linkages among environment, competitive strategy, and manufacturing strategy to achieve business performance. In most studies, operations and manufacturing strategies refer to the dimensions of cost, quality, delivery and flexibility. Ward, *et al.* (1995) achieved similar findings in their study comprising business environment, operations strategy and performance using a sample of Singaporean manufacturers and found additionally positive links between environmental dynamism and quality as well as delivery capabilities among high performing firms. By using a sample of United Arab Emirate manufacturers, Badri, *et al.* (2000) studied the effects of environment on the choice of operations strategy and performance. Environmental dynamism was found to correlate significantly with the choice of operations strategies of delivery performance, quality and flexibility and with the emphasis on responsiveness to customers.

By applying Fisher's (1997) typology of supply chains, Chi, *et al.* (2009) researched the relationship between business environment characteristics, competitive priorities, supply chain structures and firm business performance. They identified flexibility as firm's competitive priority and as a response to dynamic and complex environments. Environmental dynamism prompted firms to implement a responsive supply chain strategy which is consistent with Fisher's statement.

Indeed, this section indicated a paradox in the relationship between cluster formation and global competition in the era of "new economic geography". Firstly, changes in technology have reduced the conventional roles of location-related competition. Secondly, clusters and network economy are important factors in determining the competitiveness of national, regional, and even metropolitan economies, particularly in developed economies. This section is in the line with the importance of port performance as an economic growth resource.

2.2.3 Industrial clusters and inward foreign investment

This section specifies that formation and development of cluster can be enhanced by FDI inflow, furthermore, this section highlights that the FDI movement is a firm's strategic decision. The significance of presence and positive effects of global companies in clusters enhancement was identified by many researchers such as Dunning (2000b, 2000a, 1996, 1994), Young, (1994), Enright (2000), Birkinshaw (2000), De Propris and Driffield (2006) and Phelps (2008). And most of them certified Porter (1990) for "*focusing solely on the home-base of a nation in determining competitive advantage and ascribing a limited and ambiguous role to inward FDI*" (Phelps, 2008)[2].

Contemporary research has specifically emphasized the importance of FDI and the presence of a global company for cluster performance. Mariotti, *et al*. (2008) and Oliver, *et al.* (2008) have shown that the presence of FDI can enhance the degree of globalization of local firms, and lead to cluster advancement by connecting clusters in different regions. Moreover, Padilla-Pe´rez (2008) empirical study indicates that cluster dynamics will increase particularly through the transfer of technology. He further concludes that technology transfer from FDI can affect regional economic activities, but it is not occurring automatically: certain regional characteristics should be considered, such as high local capabilities, universities engaging in industry-related research and specialized labour. In addition, the level of benefit of domestic firms from FDI and presence of global firms often needs specific conditions. De Propris and Driffield (2006) suggest that such gains for domestic firms are found to occur when a cluster already exists. An additional suggestion on requirements of an existing local specialization to be in place in order to attract FDI and global firms to the region is established by Mariotti, *et al.*, (2008). They specify that the presence of FDI and global companies will improve the globalization process of local firms when these local firms in a district have already started the globalization process. They further argued that the characteristics of the global firms such as export-orientation of the firm, the employment of skilled workers, the development of an R&D facility, the responsibility for leading products, and marketing and sales functions as well as the ownership of valuable competencies and the assignment of strong mandates are also important in determining their contribution to a local cluster.

Furthermore, Phelps (2008) and De Propris and Driffield's (2006) empirical results showed that even though there can be adverse competition effects due to global firms' presence in clusters, this is compensated by the spillover gains from global to local firms (e.g. *"the external economies produced in FDI-dominated clusters, such as a specialized labour market and knowledge flows shared predominantly among the foreign investors themselves as such clusters inherently lack a strong indigenous base"* Phelps (2008).

2.3 Global supply chain design and formation

Firms' global outsourcing strategy aims at gaining a competitive advantage. In this context, firms may relocate their sourcing and production facilities to countries with low labour cost to benefit from cost savings. Therefore, the management of this supply chain becomes more complex and global distribution of the products more challenging.

The recent business trends mentioned above raised performance expectations of supply chain networks, delivering more value in new ways, being faster to markets, and becoming more flexible to respond to customer demand changes.

Strategic decisions must be matched with a firm's business environment to promote success. As transportation mode selection has become more strategic in nature, it must be aligned to the surrounding industry dynamics. The purpose of this dissertation is to examine the relationship between industry dynamism and transportation mode and port selection. As transportation is a function of supply chain, the need was identified for a more integrated perspective of how transportation decisions should be aligned with a firm's supply chain strategy, business strategy and business environment. This section deals with the way this alignment should be done.

In 1980s, the main manufacturers' strategy was in-house mass production in order to benefit from economies of scale, with minimum product or process flexibility. Material Requirements Planning

(MRP) was developed in the 1990s, when manufacturers understood the significant effect of inventory level on manufacturing cost, product development, customer relationship, and delivery lead-time. The beginning of the 2000s witnessed strong global competition based on low-cost, high-quality, and reliable products with greater design flexibility. Manufacturers' concerns become Just-In-Time (JIT) and other management programs to improve materials management and cycle time. The Supply Chain Management (SCM) further evolves by conducting best practices to select strategic suppliers and logistics performance to improve efficiency and effectiveness (Jain, *et al.*, 2010).

Mentzer, *et al.* (2001) state that the major purpose of SC design is to provide a strategic capability to construct and improve sustainable competitive advantage by cost reduction while improving the service level. The advantage and importance of SC is influencing the expertise, experience, skills and capabilities of the supply chain participants. Furthermore, Fawcett, *et al.* (2008) suggest that the important issues in this respect are the ability to identify the business environmental forces that drive the SC and the barriers. They also suggested proving solutions that facilitate the supply chain is an important issue to preserve competitive advantage. Moreover, they reviewed main benefits of SCM proposed in literature and suggest the following in terms of benefits "*increased inventory turnover, increased revenues, SCM cost reduction, product availability, decreased order cycle time, responsiveness, economic value added, capital utilization, decreased time to market and reducing logistics costs*". Verma, *et al*. (2006) and Heng, *et al*. (2005) emphasize that the perfect planning in SCM regarding material management, production schedule and distribution not only reduces the inventory and inventory cost but also reduces the wasted time and energy and consequently total costs.

2.3.1 Ongoing and emerging issues in global supply chain design

Swafford, *et al*. (2008) investigate the relationship among IT integration, SC flexibility, SC agility and business performance through a US case-based study. Their study reveals the 'domino effect' among the mentioned items. In a comprehensive review of literature, Meixell and Gargeya (2005) specified the emerging trends in the historical perception of global supply chains, such as outsourcing, vendor managed inventory (VMI), integration across tiers, internal and external integration, and the need of various performance measurement criteria. In this line of research, Vonderembse, *et al*. (2006) highlighted the need for matching between product life cycle and types of supply chains, including agility and lean supply chain classifications. Using help of three case studies - Black & Decker, IBM and Daimler Chrysler - they described the lean and agile supply chain. These collections of research clearly reveal the main trends and the significance of the IT integration, flexibility, agility and lean concepts for today's supply chain management.

Puigjaner and Lainez (2008) emphasize the significance of capturing supply chain dynamics at various decision making levels and they are clearly indications of the need for further modelling in supply chain dynamics.

2.3.2 Transport infrastructure and supply chain performance

The strategic decision to choose the suitable mode and carrier is critical in order to guarantee seamless supply chain operations. Just-in time practices have become a common practice in many industries where time-definite shipments are vital for a firm's overall commercial success and long-term viability. For example, late delivery may paralyze entire production processes which can be rated as bad as early arrival resulting in higher inventory costs. It will be those firms with seamless supply chains in place that will have the speed and flexibility to fulfil the needs of tomorrow's customers (Data2logistics, 2010). Synchromodality is also a concept which got introduced recently and "encompasses an integrated view of planning and use of different transport modes to provide flexibility in handling transport demand" (Behdani, *et al*, 2016). Synchromodality includes the combination of vertical as well as horizontal integration emphasising the later. Synchromodal services provide a coherent transport system, increase the utilization of transport services and help using all transport modes optimally, and also further integrating the hinterland network (Zuidwijk and Veenstra, 2014). Therefore, the logistic service providers as well as policy makers need to take this new concept into account for further development and attractiveness of the regional logistics profile.

There exists a large research stream in transport mode and carrier selection; most studies examine shipper-carrier relationships (Lagoudis, *et al.*, 2002) in order to identify selection criteria shippers put emphasis on when shipping their products. Shift in geographical location increased the importance of supply chain efficiency for competition between firms.

Most supply chain performance research investigates the influence of supply chain strategies on performance (Sun *et al.,* 2009). Moreover, the existing research on alignment of environmental uncertainty and supply chain strategies does not discuss how logistics in particular transport decisions should be aligned to supply chain strategies in the light of environmental uncertainties. Regarding the points mentioned, the question comes up whether a firm's business environment and supply chain design influences a firm's emphasis on certain mode selection criteria. The choice of the right transport mode is '*a fundamental part of the distribution management*' (Slater, 1979) and needs to be carefully examined in order to find the right mode as the decision has a direct impact on a firm's efficiency. Inaccurate decisions can incur higher costs or result in lower service level. Decision making is not an easy but rather a complex task as there is a huge spectrum of choices available.

Tuzkaya and Onut (2008) applied the Fuzzy Analytic Network Process method in order to evaluate qualitative factors in the transportation mode selection between Turkey and Germany. McGinnis (1989) reviewed eleven empirical studies of freight transportation choice based on survey methods and found that non-cost related variables are important in mode choice. The factors he identified were reliability (dependable transit times, meets pick-up and delivery dates, on-time performance), transit time, and damage (frequency of cargo loss and damage, security, claims/freight loss experience), shipper market considerations (market competitiveness, external market influences, specific customer complaints, changing need of customers, user satisfaction, client deadline) and product characteristics (perishability, new product introduction, packaging requirements). However, the authors neither specified transportation decision factors nor did they include how transportation decisions should be integrated in supply chain strategies.

Meixell and Norbis (2008) conducted a broad review of transportation choice and identified a lack in supply chain integration concepts that include transportation choice. They found that transportation choice has only been integrated with lot sizing and supplier selection and with production schedules. Furthermore, they argue that mode and carrier selection has been modelled as parameters and not as decision variables which they identified as an area for future research. As it can be seen from the above mentioned literature, most studies are shipper-carrier related and intend to find attributes that determine mode choice. There seems to be a lack in the literature that questions the background of these attributes in regard to what drives firms to rank some criteria higher than others. Moreover, transportation mode attributes have not been researched regarding the capabilities of different transportation modes offered.

2.4 Transport infrastructure and economic development

As mentioned in the introduction chapter, this research focuses on the "contemporary literature", mainly from the last two or three decades. In other words, the primary works on economic development, growth models, development processes, industrialization, and fixed capital formation (e.g. Solow, 1994; Hirschman, 1985; Ackley, 1961; Domar, 1946; Harrod, 1939) are outside the scope of the literature review of this research.

Economic development can be influenced by transport infrastructure mainly through two channels. The first channel - direct effects - activates the transport sector contribution to GDP by granting easier access to the inputs and/or reduced cost of intermediate purchases. The second channel – indirect effects- works through additional input to other sectors. An advanced transport network provides faster, cheaper, and more reliable and flexible transport service which creates higher productivity in manufacturing and production. Furthermore, it contributes to the concentration of production which results in economies of scale and access to specialized inputs. It also has a strong complementarity with physical and human capital.

All aforementioned effects improve accessibility of firms to better resources, including labour markets, to support productive activities particularly in trade-oriented countries (Kawakami and Doi, 2004). Moreover, demand for goods and services increase (Roller and Waverman, 1996), and the total factor productivity rises, resulting in increased total productivity through facilitating just-in-time inventory management. However, there are spillover effects resulting in externalities (Lakshmanan, 2007).

Public investment - and transport infrastructure as an item of public capital - provides a one-off enhancement to the level of productivity, however, it is not a long-lasting source of increased income. Furthermore, due to sustainability, time scope and magnitude of transport infrastructure effect on economic growth are two main categories with incompatible results. The stock of public infrastructure capital is considered an important element of total factor productivity growth in this study. Recent studies relate more modest effects of infrastructure capital for developed countries (World Bank, 2011).

Kopp (2007) and Haughwout (1997) examined the contribution of transport infrastructure to equilibrium aggregate output while it is measured for only road transport. Transport infrastructure can also be evaluated in terms of social rates of return (Canning and Bennathan, 2007). Straub (2008) assesses the contribution of infrastructure to economic growth concentrating on new economic geography and public policy and urban economics and the role of cities. Johansson (2007) estimates the influence of infrastructure networks on spatial organization of an economy. McQuaid, *et al.* (2004) conclude in a report under business' location decision that transport is not the only element in business location decision.

There is no overall and general impact of transport system improvement on different economic development levels; its effects differ for developed and developing economies. There can be also an incompatibility between immediate benefits and sustainable growth (SIKA, 2004). Kilkenny (1998) argues that overall reductions in transport costs slow down the economic development of rural places. Lakshmanan (2007) has compared some results of estimations of economic benefits which are ensuing from transport infrastructure investments. He has concluded from these investigations that investment in infrastructure involves some externalities which traditional micro Cost-Benefit

Analysis studies ignore. He comments that less tangible effects, such as various risks which could contribute to partial or total project failure, loss of reputation or long-term enterprise strategy alignments, may be ignored by cost benefit analysis. Consequently, when governments use this technique to make a decision whether to build a new road or develop the infrastructure, they must assign these effects. Macro-economic models can identify the social return on investment in transport infrastructure.

From the results of previous studies, some agreements and some sharp disagreements concerning the transport infrastructure effects can be derived. The economic impact of transport infrastructure for seven countries (United States, Japan, United Kingdom, France, Germany, India and Mexico) is based mainly on the effect of public capital, highway capital and transportation infrastructure. The major agreement is the idea that transport infrastructure contributes to economic growth and productivity. This contribution is positive, modest and not constant over time. The compared studies have used various specifications of production and cost functions in different countries with different level of developments, over different time periods and same variables. Disagreements and conflicts in the results of these studies appeared in different measures of output or cost elasticity or rate of return of transport infrastructure. Differences and conflicts in results are not relative to methodological insufficiencies. These differences can be classified in three groups: “for the same country, at different periods of time”, “for different countries at the same stage of development”, and “for different countries at different stages of developments”. The author’s purpose is to show how investment in transport infrastructure develops markets and creates conditions, which influence economic structure and performance (Lakshmanan, 2007).

Another attempt to analyse the impact of transport investment on the economic situation is a comparative study by Hulten (2007), for three countries at different levels of development: the US, Spain and India. The author assesses the impact of highway investment on the growth of the manufacturing sector. The applied model starts from a macro-economic production function which considers two channels. The first channel (direct effects) operates as a facility to purchase input easier and reduces the cost of the intermediate purchases, which improves the quality or quantity of the infrastructure network. The second channel (indirect effects) shows the effect on manufacturing industries through the addition or extension of critical links, or removing the bottlenecks. It leads to developed product and input markets, a concentration of production at various points in the network that makes economies of scale, and access to specialized inputs. All of the mentioned changes may cause a relocation of production within the network area. Also, these effects tend to increase total productivity by making convenient conditions to improve some of the technologies (such as just-in-time inventory management). The expected conclusion is that transport investments depending on the development stage of the economy relocate the economic activities towards the lower-cost regions especially in built-up network countries, while it may improve productivity and enhance output in underdeveloped network system countries.

Kopp (2007) studies the effect of road investment on macroeconomic productivity. His survey indicates that there are some links between transport infrastructure and growth rates which are less direct than claimed usually by some public debates. The transport network may affect the urbanization and change the urban form and size. Also he has argued that there is a strong correlation between public capital and macro-economic productivity, however, transport infrastructure - as an item of public capital - is an endogenous variable. Transport infrastructure grows in response of increased aggregate income and consequently an increased demand for infrastructure services. Another derived result denotes a positive relationship between highway density and productivity growth in industries which are relatively vehicle-intensive in the US. It is argued that public investment provides a one-off boost to the level of productivity, but is not a perpetual route to increase income. This investigation analyses the effect of road investment on macroeconomic productivity in thirteen western European countries. As a conclusion, it is not justified that national road infrastructure investment levels should be increased. The rate of return is relatively low and it could be due to misallocation at the local level. On the other hand, demand for transport network is distributed unequally over time and space; consequently local road infrastructure investment projects can have high expected rates of returns.

Canning and Bennathan (2007) estimate the social rate of return of paved roads as a component of public capital, based on the assumption that paved roads are highly complementary with physical and human capital. To find the benefits of infrastructure, an aggregate production function is estimated for a panel of countries over the 40 years. The only independent variables included in the production function are physical capital and human capital. They find that infrastructure has a strong complement with physical and human capital, which shows the important role of infrastructure in the balanced growth process. In countries with acute shortages of infrastructure and where the costs of infrastructure construction are low- middle-income countries- the rate of return to infrastructure is highest. The rate of return to infrastructure is low in both underdeveloped and most developed countries, with even negative returns being present in Austria and Australia.

SIKA (2004) indicates that additional goal conflicts can exist between regional enlargement and transport policy, road safety, environmental and equality goals and between international transport network or good intra-regional access. But the certain effect is that increased accessibility in the transport system is distributed to other sectors, as a consequence of a more widely spread pattern of population, changed organization of private and public services and specialization in production.

There are some studies (such as Larsen and Butler, 2005) which have investigated externalities using Computable General Equilibrium (CGE) models such as the Social Accounting Matrix (SAM). They use SAM as a data source, mean value of wages and salaries as dependent variable, and other variables which were categorised[3] as independent variables. The geographical area of the research is Denmark, to examine the effect of transport system changes on economic activities and redistribution impacts on economic activity.

2.4.1 Impact of transport infrastructure and costs on relocation of economic activities and the New Economic Geography

Companies' economic performance is encouraged through the reduction in transport and production costs. Other activities such as reorganization and distribution concern labour and production costs.

Straub' (2008) economic geography model includes the relation between agglomeration and dispersion forces. Increasing returns (internal or external) in the industrial sector stimulate agglomeration forces. Internal increasing returns occur through backward linkages (demand linkages, which push firms to locate their activities in regions with bigger markets to be able to serve consumers avoiding trade costs) or forward linkages (cost linkages, which lower input prices leads firms again to crowded locations). External factors such as knowledge spill-over and labour market externalities, which provide more availability and high quality of training for workers, increase returns and, consequently, stimulate agglomeration. On the other hand, dispersion forces offset the agglomeration ones. Immobilization of land and some types of labour encourage dispersion and lead to ignoring distant markets. The author has mentioned the direct impact of an increase in the quantity of infrastructure and the indirect impact through better or more infrastructures on the productivity of other factors. The new economic geography framework is concerned with the link between infrastructure stocks and economic activity, spatial distribution of firms and assets. Other sectors such as water and electricity, which affect the cost of living, are included in the models.

The purpose of the study of Davis and Weinstein (1998) is to estimate the home market effect, and find evidence of the importance of increasing returns, in combination with comparative advantages.

They focus on the class of trade models which interact with increasing returns and trade costs in general equilibrium. The mentioned models are known as “economic geography”. The approach is used in the comparative advantage framework, and is based on simple Leontief input coefficients. The “square” Heckscher-Ohlin (HO) model of comparative advantage has been used here.

The results of the study emphasize the economic geography hypothesis of the existence of home market effects. Moreover, based on obtained results, increasing returns have important and measureable effects on the production structure from one-half to two-thirds of the OECD manufacturing output.

To study the influence of infrastructure networks on the spatial organization of an economy, and the influence of spatial organization on the growth of functional urban regions and the entire economy, is the purpose of Johansson’s study (2007). Accessibility indicators and physical attributes of transport networks are introduced to depict the spatial organization of functional urban regions (FUR) and urban areas inside a FUR. A model has been presented to show the interaction between an individual urban area's accessibility and labour supply and jobs. The results suggest that high accessibility household services in an area implies high accessibility to jobs, because household services are wielded by people who work in a place where the services are supplied. Also in a certain area with a high accessibility to jobs, a high accessibility to labour supply tendency will exist.

The relationship between transport costs and new economic geography was investigated by Kilkenny (1998) to illustrate that overall reductions in transport costs rebate the economic development of rural areas which are of low density. Rural places should be connected to urban places, where concentrations of population and industries are. The question here is whether changes in transport costs encourage firms and people to disperse or makes them even more intensive. The result shows rural development depends on increasing the amenities in and diversity among rural places.

McQuaid, *et al.* (2004) consider convenient transport links as part of a portfolio of a region's assets which encourage potential investors to make their location decision. Consequently, transport costs play a role in location decision making. Moreover, the importance and effect of transport varies according to firm characteristics, local characteristics, and external conditions. They mentioned that transport costs are often a relatively small proportion, but spotted of total costs. What attracts increasingly other businesses is the location of specialist logistics firms, rather than transport infrastructure. Transport infrastructure, however, has an important impact on those specialized logistics, much more than on manufacturing and service firms. Transport infrastructure influences the decision of where to locate within a certain region where has been chosen before. Ports are a main regional as well as global transport infrastructure and seen as an important integral part of supply chains, particularly in the more developed Western economies such as the European Union and the United States.

It is, therefore, reasonable to expect that Modern Industrial Dynamics (MID), the formation of clusters and the establishment of global supply chains would have major implications on how different port user groups choose the ports that they would use. This also has implications on the nature of competition between ports, particularly as the demand for closer integration between ports and other parts of the supply chain becomes an increasingly significant factor. In particular, the scope for strategic alliances and other moves that would extend the supply chain and provide much sought access to the hinterland through ports are also important (Rosso, *et al.*, 2009; Heaver 2002). In this regard, increasing port regional attractiveness and port selection is dealt in the section 2.5.

2.5 Port Selection

Port selection literature can be categorized into the studies which analyse individual port actor decision making criteria and others which studied all three main supply chain players' (ship operators, forwarders and shippers) port selection decision factors. For example, shipment information and a low level of loss and damage also count amongst factors that are important to ship operators (Murphy and Daley, 1992). Their study of five user groups indicated that freight forwarders value a port's ability to handle large volume shipments.

Major factors that some researchers (e.g. Magala and Sammons, 2008; De Langen, 2007; Murphy, *et al*., 1992) have found to be important to all users in studies that have assessed the demand for port services by different groups are cost, hinterland connection, and productivity. Similar to previous studies, they also incorporated variables that could affect port choice. While they found significant differences between groups in the majority of these variables, they also found that some variables were important to certain groups.

The body of research on port choice addresses a number of questions that seek to investigate the key factors that influence the port choice of major user groups and to determine whether there are significant differences between different user groups in these choices. For the purposes of this thesis, the literature on the choices of three major groups will be considered: shippers (purchasing managers), ship operators (carriers) and freight forwarders.

The bulk of existing literature on port choice models have dedicated to port choice by shippers (De Martino and Morvillo, 2008; Meersman, *et al*., 2008; Shintani, *et al*., 2007; Song and Yeo, 2004; Lirn, *et al*., 2004; Ha, 2003; Murphy, *et al*., 1992). Ship operators' port choice behavior has been recognized by few authors. Malchow and Kanafani (2001) using a multinomial logit model classified the elements affecting the port selection by ship operators who are involved in the US export. Their findings indicate that sea hinterland distances are the main variables in port selection, therefore their study specifies port location as the most important distinctive elements of a port. In a historical investigation, Kim (2004) distinguished among external factors from internal in port selection by ship operators in order to understand if these factors changed over time. They conclude that internal factors have not changed over the time, whereas external factors were subject to change. Ng (2006), through a case study on container transhipment in Northern Europe, differentiates the influential factors influencing port attractiveness from a ship operators' point of view. His results suggest that monetary cost is an important factor for ship operators, however, other variables such as time efficiency, geographical location and service quality are taken into account. Chang, *et al*. (2008) identify the factors affecting ship operators' choice as: local cargo volume; terminal handling charge; berth availability; port location; transhipment volume and feeder network. Exploratory factor and confirmatory factor analysis identified five port choice categories, i.e. advancement/convenience of port; physical/operational ability of port; operational condition of shipping lines; marketability; and port charge. Tongzon and Sawant (2007) specify that port costs and range of port services are the only significant factors for the port operator. Other studies are interested to see if there are differences in valuation of port choice criteria among the major port users. Lirn, *et al*. (2004) applied the AHP method to understand transhipment port selection. Their results illustrate that in most important port service attributes both ship operator and terminal operator have a similar opinion. However, the weights between the sub-criteria indicate some dissimilarities between the two groups. Their five port selection factors are handling cost, proximity to main navigation routes, proximity to import/export areas, infrastructure condition, and feeder network. De Langen (2007) studied Austrian shippers' and freight forwarders' port choice factors. He suggested that although they share similar port selection criteria and do not value them differently, they differ in terms of their response to prices: the shippers have less price-elastic demand. The literature survey envisaged that most research has emphasized the regional or national level and has used similar factors.

While these studies have contributed significantly to identifying a group of factors that are likely to affect the demand for ports by different groups, some key aspects remain largely unexplored. In particular there is little literature on how the interaction of the decisions of different user groups ultimately affects port choice and the competitive position of individual ports as well as of a group of ports located in the same region.

A detailed literature review on port choice criteria is presented in a table in appendix 1.

2.6 Conclusion

Given the new geographical configurations and environmental dynamism which businesses face as a result of globalization, outsourcing has become an integral part of defensive as well as offensive business strategies. The review provided a critical appraisal of the merits and risks of outsourcing and the circumstances under which outsourcing would be a favourable proposition.

A determinant factor in location decision making might be transport costs, but does not have the most important role. Location of specialist logistics firms attracts other businesses, so they impact at intra-region rather than inter-region level.

Global supply chains arise out of firms' outsourcing strategies and the need for planning and controlling materials, manufacturing and businesses processes. The supply chain literature provides an important means of examining the role of transport infrastructure in the design of supply chains and how this design itself can bring benefits which can affect ultimately national economic development. Supply chain methods and design differ according to how transport infrastructure is configured. Different configurations can lead to different utilization levels of transport infrastructure which is a national economic resource, given the impact it has on production and distribution of goods and on labour markets. As firms' strategies change in a dynamic environment, their supply chain design and configuration also have to adapt. These adoptions of the supply chain have to embrace transport infrastructure. Consequently, transport infrastructure should be incorporated as a key element of supply chain design and in understanding the impact of the new economic geography on economic development.

The reviewed studies regarding infrastructural developments revealed that transport infrastructure significantly affects the regional economy through business strategies aimed at benefitting from economies of scale, and global trade. Domestic production and economic growth are affected by transport infrastructure through supporting clusters and agglomerations of economic activities. Opening up access to new markets increases competition and consequently, provides consumers with more choice. Reducing the costs of trading, domestic and international trade increases and allows business to trade over a wider area.

This chapter indicates that transport infrastructure's contribution to economic growth and productivity is positive. Using infrastructure efficiently has been found a main factor which makes a difference in benefiting from public goods. In the context of a balanced growth process, infrastructure has a strong, complementary relation with the supply chain. As a total result of the effects of investment in transport infrastructure at macro and micro levels, in a global economy, an "infrastructural system" is a main influential factor for regional development.

Furthermore, transport infrastructural research is mainly dominated by the use of macroeconomic models. These studies explored the productivity and spillover effects of improvements in transportation and the impact of such improvements on aggregate demand and economic growth[4]. The impact is transmitted through the effect on local prices and the response of workers and producers to these changes in domestic prices. This work defines any outsourcing in the production or distribution networking process as a partial relocation. By this definition of relocation, any environmental or strategic changes towards in-sourcing or outsourcing would be a subject of study for relocation. The global production process would increase a need for a wider transhipment system. The main subject which was not covered in any of these studies was that in global economy and trade, local transport infrastructure in one region cannot be considered a factor of economic development. In a global economy, there is a need to consider a "global transport infrastructural system" as a main influential factor for regional development. Local infrastructure needs to be defined in conjunction with other regional and international infrastructural availability. A transhipment system as defined in chapter four connects these infrastructures in an effective and efficient way. This study suggests that the "global transport infrastructural system" should be considered as a factor of regional economic development.

In summary, theoretical support for a model linking business environment, competitive priorities, supply chain structure and firm business performance has been established in the literature. Making the right strategic decisions and achieving alignment is a major theme in strategic and operations literature and refers to strategic decision making according to environmental conditions in order to achieve desirable performance. However, there is a lack in previously developed frameworks in order to include and consider logistics processes in particular transport infrastructure and how they should be aligned to a firm's supply chain strategy, competitive strategy and business environment. To the best of the author's knowledge, there exists no model that links all these elements in one framework.

Specifically, there seems to be a lack in the literature that identifies modern global business environment and transport infrastructure as an element of supply chain and national developments. The gap in the literature includes such questions as:

- What is the role of strategic transport infrastructure at national level for the existence of agglomeration economies generated by outsourcing and global supply chains?
- What is the role of the port function for the national economy in the context of growing global specialization?
- What factors enhance a specific port's attractiveness and how are they prioritized in form users' point of view?

Chapters three, four, and five are respectively devoted to answering these questions.

3. CHAPTER THREE: TRANSPORT CONTRIBUTION TO ECONOMIC DEVELOPMENT

3.1 Introduction

The explicit purpose of efficient and productive transport infrastructure is to strengthen economic activities and development. Well-developed transport infrastructure facilitates sustainable economic growth and competitiveness through its impact on goods and services markets and through higher productivity. This phenomenon is more relevant to the Belgian economy than to many other countries. Although Belgium is a small country, because of its openness the Belgian economy is influenced by the global economy or spillovers of other economies. Pritchett (1996) defines Openness as "economy's trade intensity". It depends on trade liberalization and trade policies, spatial characteristics of the country, as well as the size, cost, quality and accessibility of the national transport infrastructure. Belgium is considered to be the third globalised country in the world (KOF Swiss Economic Institute, 2015) and is ranked amongst the twenty most competitive nations (WEF, 2016). It is also ranked fifth for FDI projects in Europe (EY, 2015). Furthermore, it was the 13th leading exporting nation in 2015, with its exports accounting for more than 80% of national GDP (WTO, country profile, 2015). "*Its exports are highly concentrated with a share of three quarters of total merchandise exports accounted for by the European Union (EU), close to two-thirds of which go to Germany, France, and The Netherlands. Developing countries and emerging markets account for a comparably small share of exports, despite recent export growth to Asia. Imports are broadly in line with the export patterns*" (KOF Swiss Economic Institute, 2013).

The statistics outlined above indicate a high degree of openness of the Belgian economy achieved by its integration into the European Union as well as by its contribution into the global economy through its economic structure and strategic location. The openness of the Belgian economy and its dependency on the global economy is also the major source of its wealth, which is based on high productivity in global connections.

Belgium's unique location in the centre of Western Europe represents significant opportunities as a gateway to Western Europe. 80% of Europe's purchasing power - 500 million consumers and Germany as a main global exporter – is located within 500 miles from Brussels (Belgian Foreign Trade Agency, 2014). These economic and location characteristics encourage the presence of many foreign companies in the Belgian market. For such an economy, regional and global connectivity, made possible by efficient and effective transport infrastructure, is a major economic resource.

In Chapter one, the thesis highlighted the important role that strategic transport infrastructures (including land transport and ports) play as major elements of the supply chain and regional development in the context of MID and GCTS. With regards to Belgium's strategic location as a main Western European gateway, most of the country's land, waterways and ports are considered strategic infrastructure for both Belgium and Western Europe. Given this context, the GCTS definition set out in chapter one, in which the GCTS links different countries' infrastructures and forms semi-homogenous global transport infrastructures, is relevant and applicable to an analysis of the Belgian economy.

The high level of openness of the Belgian economy and its high commitment and contribution to global trade results in the economy being directly affected by transport infrastructure performance and productivity. However, recent arguments over the environmental effects[5] of ports functions indicate that such issues could lower port public popularity (Meersman, *et al*., 2011). Therefore, a balanced approach to study port development should focus on the sustainable economic growth and improved transport infrastructure and mobility. In seeking to achieve balance, the aim of transport policy in the European Union is to promote the concept of 'co-modality', defined as the optimal and sustainable use and combination of the various modes of transport, in combination with measures to fully internalize the costs of the different modes" (United Nations Economic Commission for Europe, 2010, p. 12).

Using an aggregate growth model, the aim of this chapter is to quantify the impact of transport infrastructure investment- including length of highways per capita and the ratio of port infrastructure investment by government to total investment- on the economic growth of Belgium (e.g. Howard, *et al*., 2011; Fraumeni, 2009; Kawakami and Doi, 2004, etc). More information is provided in Table 3-2). Such analysis is essential given the preceding discussion which has outlined the extent of openness of the Belgian economy and identified that there are potential economic benefits to be gained that from such a position should appropriate and effective transport infrastructure be in place. The rest of this chapter is organized as follows. Section 3.2 sets out in detail how the transport sector contributes to national and regional economies, while section 3.3 explains its role in the EU and particularly in the Belgian economy by data presentation. Section 3.4 presents the methodological approach and estimation process that is used to quantify the effects of total transport infrastructure on economic growth and outlines the data collection process. Detailed empirical results and conclusions are provided in sections 3.5 and 3.6 respectively.

3.2 The role of transport infrastructure for the economy

The magnitude of the impact of the transport system on the national and the regional economy is subject to the level of economic development and varies in rural and urban areas. Furthermore, there could be incompatibility between immediate benefits and sustainable growth in some cases. Also there can be an inconsistency in the scale of its effects over different time periods. However, as specified in the literature review chapter, there is a general consensus that transport infrastructure contributes to economic growth and productivity but not in a constant manner over time.

Due to some feature aspects of transport infrastructure investment – e.g. sustainable economic development and environmental issues – there could remain an uncertainty regarding long term effects in different economic and regional conditions. More detailed studies of short and long term effects of transport infrastructure investment are provided in the sub-sections 3.2.1 and 3.2.2.

3.2.1 Short run benefits of transport infrastructure investment

As an immediate result of improved transport infrastructure, reduced congestion brings about lower travel time, better and more accessibility and an improved distribution system, consequently lower fuel consumption and vehicle depreciation costs, and more reliable freight transport, through which manufacturers, become able to diminish their assembly and delivery costs.

Investment in infrastructure benefits the economy in the short run also by creating jobs in different industries: "*especially those which are difficult to ship overseas. For example road building requires construction workers, grading and paving equipment, gasoline or diesel to run the machines, smaller hand tools of all sorts, raw inputs of cement, gravel, asphalt, surveyors to map the site, engineers and site managers, and accountants to keep tracks of costs"* (The White House, 2014). Public infrastructure investment is found to have some of the highest multipliers of GDP in the short run specifically in developing and low income countries (Lakshmanan, 2007). Therefore, when there exists a considerable insufficiency in transport infrastructure, high estimated multipliers are expected which trigger off the economic activities and GDP in the short run. It might take place through an enormous reduction in the internal trade cost.

The next sub-section deals with long term added value of transport infrastructure investment to the economy.

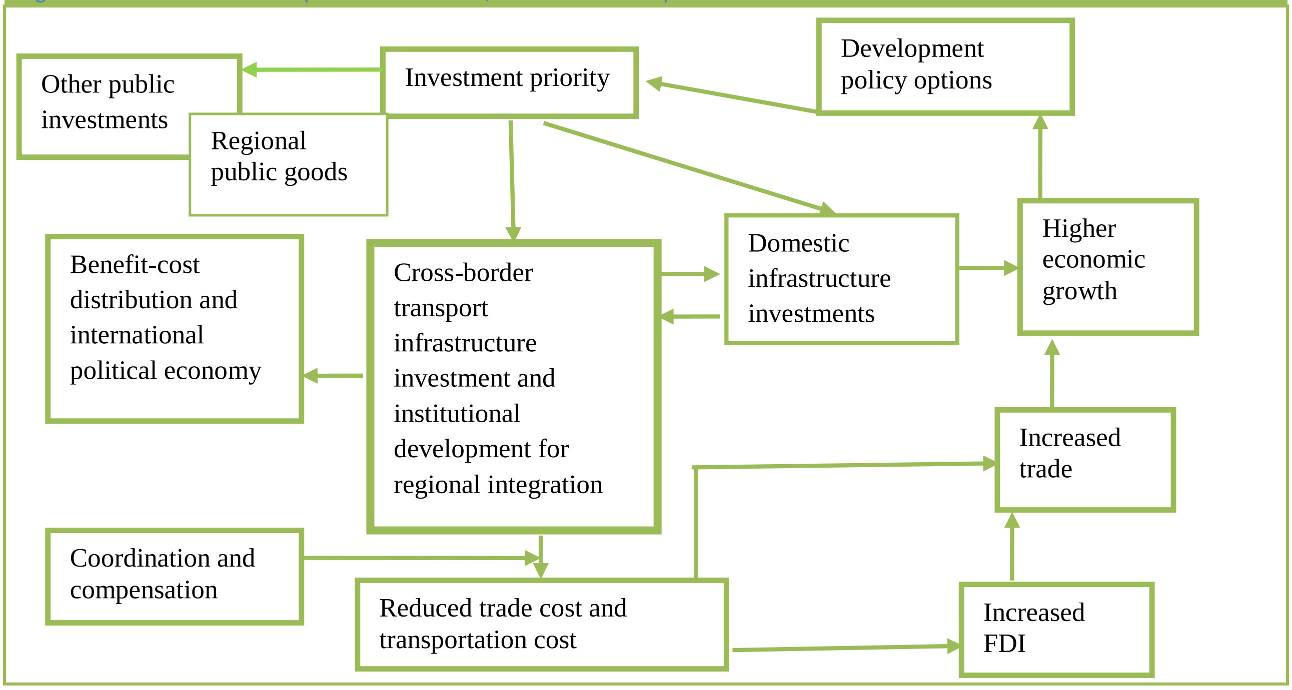
3.2.2 Long run and sustainability effects of transport infrastructure investment

The most vital and influential impacts of infrastructure investment come in the long term. The importance of GCTS and commercial cluster's function- as necessities to achieve long time transport policies' goals - are discussed in chapter four.

Cheaper transport initiates increase accessibility to demand and supply market-, flexible and skilled labour and better input, and cheaper and better neighbouring business services as input. Hence, the progress of imports and exports becomes smooth. An increase in the level of imports increases local competition which, in turn, puts firms under pressure to increase their productivity. In certain conditions, increased exports, – when other influencing factors remain steady, might result in expansion of sales, and consequently in increased profits of manufacturers. Thus strengthen the business cluster formation around the ports. This cluster formation is considered as a main value adding factor to economic growth in this study.

Cross-border transportation infrastructure as a necessity for regional economic integration is discussed in Fujimura's (2004) study based on common benefits generated by participating countries. The author draws the relationships between factors as shown in figure 3.1. The combination of domestic and cross-border transport infrastructure causes a decrease in trade costs and an increase in the trade and foreign direct investment (FDI) which leads to an increase in economic growth. Moreover, investment in cross-border transport infrastructure affects the international political economy and the distribution of costs and benefits. He suggests that "*Such long-term changes in the scale, composition, and location of economic activities induced by transport investments are more like developmental effects than growth effects*".[6]

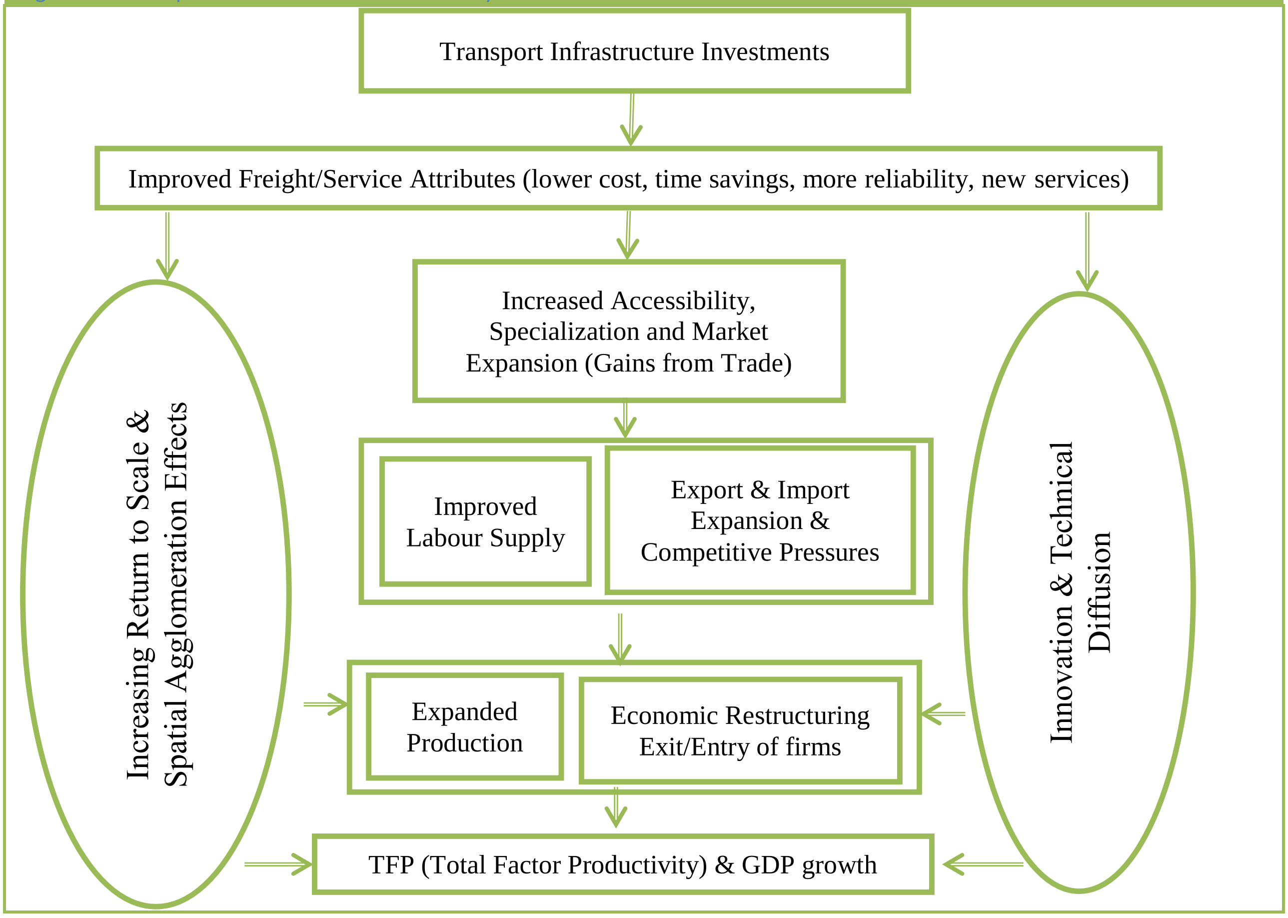
Figure 3-1 Cross-border transport infrastructure, trade and development



Source: Fujimura (2004)

In a General Equilibrium Model, Figure 3.2 below adopted from Lakshmanan (2007, 2011) offers an overview of the mechanism and processes underlying the wider economic benefits of transport infrastructure investments. He calls it "Forward linkages" of transport infrastructure based on Hirschman (1985), Williamson (1974), and O'Brien (1983). These effects are shown in t Figure 3.2 through two mechanisms in the oval boxes, one dealing with innovation and the other with spatial arrangements in the economy. These two mechanisms create, in the context of transport infrastructure improvements, conditions (in activity clusters) which enhance economic performance, and promote total factor productivity and endogenous growth. In this figure, the central elements which are framed in the middle of the figure are supply chain factors including supply chain infrastructural elements. The figure illustrates the relationship between supply chain factors and its infrastructural elements to regional and national economic developments.

Figure 3-2 Transport infrastructure and economy-wide benefit

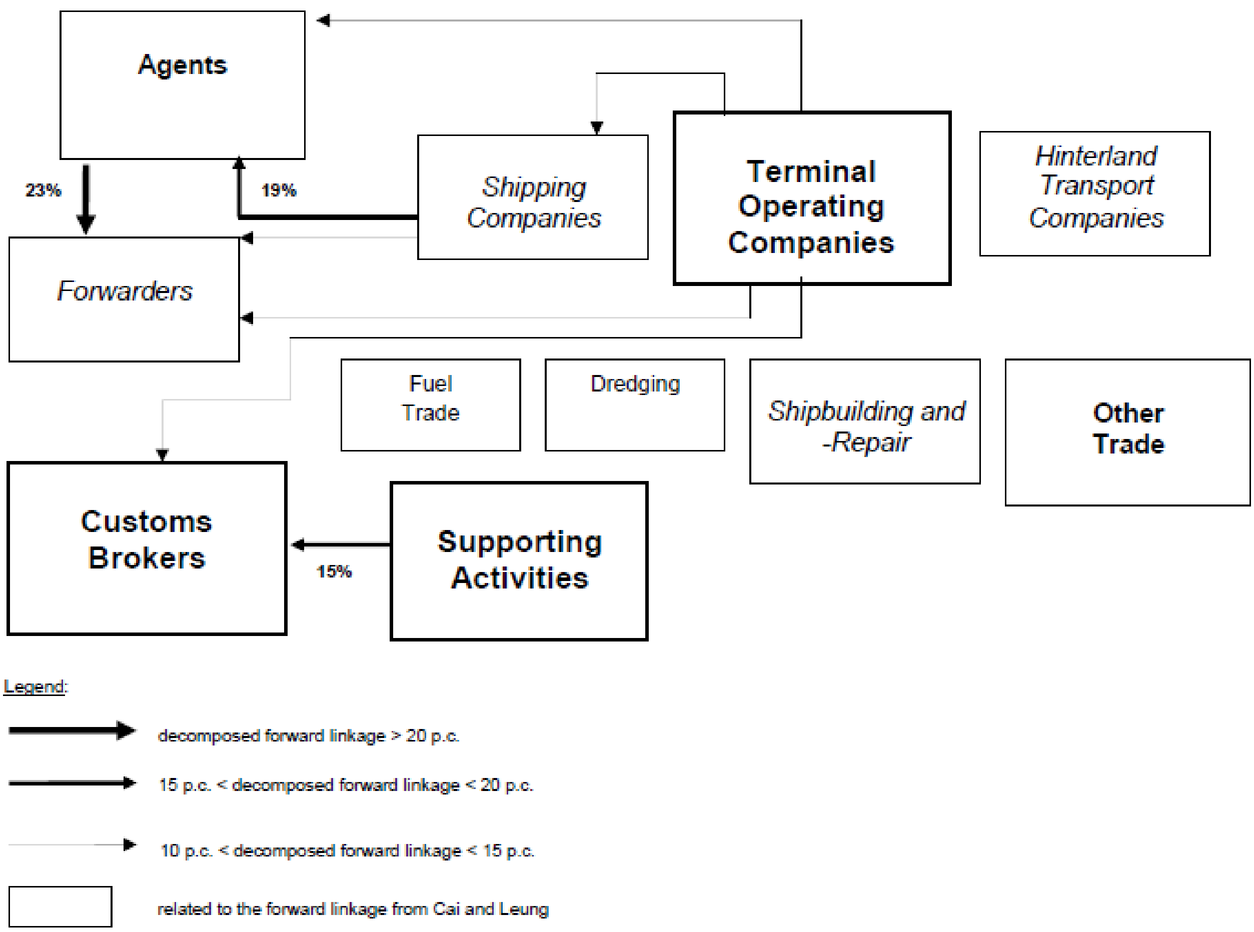


Source: Lakshmanan, 2007

In the longer term, sustainability in transport technology and infrastructure will stimulate structural changes in national and regional economies, and also facilitate integration to the globalization processes, sustainable production systems, and dynamic institutions (Lakshmanan and Chatterjee, 2005).

Meersman, *et al*, (2012) and Coppens, *et al*, (2007) use input-output analysis in combination with detailed business accounts to quantify the relationships between port actors and the percentages effect of deliveries to each sub sector. Figures 3.3 and 3.4 depict the relationship between port actors based on forward and backward linkages respectively.

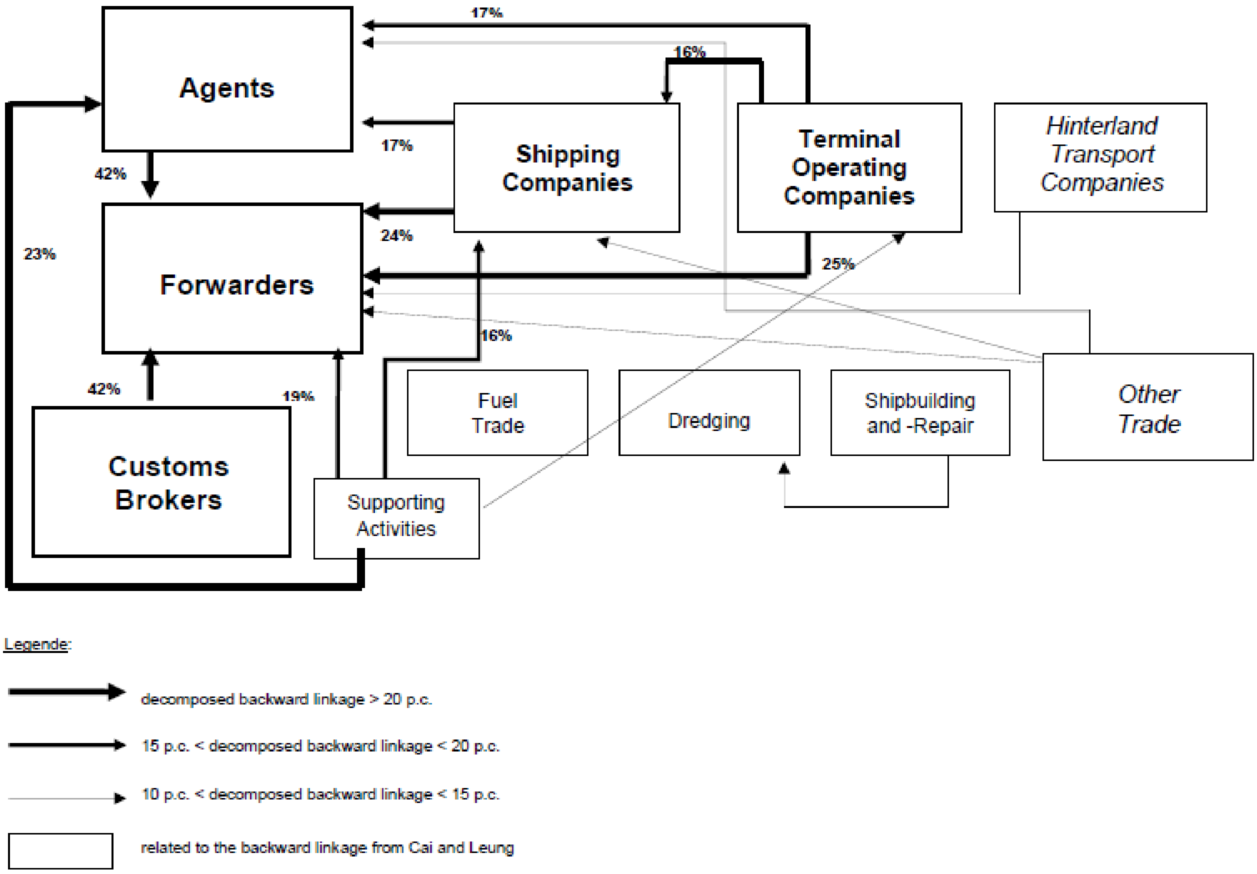
Figure 3-3 the relationship between port actors, based on decomposed forward linkages



Source: Coppens, *et al* (2007)

As a complementary approach to capture the broader effects of transport on the economy Meersman and Nazemzadeh (2016) discuss the concept of a commercial cluster which would arise in and around a port and provide an important competitive edge for the port and consequently enhances the regional economy. By applying the concept of cluster effects on port study, they suggest additional effects of port development on economic growth beyond the direct and indirect effects that exist in the sought literature.

Figure 3-4 the relationship between port actors based on backward linkages



Source: Coppens, *et al* (2007)

The effects of a modern global business environment are equivalent to those of the past industrialisation era. The driving factors in both eras were advances in transport infrastructures, communication, and production technologies together with structural changes in public institutions and business organization. Those economic agents who are pursuing FDI opportunities are seeking regional and national comparative advantage infrastructure investments that improve accessibility to increase returns on investments. This explains the growth of FDI movements to regions with well-developed transport infrastructure such as North Europe. Lakshmanan and Chatterjee (2005) provide a summary of the short and long time effects of transport infrastructure investment as well as very long term- sustainable- effects in Table 3.1.

Table 3-1 Summary of temporal effects of transport infrastructure investment

Short term/ immediate	Long term	Very long term	Short term/ immediate
• Reduced congestion. • Shorter travel times and lower vehicle operating costs. • Rising demand and output. • Logisticsreorganization. • Inventory cost reduction. • Local and regional growth. Job creation in construction sectors.	• Larger markets for products, labour, and services. • Export expansion. • Entry and exit of firms. • Regional/national integration. • Structural and developmental effects. • Increased reliability. • Industrial clusters formation. • Commercial clusters formation.	• Promotion of globalization processes • Global distribution and production • Global flows of goods, services, capital, and knowledge. • Sustainable regional competitive advantages.	• Reduced congestion. • Shorter travel times and lower vehicle operating costs. • Rising demand and output. • Logistics reorganization. • Inventory cost reduction. • Local and regional growth. • Job creation in construction sectors.
• Increased competition. Supply and demand forces.	• Monopolies may emerge. • Economies of scale. • Agglomeration. • Cumulative causation. • Endogenous growth. • Increased competition.	• Confluence of technical and organizational/ institutional changes in transport, communication, and production sectors. • Emerging of new economic geography.	• Increased competition. • Supply and demand forces.
Cost-benefit analysis.	• New Economic Geography theory. • Notion of gains from trade. • Computable general equilibrium Models. • Multivariate Econometric modelling. • Growth models	• Economic history analysis	• Cost-benefit analysis

Source: Own complained based on Meersman and Nazemzadeh (2016), The White House (2014), and Lakshmanan and Chatterjee (2005)

To synthesize the above aforementioned to the main theme of this research, the mechanism of the effects of transport infrastructural investment on GDP is through supply chain performance, and could be classified into four categories which are provided in sub sections 3.2.2.1 to 3.2.2.4.

3.2.2.1 Infrastructural element of supply chain and cluster formation-FDI

The occurrence of FDI in business clusters triggers further progression and dynamic development of the clusters. This will attract more global companies and the presence of global companies restructures regional specialization and productivity. Moreover, for the benefit to both the national and regional economy to be realised there is a need for specific conditions which suggests that such gains depend on the level of development of strategic transport infrastructure when a cluster already exists.

Phelps (2008) and De Propris and Driffield's (2006) empirical results exhibited that even though there can be adverse competition effects of FDI due to global firms' presence in clusters, this is compensated for by the spillover gains from global to local firms.

In the next chapter the business cluster is defined as a concentration of specialized skills of businesses which are highly related to each other with complementary knowledge in a specific region. Closeness in geographic, cultural, and institutional specialisation allows for wider access, better information, dominant motivations, and other benefits in productivity and growth which are hard to achieve from a distance.

Clusters study is a complementary way to both policy and economic development studies especially in an economy with a high level of openness. The state of clusters discloses key understandings into the potential path of progression of an economy and the limitations on its future development. Adopting a cluster approach to economic development encourages competitive behaviour.

Both a high level of economic openness and the ease of transport contribute to enlarging outsourcing, a process in which companies relocate their capacities to different locations to increase competitive advantages. However, in the context of clusters, overseas sourcing is a second-best option compared to using a local cluster member as a outsource provider.

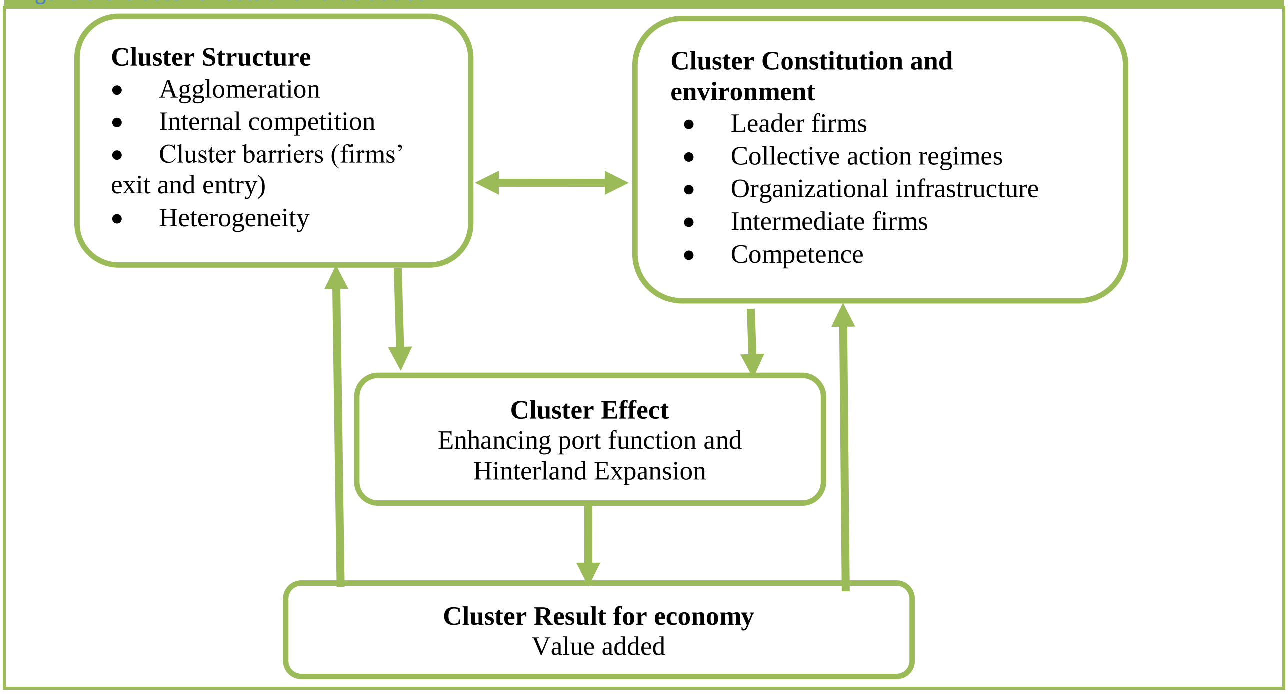
In this research area, a case study approach that frames a specific cluster, the Port of Antwerp, is valuable. Cluster theory can inform, and be informed by different cases in a range of literature in economics and management including, port studies. Applying cluster-based approaches to port studies would encourage policy makers and practitioners to see globalisation, competition and regional competitiveness as important factors that demand constructive actions. Policies and actions that relate to clusters and their role in development need to encompass trade and transport

There exist a bilateral relationship between continuous growth of global trade in absolute terms as well as relative terms (to global GNP) and the level of containerization[7]. In this respect, the contemporary era witnesses an increasing role of multinational corporations with a substantial share of international trade that occurs within corporations. This phenomenon leads to a global economy which is reliant on an efficient transport system as well as liberal trade facilitation. These two factors encompass multimodal and intermodal freight transport systems consisting of different modes, more liberal trading policies and handling of documentation procedures, more effective banking and finance activities, emergence of economic blocks and finally comprehensive insurance facilities.

The commercial cluster discussed here is more concerned with a government trade and transport policy framework as well as the regional economy, local comparative advantage and clustering effects. The application of this way of thinking to logistics and port analysis is provided in Figure 3.5.

A commercial cluster can be formed around a container port which is involved with different transport, distribution and commercial activities. Figure 3.5 illustrates the inter-relationship between different components in a commercial cluster which results in cluster effects to add value to the regional and national economy. The Cluster structure consists of four elements –agglomeration, internal competition, cluster barriers (firms' exit and entry) and heterogeneity.

Figure 3-5 Cluster effects and value added



Source: Own compilation based upon the ideas from Lehmann and Benner (2015)

The agglomeration concept relates to the idea of economies of scale and network effects and how these create synergy. This applies to the benefits that firms gain by locating in close proximity to each other. As more firms in related fields of business locate in the same vicinity, their costs of production may decline significantly as a result of division of labour and specialization. This is because the cluster attracts more suppliers and customers than a single firm could achieve alone. This will on the one hand increase the level of competence of competing firms in the same cluster. On the other hand, at the interface of MID and economic geography, the central question of how commercial clusters can affect the entry, growth and exit through agglomeration economies is crucial.

The heterogeneity factor creates knowledge spill overs, whereby only the most productive firms will invest in R&D, and these R&D investments may spill over to other firms. This occurs either directly by reducing the required budget for R&D firms, or indirectly, by making R&D investments cheaper. The cluster's composition and environment is influenced by five variables. The first variable is the quality of its composition which is related to the presence of leader firms. Leader firms have incentives and resources to invest in improving different market frontiers and can play a leading role in the development of alliances. Therefore, they are important for increasing the quality of a co-operative action (Olson, 1971).

The second variable is participation in cluster activities. This variable influences the quality of a regime. Public organizations frequently contribute financially to collective action regimes (Porter, 1990).

The third variable is organizational infrastructure which enables cooperation and thus serves as a means of assembling the essential resources. The infrastructure for collective action consists of an association's public–private organizations, and the internal network structure of clusters. These do not develop automatically, as there is a need for significant public investments.

The fourth variable is the presence of intermediate firms, which develop an effective environment which leads to better coalitions and resource availability. Finally, the competence of individual firms contributes to the quality of a cluster. The competence of firms increases the attractiveness of the cluster.

The performance of Cluster Structure variables and Cluster Constitution would be measured by the level of economic value added. The development of cluster structural and constitutional components and the bilateral and multilateral relationship among them is what would dictate the cluster effect and level of value that is added.

3.2.2.2 Infrastructural element of supply chain and geographical location

As stated in chapter two, firms' decision to outsource and their location strategies as drivers of the business cluster formation, have become the main theme in the new economic geography and Modern Industrial Dynamic (MID). Obviously, developed and more efficient and effective supply chains facilitate firms' growth. Outsourcing allows manufacturers to reduce their costs and specialize in core areas also to gain power from their skills and resources for increased competitiveness, including when entering into a contractual agreement with logistics providers.

Efficient and effective transportation and information which can connect different locations can manage risks associated with outsourcing. In the next step, firms that developed collaborative relationships with their suppliers will acquire market value improvement and sustainability in the longer period. A highly dynamic business environment and a new economic geography, characterized by business function clusters which influenced competition at a global level, - results from outsourcing decision making. Agglomeration and dispersion forces also action the new economic geography formation. Increasing returns in manufacturing advances agglomeration forces[8], thus firms locate their activities in regions with bigger markets. They also become able to avoid trade costs (by lower input prices) which lead firms to locate their manufacturing in other location. Moreover, increasing returns have important effects on the production structure. Accessibility indicators and physical attributes of transport networks are introduced to depict the spatial organization of FUR and urban area inside a FUR. Also in a certain area with a high accessibility to jobs, a high accessibility to labour supply tendency will exist (OECD, 2008). In other words, suitable transport links are part of a portfolio of a region's advantages which encourage possible investors to make their location decision in favour of that region. Transport costs are often a rather small proportion of total costs. Moreover, what attracts other businesses increasingly is the location of specialist logistics firms, rather than transport infrastructure (Transport and Logistics, 2010). In this respect, what gives the vital importance to transport infrastructure is its influence on those specialized logistics, much more than on manufacturing and service firms. Transport infrastructure impacts the firms' decision of where to locate. For examples, the decision can be influenced by which port within a certain region, such as North Europe has been chosen before. Therefore, transport infrastructure can displace business and employment from one area to another.

3.2.2.3 Infrastructural element of supply chain and labour market

Transport infrastructures contribute to the benefits of positive externalities and agglomeration economies being achieved. Agglomeration economies contribute to lower production costs and increase output growth. This is achieved, alongside other variables, by better accessibility to the bigger pool of labour market as well as more specialized skilled labour. Moreover, negative externalities that result from an increase in congestion need to be mitigated by an efficient and effective transport network (Iacono, 2013; Graham, 2007). Agglomeration economies effects are less significant in rural areas and smaller cities. However, even in small cities and rural areas, transport networks and infrastructure foster growth by 1) increasing the existing (labour, capital) resources utilization, 2) improving the productivity, and 3) attracting new resources and productive inputs (such as firms and households) to that area (Fox and Porca, 2001).

Iacono (2013) explains that improved transport infrastructure affects the quality of life in the related area positively. However, measuring the relationship between improved infrastructure and growth is difficult because data of good quality is scarce. Furthermore, location decisions are complex decisions that reflect multiple criteria which has implications on modelling such decisions.

3.2.2.4 Infrastructural element of supply chain and manufacturing costs

The fundamental objective of a SC configuration is to provide a strategic capability to create and expand sustainable competitive advantage by cost minimization while improving the service level by promoting the expertise, experience, skills and capabilities of the supply chain participants. This will be discussed in detail in chapter four.

With reference to the literature, the benefits of SC are highlighted as increased inventory turnover, increased revenues, product availability, decreased order cycle time, responsiveness, economic value added, capital utilization, decreased time to market and reducing logistics costs. The efficient configuration of SCM in material management, production schedule and distribution reduces the inventory level and cost, wasted time and energy, and consequently total costs.

The total cost of the supply chain tends to increase due to many factors such as significant capital costs required for productive global businesses, mounting real estate costs and freight charges. However, these factors would depend up on choice of the right transport mode which is '*a fundamental part of the distribution management*' (Slater, 1979) and needs to be carefully examined in order to find the right mode as the decision has a direct impact on a firm's efficiency. Decision making in transport is a complex issue as a spectrum of choices of transport modes combinations is available.

3.3 Methodology and data collection

Table 3.2 shows a summary of relevant research on transport infrastructure and economic growth, including their approaches, used data, and main conclusions. This review aids an understanding of what models and data are considered to be the most appropriate and of those that are commonly used by researchers.

To quantify the effects of total transport infrastructure on the Belgian economic growth, the next sections provide details of data collection and of the methodological approach applied in this study.

A key goal of this chapter is to determine whether there is a relationship between transport infrastructure investments on the one hand and economic growth and employment on the other hand.

Table 3-2 Summary of applied models in the literature of transport infrastructure effects on the economy

Author	Topic	Model/ study	Variables	Country/ scope	Result
Egert, *et al*, 2009	Infrastructure and Growth: Empirical Evidence	Exogenous growth model $Y(t) = K(t)^{\alpha} H(t)^{\beta} (A(t)L(t))^{1-\alpha-\beta}$ $\alpha + \beta \langle 1$ Aim: Network infrastructure impact on economic growth by analysing causal relationship between GDP, port capital, private capital, and transport user cost.	Y, K, H, A, L are: GDP, total capital, human capital, the level of technology, labour force	24 OECD countries/ 1960-2004	Positive impact of infrastructure investment on GDP. The effect varies among countries, sectors, and over the time.
Kawakami and Doi, 2004	Port capital formation and economic development in Japan: A vector autoregression approach	Lag-augmented (LA)-VAR $y_t = \gamma_0 + \gamma_1 t + J_1 y_{t-1} + ... + J_k y_{t-k} + \varepsilon_t$ Aim: investigating the empirical relationship between infrastructure (private capital, transport user cost, port capital) and economic growth.	Real GDP, ratio of transport inflator to GDP inflator, real capital stock, real port capital stock	Japan/ 1966-1997	Causal relationship between port capital and other variables are significant. Structural economic effects of forming port capital are substantial for Japan.
Ferrari, *et al*, 2012	Ports and regional development: a European perspective	Conventional GMM panel data $\ln Emp_{it} = \alpha \ln Emp_{it-1} + \beta Y + \gamma X + u_{it}$ Aim: studying the impact of port activity on regional employment.	Emp, Emp_{t-1}, Y, X are: Employment, the first lag of employment, port activity (port throughput), regional control variable	560 western European regions, including 116	Positive regional employment correlation with port throughput.
Essoh, 2013	Analysis of relationship between port activity and other sectors of the economy: Evidence from Cote d'Ivoire	Aim: study the relationship between port activity and the activity of the different service sectors by comparing trends and analysing the causality relationship between them.	Port traffic, real GDP, nominal GDP, GDP for agriculture, GDP for trade, GDP for industries, GDP for services, GDP for banking and insurance, GDP for transport and telecommunication, fiscal income and taxes collection	Cote d'Ivoire/ 1992-2011	The contribution of port activity can accelerate the economic growth.
Peterson and Jessup, 2008	Evaluating the relationship between transportation infrastructure and economic activity: Evidence from Washington State	VAR, ECM, directed acyclic graphs (DAGs) Aim: evaluate the interrelationship between highway infrastructure and economic activity.	Employment, average wage, and the number of establishments in related economic sectors	Washington State/ 1990-2004	The relationship between infrastructure investment and economic activities are often weak and are not uniform effect.
Roller and Waverman, 1996	Telecommunications infrastructure and economic development: a simultaneous approach	Growth model: $GDP = f(K_{it}, HK_{it}, TELECOM_{it}, t)$ Aim: investigating the telecommunication impact on economic development	K, HK, telecom: Stock of capital, human capital, the stock of telecommunications infrastructure	21 OECD countries/ 20	Positive causal link provided that a critical mass of telecommunication infrastructure is present.

Aschauer 1989	Is Public Expenditure Productive?	Aggregate production technology model: $y_t = A_t\ f(N_t, K_t, G_t)$ Aim: study the relationship between aggregate productivity and stock and flow government spending variables.	Y, A, N, K, G: Aggregate output of private sector, a measure of productivity, capital stock, employment of labour service, flow of services from government sector	US/ 1948-1985	Positive relationship between infrastructure investment and economic productivity.

This will be done using an aggregate growth model:

y_t = f {physical capital (for example, productive capital stocks, gross fixed capital formation), human capital (for example, total employment growth, total population growth), quality of human capital (for example, economically active population, and labour productivity of the total employment, the number of high educated individuals), infrastructure (for example, the length of motorways, the length of other roads, total port infrastructure investment, navigable inland waterways, railway transport), quality of infrastructure (transport infrastructure investment and maintenance spending), trade (for example, import and export, the openness ratio of the economy), and technological changes}.

3.3.1 Methodology and modelling

Several methods could be adopted to analyse empirically the impact of transport infrastructure on economic activity and trade. A good overview can be found in Goetz (2011) in terms of theoretical - macro and micro economic analyses, empirical literature, and used measures[9]. A comprehensive analysis to trace and quantify the direct and indirect effects of the transport sector on other economic sectors is input-output analysis. This approach requires detailed input-output tables which are often difficult to obtain. The Belgian National Bank uses the input-output methodology to analyse the direct and indirect impacts of the ports, airports and the logistics sector on the Belgian economy. Moreover, investment in infrastructure (including land transport and pipelines, inland waterway transport, air transport, supporting and auxiliary transport activities, agencies) impacts are also analysed in input-output analyses. Each large infrastructure investment project in Belgium requires a social cost-benefit analysis (SCBA) which should also contain the impact of the project on the economy. However, as the SCBA is most of the time executed by a private consulting company, the full model or instrument for calculating the economic impact is often not available.

In a normal econometric approach where the economic variables are related to each other in different ways and affect each other simultaneously, the natural starting point for empirical analyses is a Vector Auto-Regression (VAR) model. Additionally, the economic theory is only minimally used in the inferential process in VAR models. This is because "*any vector of time series has a VAR representation under mild regularity conditions and this makes them the natural starting point for empirical analyses*" (Pesaran and Shin, 1996). This study initially developed different VAR model specifications most of the results of which were vague and not consistent with each other. This could be due to the fact that VAR models require a rather long time series in order to be able to find significant relations between the variables.

Due to data limitations because of the number of annual observations which is available is insufficient, a VAR model could not be employed in this study[10]. Therefore, alternative methodological models were determined from the existing literature.

An alternative way to study the impact of transport infrastructure on economic activity which is applied in this research, is by using aggregate economic growth models. There are several issues and ambiguities which should be taken into account when investigating empirically the relation between transport infrastructure and economic growth:

- the way in which transport infrastructure affects economic growth is not necessarily a direct and unidirectional one; there are reasons to assume that transport infrastructure has an impact on international trade which itself has an impact on economic growth which will generate funds for expansion of the transport infrastructure, etc.
- there exist a large amount of empirical growth models with often very different sets of explanatory variables and often diverging conclusions concerning the impact of transport infrastructure investment;

- The impact from infrastructure to economic growth is expected to be stronger for developing economies than for developed economies; for the latter they are mainly ground-breaking innovations or very large-scale developments that may have an impact on economic growth;
- it is suggested that transport infrastructure will have an impact on economic growth in the long run and not in the short run;
- outcomes of empirical investigations are determined by data availability, the variables used in the specifications, the degree of disaggregation and the statistical methods used.

A single equation two-step cointegration approach is used which is suitable if 1) the series are non-stationary and I(1), and 2) the causality is clear from for instance economic theory or other empirical works.

The cointegrating relation is estimated and its residuals are tested for stationarity: if they are, the estimated relation is the cointegrating relation.

In order to have reliable standard error of the estimated equations, the cointegrating relation cannot be estimated by OLS, but an adapted estimator method is needed such as DOLS and fully modified OLS (FMOLS). DOLS introduces lead and lags and therefore demands long time series. FMOLS, initially designed for dynamic panel data modelling, can also be used for time series with small amount of observations and/or equations with a considerable number of explanatory variables.

FMOLS was introduced by Phillips and Hansen (1990) and developed by Pedroni (2001, 2000, 1996, and 1995) and Kao and Chiang (2000). FMOLS uses structural equations, in which the specific relationships between variables are based on economic theory. It is mainly proposed to estimate the long-run cointegration vector for non-stationary series. The advantages of FMOLS over OLS are that first, it allows for checking the robustness of the results when the sample size is rather small and the equation is cointegrated. Second, it specifies the potential endogeneity of regressors and serial correlation that are normally present in a long run relationship (Mehmood and Shahid, 2014; Chen, *et al*, 1999; Montalvo, 1995, Bangake and Eggoh, n.d.). FMOLS in addition to producing asymptotically unbiased estimators produces nuisance parameter free standard normal distributions (Pedroni, 2000).

However, there are few disadvantages related with the FMOLS estimators. One of these is that it relies on a very strong assumption of cross-sectional independence of the error terms. Moreover, this method is not independent of different normalizations, such as the choice of which variable to put on the left-hand side in the regression (IMF, 2007).

The advantages of FMOLS for the purpose of this study outweigh its disadvantages; therefore it is used to examine the behaviour of GDP and explanatory variables.

Taking into account the sought literature and previous studies (e.g. Figures 3.1 and 3.2, and Table 3.2),

in the first instance equation 3-1 was considered.

$$gdpcap = f\,(inv, portinv, motoways, moways, open, def\,, niw, rail, road, tran\sin v,$$
$$heduc, emp\lg, popg, actpop, labprod, t\,) \qquad (3-1)$$

Where

gdpcap (y) = real GDP per capita.

inv (k) = the ratio of Gross fixed capital formation to GDP.

portinv (p) = the ratio of port infrastructure investment by government to total investment.

motoways (m) = the length of motorways (kilometre)[11]per capita.

open = openness ratio: (Import+ Export) /GDP.

def = ratio of deflator in the transport sector to total deflator ratio.

niw = Navigable inland waterways.

rail = the length of rails.

road = the length of roads.

transinv = total transport infrastructure investment.

heduc = the number of highly educated individuals.

emplg = total employment growth.

popg = total population growth.

actpop = economically active population.

labprod = labour productivity of the total employment.

t= a time trend as proxy for technological change

Equation 3-1 introduces the primary model. Initially all the relevant variables were considered, but a number of them did not appear with a significant impact on GDP in the short run and in the long run. They were dropped from the model and the following specification was (equation 3-2):

$$y = f\,(k, m, p, open, def\,, t) \qquad (3-2)$$

In the next stage, the following log linear model has been used to estimate the long run relationship between variables as this form theoretically and empirically provides more reliable results than the linear form (Layson, 1983; Ehrlich, 1977).

$$\ln(y_t) = \alpha_0 + \alpha_1 \ln(k_t) + \alpha_2 \ln(m_t) + \alpha_3 \ln(p_t) + \alpha_4 \ln(open_t) + \alpha_5 \ln(def_t) + \alpha_6\, t + \varepsilon_t \qquad (3-3)$$

Equation (3-3) captures the long-run relationship between variables of the model. To capture the shorts-run dynamic effects, equation (3-4) - an error correction model (ECM) - is estimated.

$$\Delta \ln y_t = \beta_0 + \beta_1 \Delta \ln k_t + \beta_2 \Delta \ln m_t + \beta_3 \Delta \ln p_t + \beta_4 \Delta \ln open_t + \beta_5 \Delta \ln def_t + \gamma(\ln y_{t-1} - \alpha_0 - \alpha_1 \ln k_{t-1} - \alpha_2 \ln m_{t-1} - \alpha_3 \ln p_{t-1} - \alpha_4 \ln open_{t-1} - \alpha_5 \ln def_{t-1} - \alpha_6\, t_{t-1}) + \varepsilon_t \quad (3-4)$$

Where

$EC_{t-1} = (\ln y_{t-1} - \alpha_0 - \alpha_1 \ln k_{t-1} - \alpha_2 m_{t-1} - \alpha_3 p_{t-1} - \alpha_4 open_{t-1} - \alpha_5 def_{t-1} - \alpha_6 t)$ = lagged error-correction term.

ε_t = white noise error term.

Equation (3-4) shows the relationship between short-run movements in output and the variability of other variables. The magnitude of coefficient γ shows how quickly the short-run deviation of variables from their long-run cointegrating relationship is corrected over time.

3.3.2 Data

Initially a number of variables are collated and collected as input for modelling in this chapter which are in the form of annual time series[12].

The data covers the period 1979 to 2010. The annual data series of GDP per capita and transport infrastructure related data are provided by (OECD/Stat), OECD (2015) in 2005 values. Port infrastructure investment data are collected from the (Overheidsuitgaven voor havens), Flemish Port Commission (2015) for the period of 1989 – 2012 at 2012 value. The primary data to calculate the deflator ratio are provided by the National Bank of Belgium (2012) (Nationale rekeningen); the ratio is calculated in the base year of 1995 to present the user cost proxy of the transport sector[13].

3.4 Empirical results

To avoid spurious regression, variables need to be tested to see whether they are stationary and, if not, if they are cointegrated. In the section 3.4.1, diagnostic test results are reported only for the variables which are used in the final model. Section 3.4.2 provides the model's results.

3.4.1 Diagnostic tests

The first part is dedicated to the unit roots (stationary) test. This part discusses the underlying properties of stationary and non-stationary (unit roots) processes. Different tests can be used to uncover whether the time series are stochastic or deterministic, such as Dickey-Fuller (DF), Augmented Dickey-Fuller (ADF) (1981), Dickey-Fuller with detrending DFGLS (1979, 1981), Phillips-Perron (PP) (1988), Kwiatkowski, *et al* (KPSS) (1992), Elliott, *et al* (1996), and Ng-Perron NP (1995).

Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests are applied to test the stationarity of a series. The results show that all the variables have unit root at level. However, their first differences are stationary, meaning that they are integrated of order one (I(1)). Table 3.3 shows a summary of used variables' descriptive statistics.

Given that time series under consideration are I(1). In the next step cointegration test is employed in order to test for cointegration between variables.

The cointegration methodology enables investigation of equilibrium relationship among non-stationary series. Several methods test the cointegration such as Engle-Granger (1987) 2-step approach, Engle-Granger-Yoo 3-step (1991) approach, and the Johansen (1988) cointegration test. In this research, Johansen's test is used.

Table 3-3 Stationary test results at level 1%

Variables	N	Mean	Median	Std. Dev	Skweness	Kourtosis	Jarque-Bera	Stationarity	Augmented Dickey-Fuller ADF		Phillips-Perron PP	
									t-statistic	Prob-value	t-statistic	Prob-value
gdpcap (y)	34	10.1968	10.19881	0.1733	-0.2286	1.6458	2.8939	level	-0.181145	0.9908	-0.395247	0.9836
								1st diffs	-4.867725	0.0023	-4.895404	0.0022
inv (k)	34	5.2756	5.3628	0.0847	-1.0576	3.0451	6.3423	level	-3.946883	0.0214	-2.554451	0.3020
								1st diffs	-4.777238	0.0029	-4.907748	0.0021
portinv (p)	24	-5.0036	-4.9430	0.2558	-0.1948	1.7122	1.8102	level	-0.933842	0.9342	-0.933842	0.9342
								1st diffs	-3.842834	0.0355	-5.345843	0.0015
moways (m)	32	-1.8402	-1.8032	0.08265	-2.0062	5.9380	32.9752	level	-3.617607	0.0451	-3.493371	0.0583
								1st diffs	-4.825891	0.0027	-5.228138	0.0010
open	35	0.3263	0.3328	0.2260	-0.1540	1.5538	3.1882	level	-2.656049	0.2599	-2.656049	0.2599
								1st diffs	-6.851318	0.0000	-6.951506	0.0000
def	34	0.1519	0.1004	0.15029	0.2075	1.3061	4.3086	level	1.168592	0.9007	-1.676892	0.7389
								1st diffs	-4.119498	0.0144	-4.119498	0.0144

Table 3.4 shows a summary of cointegration test's results for the sample period from 1991 to 2012.

Table 3-4 Johanson tests result for the number of cointegrating vectors between variables

variables	gdpcap, inv, moways, portinv, open, def							
lags	Hypothesis (maximal)		Test statistic	Hypothesis (trace)		Test statistic	95% critical values	
	H_0	H_1	λ_{max}	H_0	H_1	λ_{trace}	λ_{max}	λ_{trace}
1	$r = 0$	r=1	59.17571	$r = 0$	r=1	109.4035	33.87687	69.81889
1	$r \leq 1$	r=2	26.67780	$r \leq 1$	r=2	50.22783	27.58434	47.85613
1	$r \leq 2$	r=3	11.98261	$r \leq 2$	r=3	23.55002	21.13162	29.79707

The estimated λ_{max} and λ_{trace} identify that there are 1 and 2 cointegrating relations between variables at the conventional significant level (Eviews output reported in Appendix 2).

Given that variables are cointegrated, the next section is dedicated to estimating the long run relationship among them. The impact of port and land transport infrastructure investment on the Belgian economic development is estimated by FMOLS methodology. The next section provides the model's results in the software Eviews.

3.4.2 Model's result

The result of FMOLS method is reported in this section. Tables 3.5 and 3.6 depict the long run and short run - error correction model (ECM) - estimation results.

The elasticity of GDP per capita regarding gross fixed capital formation/GDP (k) is 0.18 - positive and significant - meaning that one percent increase in the capital formation/GDP results in an 0.18% increase in average in the real GDP per capita. The length of highways per capita (m) for the investigated period is found to have the largest impact on GDP (0.71%). One percent increase in the ratio of port infrastructure investment by government to total investment (p) and openness ratio (open) increase in average the real GDP 0.03% and 0.30% respectively. While increasing the ratio of deflator in the transport sector to total deflator (def) decreases the real GDP 0.04% in the investigated time. Finally, one percent increase in technological improvement cause GDP to increase by 0.007%.

Table 3-5 FMOLS estimation of the long run relationship between variables: 1990-2010

Dependent Variable: lny

Method: Fully Modified Least Squares (FMOLS)

Variable		Coefficient	Std. Error	t-Statistic	Prob.
Lnk	α_1	0.185110	0.038063	4.863180	0.0003
Lnm	α_2	0.712382	0.160325	4.443374	0.0006
Lnp	α_3	0.033578	0.012270	2.736588	0.0161
Lnopen	α_4	0.390872	0.051204	7.633576	0.0000
Lndef	α_5	-0.045848	0.022819	-2.009191	0.0642
t	α_6	0.007584	0.000966	7.849661	0.0000
C	α_0	10.36647	0.364516	28.43897	0.0000

R-squared	0.995541	Mean dependent var	10.28712
Adjusted R-squared	0.993630	S.D. dependent var	0.102478
S.E. of regression	0.008179	Sum squared resid	0.000937
Durbin-Watson stat	2.442849	Long-run variance	1.95E-05

Apart from direct effects, investment in the transport sector can raise GDP by triggering related transport sector – supporting activities such as cargo handling, cargo storage, forwarders, agencies, and postal services. This complementary impact has been recognised recently by the Federal Planning Bureau: *Belgium's location [is] close to the Western European consumer market makes it attractive* *for establishing support activities*[3] *for transport. Support activities for transport are the main transport branch in Belgium, with a share of GDP of 2.8%* (Federal Planning Bureau, 2014).

Increasing the ratio of government investment in port infrastructure/total investment causes on average 0.03% growth in GDP. Lee and Do (2015) stated that "…*return on investment of infrastructure projects usually appears in long term periods. So discount rate is appropriate index to evaluate feasibility assessment of projects*". However, the lower rate of elasticity of port comparing to motorways can be due to two reasons. First, the motorways are used for both passenger and freight purposes, while port infrastructure is dedicated mainly to freight. Second, the amount of 0.03% of port infrastructure elasticity represents the direct effect. Port function contribute to the GDP through other channels as well (indirect effects), openness degree of the economy is the best example. Growth in sea transport sector in this period is mainly attributed to increased investment particularly in the sub sectors of shipping and supporting activities (Lagneaux, 2008).

The elasticity of GDP per capita to openness ratio is found 0.39%, indicating that one percent increase in the openness ratio results in a 0.39% increase on average in the real GDP per capita.

The deflator ratio decreases real GDP per capita very slightly (-0.045%). This result is also consistent with the related theory in this area (e.g. Ismail and Mahyideen, 2015; Barro, 2013; Khan and Senhadji, 2001; Ghosh and Phillips, 1998; Christoffersen and Doyle, 1998; Faria and Carneiro, 2001; Bruno and Easterly, 1995; Barro, 1995; Fisher, 1993).

[3] Including financial, legal, IT, handling and maintenance, packing, storage, warehouse, training and training devices, security, and etc.

Table 3-6 Error correction model estimation of FMOLS technique: 1991-2010

Dependent Variable: Δ (Lny)
Method: Least Squares

Variable		Coefficient	Std. Error	t-Statistic	Prob.
Δ (Lnk)	β_1	0.164299	0.107471	1.528773	0.1503
Δ (Lnm)	β_2	-0.005488	0.482069	-0.011385	0.9911
Δ (Lnp)	β_3	0.040084	0.025586	1.566628	0.1412
Δ (Lnopen)	β_4	0.440101	0.085782	5.130490	0.0002
Δ (Lndef)	β_5	-0.062150	0.053040	-1.171762	0.2623
C	β_0	0.006538	0.002896	2.257637	0.0418
ECM (-1)	γ	-0.642982	0.289011	-2.224770	0.0444

R-squared	0.753211	Mean dependent var	0.013511
Adjusted R-squared	0.639308	S.D. dependent var	0.016800
S.E. of regression	0.010090	Akaike info criterion	-6.085362
Sum squared resid	0.001323	Schwarz criterion	-5.736855
Log likelihood	67.85362	Hannan-Quinn criter.	-6.017330
F-statistic	6.612759	Durbin-Watson stat	2.363893
Prob(F-statistic)	0.002214		

with ECM = lngdpcap – 10.36 - 0.18 lninv - 0.71 lnmoways -0.033 lnportinv – 0.39 ln open + 0.04 ln def – 0.0076t

The error correction model (Table 3.6) reveals that changes in the Belgian real GDP are caused by the current changes in the explanatory variables and an error correction term. The error correction term is supposed to show the speed of adjustment to deviations from the long run equilibrium in the previous period. Based on theory, the adjustment term is to be between zero and one and negative to give an adjustment to deviation from long term equilibrium. In this model, the adjustment speed (γ = -0.64) is rather high, meaning that in each period, 64% of deviation gets corrected. A summary of long run and short run results is shown in Table 3.7.

Table 3-7 Land and port transport infrastructure investment effect on DGP

Long run: Fully Modified OLS	**Adj.R^2**	**variables**	**inv**	**moways**	**portinv**	**open**	**def**	**t**
	0.99	coefficient	0.18	0.71	0.03	0.39	-0.04	0.007
		t-statistic	4.86	4.44	2.73	7.6	-2.00	7.85
ECM: OLS	**Adj.R^2**	**variables**	**inv**	**moways**	**portinv**	**open**	**def**	**ECM_{t-1}**
	0.75	coefficient	0.16	0	0.04	0.44	-0.06	-0.64
		t-statistic	1.53	-0.01	1.56	5.13	-1.17	-2.22

The impact of the length of highways per capita, the ratio of port infrastructure by government to total investment, and the total investment on economic growth in Belgium are positive and significant in the long run, but their coefficients are insignificant in the short run. Meaning that increasing these factors does not explain the immediate economic growth. While the openness ratio affects GDP significantly and positively in the long run and in the short run. Therefore, increased openness ratio increases GDP immediately. It highlights once again the role of transport infrastructure in Belgian economic growth since the openness ratio growth depends on a number of factors such as Belgium's strategic location as well as transport infrastructure. The deflator ratio growth causes a decrease in the real GDP per capita in the long run slightly, while in the short run it does not affect GDP.

The estimated results are consistent with theoretical arguments that transport infrastructure functions as an economic growth resource. Results from previous studies (National Bank of Belgium, 2014, 2011, 2009, 2008, 2007) and the input output tables for Belgium in 2010, 2005, 2000, and 1995 (Federal Planning Bureau, 2016) identified the importance of the contribution made by the transport sector – including the impact of re-exporting - to the total Belgian GDP. For example the share of total (direct and indirect) value added of Belgian ports[14] to the GDP and country's domestic employment were 7.9% and 6.4%, in 2012 respectively[15] (National Bank of Belgium, 2014). This fact is described by Duprez and Dresse (2013) with emphasis on the Port of Antwerp as a point of entry and exit of merchandise on a scale that goes far beyond Belgium, and the importance of infrastructure in the European market. The findings of this study also show the importance of the transport sector. Demand for transport infrastructure in developed countries, including Belgium, is predicted to increase.

These contextual factors will be elaborated on in the next chapter where the framework of global production process and transport mechanism will be discussed.

3.5 Conclusion

This chapter identified and quantified the role of transport infrastructure investment and developments in national and regional economic development.

Investments in transport infrastructure can stimulate economic activity, especially in small open economies, such as the Belgian economy. While a number of theories support this view, others question the impact of transport infrastructure investments on economic growth in developed countries.

This chapter highlighted the importance of several variables in this process, including the ratio of gross fixed capital formation to GDP, the ratio of port infrastructure investment by government to total investment, the length of motorways per capita, the openness ratio, and the deflator in transport sector/total deflator ratio. The model illustrates the positive and significant impact of gross fixed capital formation, the length of highways per capita, port infrastructure investment by government to total investment ratio, and openness ratio of the economy as well as technological changes on Belgian economic growth, while the deflator ratio has a negative relationship with GDP in the long time. For the period covered by the study (1991-2010), the "length of highways per capita" variable is the most influential variable while "the ratio of government investment in port infrastructure/total investment" variable is the least influential in this model. In addition, the only influencing factor which contributed to economic growth in the short time is the openness ratio. Other factors do not seem to have an impact on GDP immediately (Table 3.6).

The contribution of the aforementioned transport elements to the economic development would take place through several channels: network effects, improvements in performance, increased reliability and productivity, and increased access to the market.

The positive and significant impact of investment in transport sector on Belgian economy on the one hand, and the substantial future demand forecast in this sector on the other hand necessitates investment in Belgium transport sector.

Although the results of applied model in this chapter indicated rather low economic impact for port infrastructure in the short time, the broader economic effects of transport on GDP generally, and total (direct and indirect) impact of Belgian ports in domestic employment and GDP specifically - found in the input-output analyses and also the contribution through openness degree- appears significant.

Therefore, next chapter is dedicated to scrutinise this contribution, as well as the potential economic development which would be caused by port development in certain conditions in the future.

Following these results which determined the magnitude of impact of strategic transport infrastructure investment on economic development chapter four discusses the characteristics and mechanism of the global economy in which these interactions would form. The conceptual framework in the next chapter specifies that outsourcing and relocating different business functions to different locations is the main theme in the strategic decision making for the freight transport sector, and consequently in the formation of the new economic geography. Furthermore, chapter four highlights the importance of commercial cluster formation in and around a port and how they create a new generation of container ports.

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4. CHAPTER FOUR: THE ROLE OF PORTS IN MODERN GLOBAL PRODUCTION PROCESS

4.1 Introduction

Chapter two reviewed the research-related literature on outsourcing, industrial economics, supply chain management (SCM) and transport-strategic development. Also the performance of ports through SCM and Global Container Transport System (GCTS) in the face of a Modern Industrial Dynamic (MID) environment which has altered the nature of port competition were discussed.

Chapter three estimated the transport infrastructure contribution to the national and regional economy. The role of the port as a part of transport infrastructure for the Belgian economy with high level of economic openness also was highlighted.

This chapter, presents the conceptual framework and describes characteristics and mechanism of the modern market environment in which supply chain players deal with cargo movements. The framework explains port competition and development in the MID environment by investigating the evolutionary trends in the global business environment and its impact on SCM and transport. These trends are the main influential factors for modern port competition. The port competition taking place within the MID environment and the (GCTS) which consists of modal and nodal components (each mode and node is an industry on its own right). Meersman, *et al*. (2012) discuss port entities as a part of the supply chain, the success of which depends on the efficiency of the related supply chain. In this context, this chapter proposes a different approach to contemporary literature for a port competition study; this approach is based on cluster theory. This thesis extends the concept of clusters to consider business function clusters in which business functional activities form the fabric of the links and networks which give rise to competitive advantages in specific locations. Commercial activities as an important business activity for many industries can be located in a same location to form a commercial cluster.

A considerable proportion of commercial cluster elements are port operations and functions which require a port within the very close vicinity. This study discusses these elements and the role of a modern port in a commercial cluster. In cluster theory, any cluster has network effects. This is due to the synergy that the network of business activities would create. This study also proposes that network cluster effects in commercial location would provide a competitive edge for the port, since commercial location accommodates many different industries ranging from car manufacturers to pharmaceutical companies and many others.

The proposed commercial cluster specifies that the port developments and competition in modern times are not only depending on port investment and hinterland connection but also on the commercial cluster (network) effects (see figure 1.3).

The current global business environment (the MID) is shaped by increasing globalization, advances in technology, the combination of increasing product ranges and more demanding customer expectations. Global competitive pressures make the establishment of global supply chains by firms a necessary part of their operations. Transport productivity has become more important and strategic than ever as it connects players in the supply chain. Furthermore, there is a tendency towards a higher level of integration between global transport and commercial systems by the development of intermodal and multimodal systems together with liberal trade and transport policies that provide opportunities for a clustering of shipping, logistics and commercial activities around ports.

Section 4.2 explains how the main characteristics of the MID environment influence the global supply chain strategies which are the response of the firms to MID. This study proposes that it is these supply chain strategies adopted by firms which provide the fundamental connection between the MID and recent developments[16] observed in transport and ports.

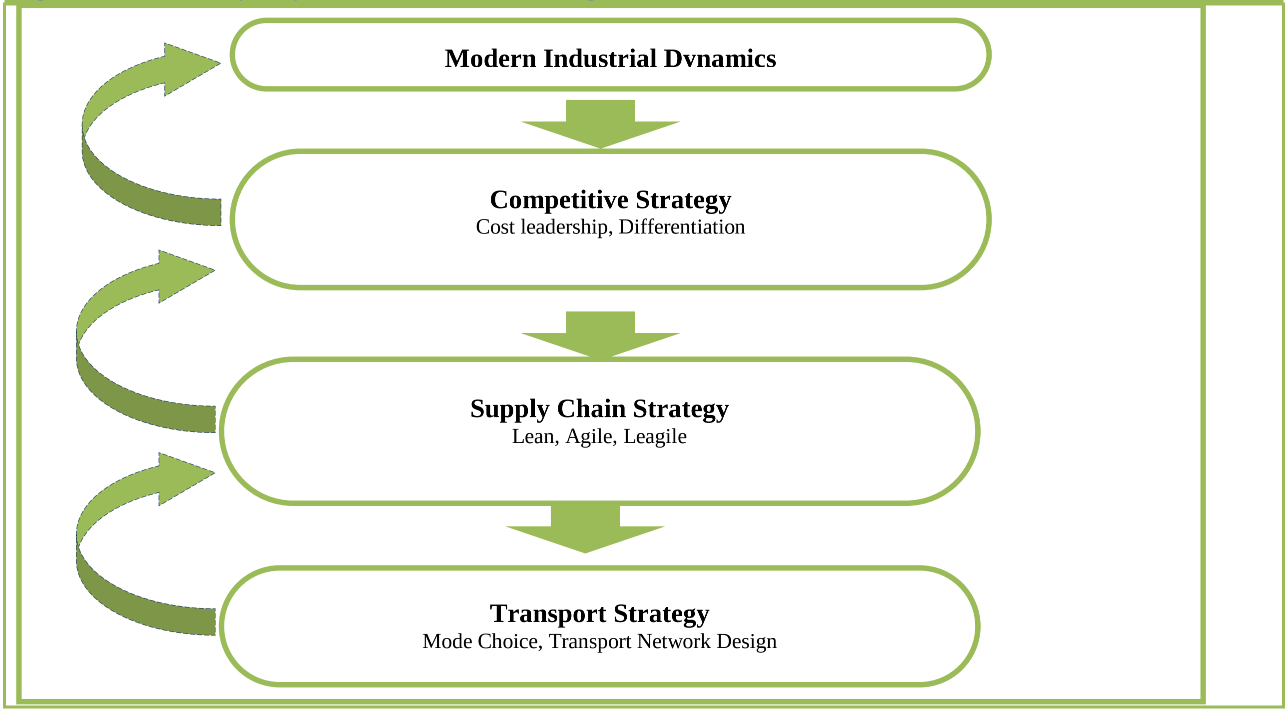
Section 4.3 introduces the concept of the "Global Container Transport System" (GCTS) which is a door-to-door operations transport network connecting spatially diverse manufacturing centres and consumer markets. The GCTS is a value adding chain which integrates transport components from different transport industries, such as land transport (road, rail and barges), marine transport (liner and feeder shipping) and port operations. Specifically, the section explores how land transport, container shipping and port (commercial cluster) formation could be influenced by supply chain strategies and government policies. This is achieved through a discussion of transport value chain, ports, logistics, and different transport modes' market characteristics and performance.

4.2 Firm strategy in MID – global supply chains

With the geographically diverse location of business functions and more global competition, there is a need for efficient and effective global supply chains integrating different firms and functional activities into a single virtual entity. This is why Rice and Hoppe (2001) suggested that competition is no longer between firms but rather between supply chains. Applying this phenomenon to the port industry, it is deducted that "*Successful ports belong to the successful supply chains*" (Meersman, *et al*, 2012). The aim of this section is to examine how global supply chain strategies evolve to better align firms within the MID environment so that firms can remain competitive. This study argues that the key development in global supply chains within MID is the emphasis on material management and service capabilities.

Chapter 2 identified dynamism and part of the environmental uncertainty which shapes the pattern of competition and is also beyond the control of firms. Environmental uncertainty in the supply chain literature is often linked to product characteristics and the corresponding demand uncertainties. Dynamism[17] refers to rapid and unpredictable change in high-velocity environments originating from a change in demand, competitors and technology, which makes it the predominant contingency dimension in the literature (Hauschild, *et al*, 2011; Ward, *et al*, 1995; McArthur and Nystrom, 1991; Dess and Beard, 1984). Dynamism would also be a suitable construct to express demand uncertainty[18]. Alignment and strategic fit in a dynamic environment occurs at interrelated levels (see figure 4.1). For a firm that operates globally, the proposed framework below captures alignment from the top business level down to the level where transportation decisions are made. The framework highlights how firms that have products manufactured globally and transported to distant markets should align their competitive strategy, supply chain strategy and transportation strategy in the light of the surrounding industry dynamism in order to achieve strategic fit.

Figure 4-1 The contemporary MID environment and strategic fit



Source: Own compilation based upon the ideas from Porter (1985, 2000) and Fisher (1997)

The framework indicates that if the competitive environment changes because of industry dynamism, a firm's strategic decision making at all strategic levels must reflect these changes, and thus, a firm might review its transportation strategies. For example, if customers become more price sensitive, a cheaper transportation mode might be the right decision. The framework links a firm's competitive environment (specified by MID), competitive strategy, supply chain strategy and transportation strategy while the alignment of these elements determines strategic fit.

As business is about satisfying customers' needs, customer requirements should be at the centre of consideration while competition contributes to changing customer requirements.

Kano's model (Kano, *et al*, 1984) categorizes the attributes of a product or service based on how well they are able to satisfy customer needs[19]. A competitive firm's supply chain strategy would change according to these characteristics. The form and design of competitive supply chains are influenced by product attributes, location, market characteristics and transport mode availability and port capabilities. Supply chains should be designed so that they meet the challenge of material management which is to match/align the following:

- Markets - manufacturing location, and consumer markets location, market positioning.
- Products - uncertain customer demand in terms of-timeliness; attributes, volume and value.

Cost, quality, delivery and flexibility of logistic distribution network are known by some authors (Chopra and Meindl, 2010; Krajewski, *et al,* 2010; Gaither and Frazier, 2007; Bozarth and Handfield, 2006) as priorities in a firm's competitive strategy. These dimensions are closely related to Porter's generic strategies which are important for this dissertation. Porter's (1985) three generic approaches, cost leadership, differentiation and focus describe how to create competitive advantage. A firm that adopts cost leadership offers the same product or service more efficiently and at a lower cost than the competitor. A differentiation strategy creates competitive advantage if a firm can offer products and services which are attractive for buyers by other factors than cost such as product innovation, unique design, brand image or method of delivery to buyers. To remain competitive, a global firm's supply chain design will be affected by whether the firm chooses a cost leadership approach or a differentiation approach. A summary of attributes of cost leadership and differentiation is presented in Table 4.1.

Table 4-1 Attributes of Porter's generic strategies

Cost Leadership	**Differentiation**
- efficiency	- effectiveness
- standardization	- customization
- mass production	- shorter production runs
- process improvement	- product development
- reduced service	- enhanced service
- stability	- flexibility
- cost accounting skill	- strong marketing

Source: Marcus (2010)

This distinction corresponds to a later classification of supply chain strategies into lean and agile. As a component of supply chains that can create competitive advantage, a port should have capabilities that will enable it to operate flexibly within both lean and agile supply chain designs.

In order to get the 'best from both worlds' (Christopher, *et al*, 2006; Christopher and Towill, 2002, 2000; Naylor, *et al*, 1999) combined the lean and agile supply chain strategies to consider a 'leagile' supply chain by introducing the 'decoupling point'. The concept is based on the assumption that the supply chain should be lean upstream and agile downstream of the decoupling point.

In the context of this dissertation, the particular interest is in those elements of competitive strategy that concern transport operations of supply chain capabilities.

4.3 Global container transport system

Within the proposed framework, attention now turns to arguing how "Global Container Transport System" (GCTS) contributes to material management within supply chains and adds value to products. The focus is on the GCTS from the origin to destination, since this industry is the main contributor to the global production process. The supply chain strategies have affected the freight transport operations significantly.

The GCTS is a combination of multimodal, intermodal and transhipment operations, providing a systematic integration of ports, shipping, road, rail and barge transports. At the operational level, the GCTS is a complex and extensive system which consists of different transport components as modes and nodes. The modes are "road, rail, and barge transport at origin and destination (land transport)" and "shipping lines", whereas the nodes are "ports" and "inland terminals and logistics platforms". These components are interacting within an industrial process in a sequential phases, positioned somewhere in between the manufacturer and the end-consumer, distribution centre or retailer (See figure 1.2).

The system starts with manufacturing, land transport at origin, port handling at origin, maritime shipping, port handling at destination and finally land transport at destination. Using the container as a transport unit in this system provides heterogeneous transport systems,-enabling efficient interaction between different modes of transport, particularly maritime and land. On the other hand, there are major dissimilarities among trading regions due to geographical and infrastructural factors, however, the GCTS links these infrastructures and forms semi-homogenous global transport infrastructures[20].

Furthermore, the GCTS has functional and operational elements. Value adding is the functional element, while the operational element of the GCTS includes land and shipping transport and port operations. For a better understanding of the system functional and operational elements of GCTS are discussed in separate sub-sections 4.3.1 and 4.3.2 respectively.

4.3.1 The functional element of GCTS (value adding process)

The value adding process involves large and complex business functions and relationships, including discrete decisions and well-defined independent actors. The main actors are shippers, ship operators and freight forwarders, with their different factors priorities on port, shipping network and land transport selection. These priorities specify the functional elements of the system. In this system, transport operators bid for shipments based on price and capacity availability with an objective which is to provide more industrial productivity and competitiveness (Merge Global, 2006).

Specifically, the functional (value adding) objective of the GCTS is to improve material management, include just-in-time delivery of cargo, reduce in-transit inventory, and make the total origin-to-destination movement of containerized cargo more accurate. In other words, the purpose is to make the whole supply chain, including all involved transactions, more efficient and responsive to the MID environment. All aspects of operations such as capacity allocation, technological implementation, location selection and scheduling are determined by functional objectives. In this context, "Container transport is therefore not just a logistics convenience measure, but also an opportunity for adding value to the goods transported and to the value of the supply chain performance" (Frankel, 2002).

As a value adding process, the GCTS comprises five connected phases which are involved in transporting a container from manufacturer to consumer. These phases are shipment origination, routing and capacity procurement; container provision; provision and operation of vessels; cargo handling; and inland distribution. The output of one phase will be the input for the next one. Although strictly speaking the initiation phase is not a transport stage, it is an integral part of value creation and is shown here for completeness. This is because the initiation phase is the starting point of the value creation process.

Figure 4.2 illustrates the interrelationship in the process and the value adding role of each phase. It defines each phase and its key activities, major players and competitor types that can be found in them.

Figure 4-2 GCTS Value Chain Phases Definition

	Shipment Origination, Routing, and Capacity	Provide Containers	Provide And Operate vessels	Load and Unload Shipments	Inland Delivery
Key Activities	• Customer sales • Shipment routing • Capacity procurement • Customer service • Billing • Trading	• Ownership of containers • Storage and maintenance • Repositioning	• Ownership of vessels • Operation of vessels	• Terminal control (ownership or lease) • Terminal operation • Container handling	• Control of stocks • Ownership of railroads • Container handling
Competitor types	• Container carriers • Forwarders/NVOCCs	• Container carriers • Container leasing companies	• Container carriers • Outsources/ third party • Dry leases • Wet Leases	• Container carriers • Captive terminal operators • Third-party terminal operators	• Railroads • TL truckers • Drayage truckers • Container carriers (limited)

Source: MergeGlobal (2006)

4.3.2 Operational element of GCTS

The operational elements of GCTS can be divided to modal and nodal components. The modal components of the GCTS comprise container shipping and land transport, made up of road, rail and barge transport. The nodal component of the GCTS is the port and inland terminals; the main concern of this section is port evolution to commercial location.

4.3.2.1 Modal components of the GCTS – (1) Container shipping

In order to understand the market structure of container shipping, this section reviews trends in the container shipping business, and pricing strategies together with operational strategies and network formation and discusses the reasons for and role of various co-operation agreements in container business.

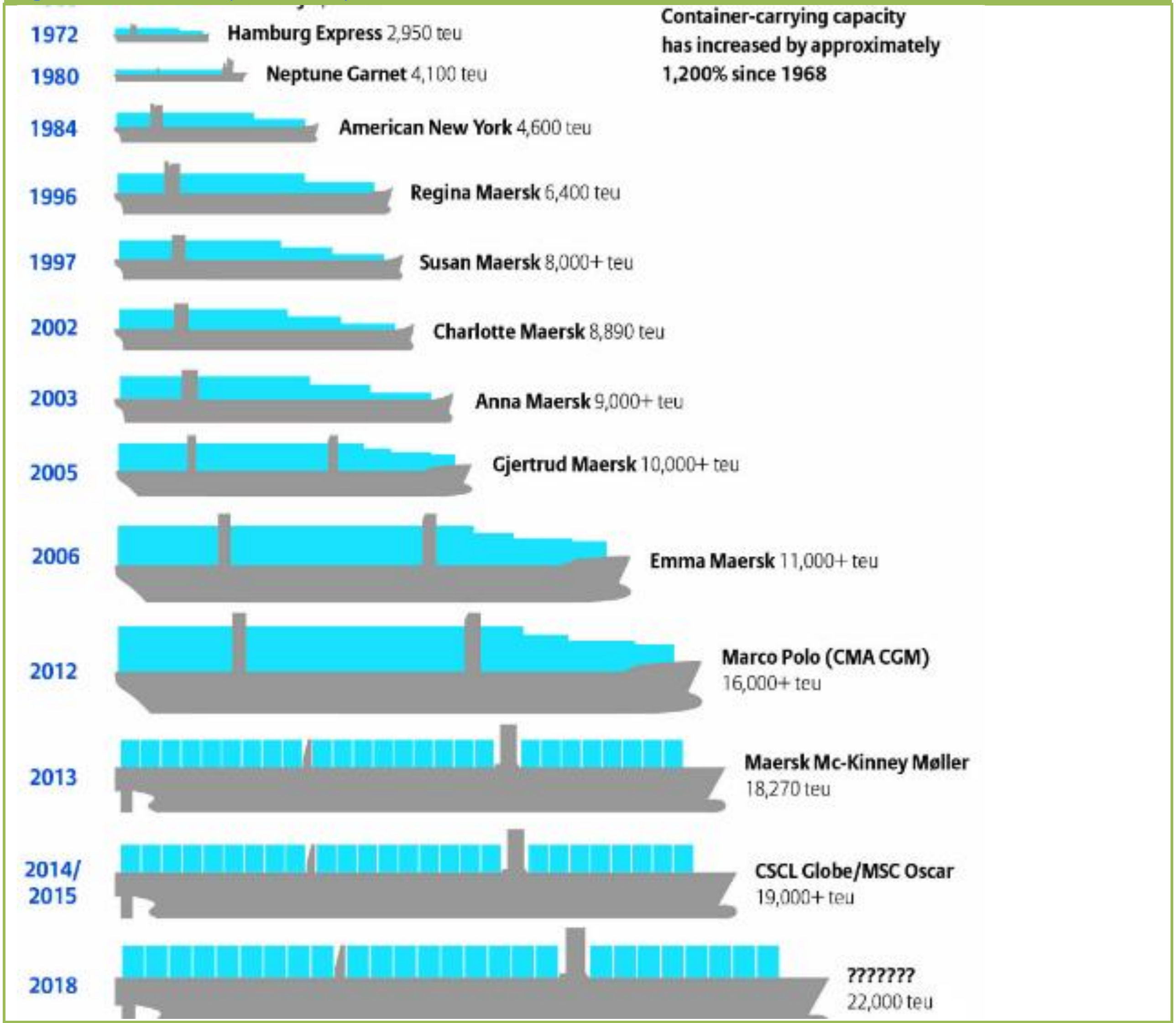
The distinctive features of container shipping are captured by Kumar and Hoffman (2002). They define container shipping as the business of offering common carrier[21] in shipping services for international trade. Historically, the goal of container shipping has been to provide efficient and reliable sea transport services at predictable rates. Container shipping refers to a fleet of ships for a fixed liner service at regular intervals, rather than a single vessel. This characteristic makes container shipping more capital intensive than other shipping sectors.

From the above, four main distinctive features of container shipping can be noted. First, a container shipping service has to be regular and scheduled. Second, with container shipping services, guaranteed cargo space has to be always available. This implies that container shipping has to have at least some overcapacity to provide guaranteed cargo space to provide logistics flexibility. Third, there are a large number of shippers involved in container shipping. This feature means there is a need for complex administrative work, with large overheads. Fourth, unlike other shipping sectors, where ships follow cargo, in container shipping, generally cargoes have to follow network configuration and the route associated with it. However, if specific needs of big shippers for container trade arise, chartering medium sized containerships can provide alternative services to fulfil the business requirements (Cudahy, 2006).

A key development is the increase in demand for and size of container ships. This is due to two factors – the growth in the global container trade and the development in containerization. It is possible to break down growth in the size of ships into five generations in terms of capacity in TEU as shown in Figure 4.3. The second key development is the concentration of container trade in three regions (North America, Europe and Asia) together with the formation of global shipping networks. The need to connect these regions is a major influential factor on supply, pricing and profitability in container transport. Any shipping line with global presence can hardly avoid a contribution on key east-west routes linking eastern economies to western economies. Specifically, the level of consumer spending in North America (NA), Europe and Asia accounts for a significant proportion of the overall demand for container shipping. For example, in the US, consumer demand accounts for 69% and in Europe 59% of container trade volumes, however, Europe generates the highest level of container demand

(MergeGlobal, 2009a). Therefore, sustainability of the consumer sector is a major factor for sustainability of container transport.

Figure 4-3 Container ship size developments

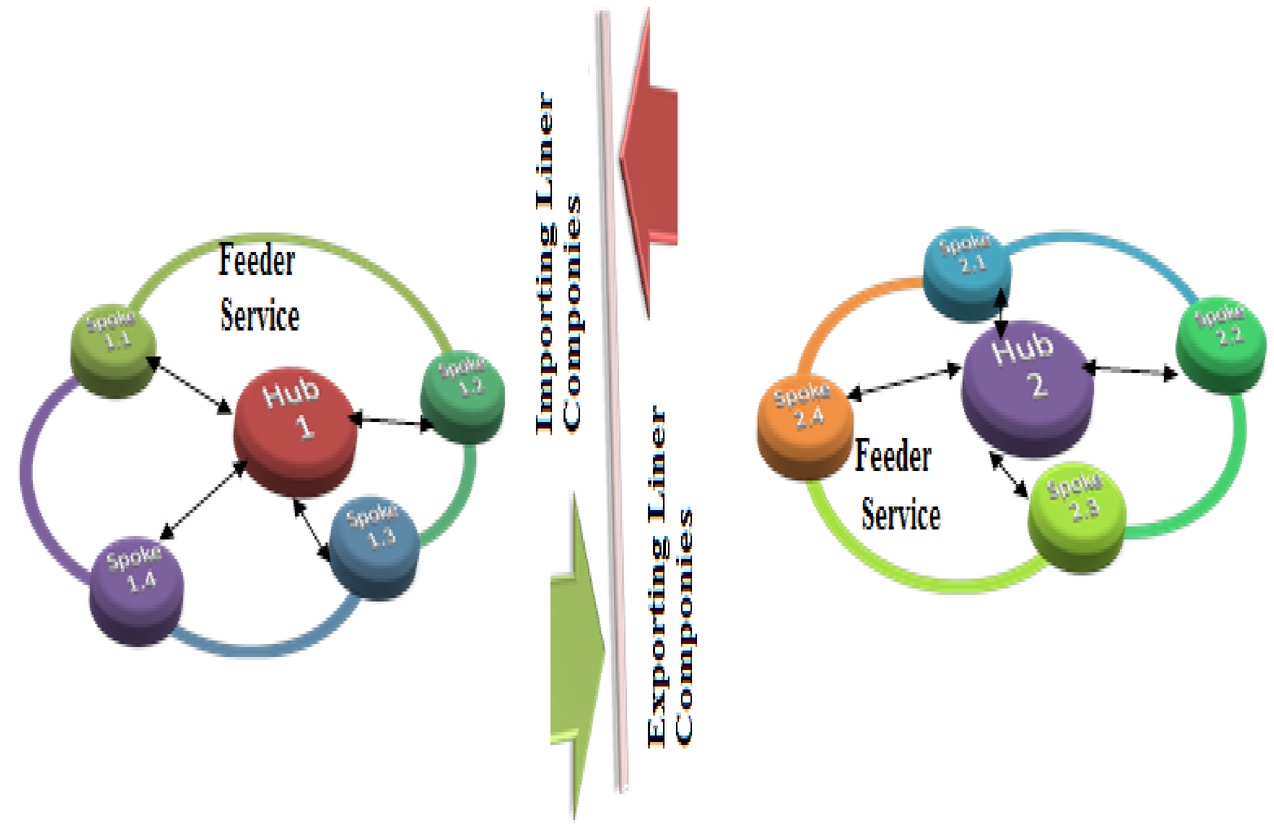


Source: World Shipping Council, 2016

Out of the expansion in global trade and the corresponding increase in ship sizes have emerged two alternative operational strategies, comprising two general network configurations: a) Indirect shipping through a transhipment hub, b) direct shipping from port to port.

Figure 4.4 illustrates a simplified version of the transhipment system. This model consists of two hubs and four spokes for each hub. The model specifies the hub-to-hub interconnectivity through liner shipping services and hubs-to-spokes connectivity by feeder services. The transhipment system would depend upon this interconnectivity. Transhipment is a very dynamic and complex system. At macro level, it involves port competition, container shipping specification and country- and regional-economic diversification. At micro level, it involves company and industry strategies and decision making behaviour, resource allocation and fund management.

Figure 4-4 Simple container shipping transhipment system: hub and spoke system

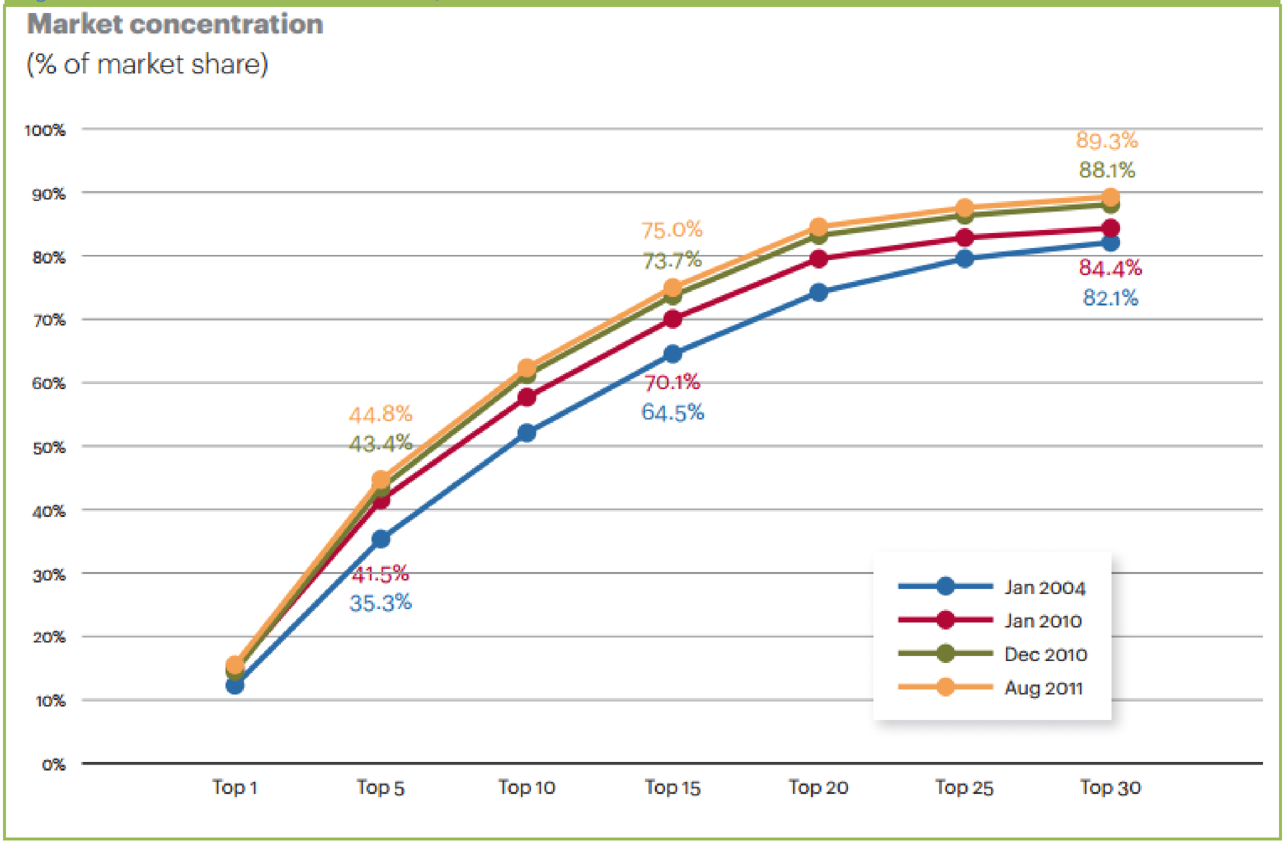


Total container shipping transport costs are divided into composition, national/international and decomposition costs. As a system, transhipment connects infrastructures around the world to create trading networks and serve as main platform for transport productivity by achieving economies of scale (Rodrigue, *et al*, 2009).

On the supply side, productivity improvements suggest that container shipping will continue to growth with large ships and more pressure to move towards a hub-and-spoke system. This pressure may result in greater instances of alliances, mergers and consortia.

The need for huge capital investment for the container shipping business has encouraged cooperation. This fact encouraged both vertical and horizontal integration among carriers to satisfy the requirements of larger networks with global coverage (Fugate, *et al*, 2010; Glen, 2003). Forming strategic alliances is one way of horizontal integration. But developments in world trade flows forced the container shipping operators to use vertical integration methods especially through merger and acquisition which are also used for horizontal integration. Increasing mergers and acquisitions between operating and shipping companies indicates intensified concentration in the container shipping sector (Sys, 2010; Van de Voorde and Vanelslander, 2009). Nevertheless, there is an agreement in the container shipping sector that alternative forms of co-operation such as global alliances, consortia, mergers and acquisitions, and discussion agreements are complementary features of the industry as they provide important benefits to the container shipping firms and their customers (Fugate, *et al*, Glen, 2003; ELAA, 2003; Fremont, 2008). These trends in container shipping raise some concerns regarding the increasingly concentrated industry in terms of pricing strategy, geographical coverage and ownership. Sys (2010), in a comprehensive study of shipping capacity concentration, quantified the Gini coefficient, from 1999 (0.6466) to 2009 (0.7716), which indicates a significant increase in concentration. Figure 4.5 shows the increase in concentration since 2004.

Figure 4-5 Container market concentration, % of market 2004 -2011 share



Source: AT kearney, 2012

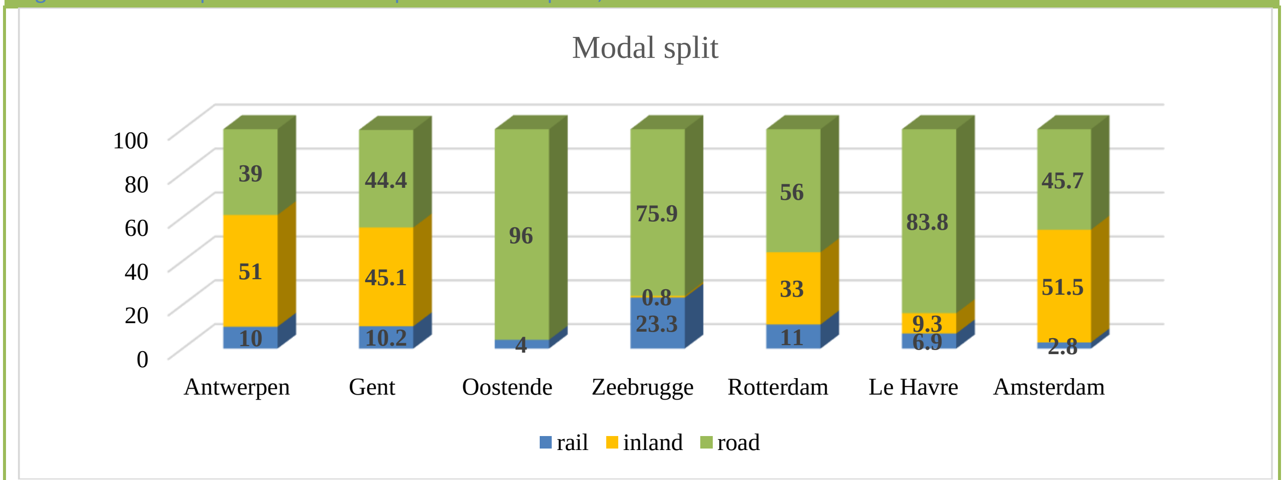
Under such a market structure, a common practice is that the freight charged for moving high value products by container is higher than that charged for moving low-value products even though the incremental cost of shipping is the same for both of them (Brooks, 2000). However, there are some limitations which may prevent carriers from implementing efficient price discrimination strategies. The carriage of cargo in standardized modular containers, and the diverse nature of the goods shipped, may prevent carriers from finely differentiating between cargoes. They point to evidence that higher value cargo may be more expensive to transport because of refrigeration and handling requirements or higher implied damage liability. Cargoes also have different packing densities and as a consequence utilize different amounts of container space, implying different handling costs (Sys, 2010).

4.3.2.2 Modal Components of GCTS – (2) Land transport

This part of the GCTS transports products from the manufacturer to the international marine port. The same applies for transport from the destination port to the customer, retailer or distribution centre. As these are inland modes for national or regional transport services, they are significant in the first and last stage of GCTS and in regional trade and port hinterland expansion, rather than in global transport. Cargo is mostly transported to/from port by truck, rail or barge. Unlike container shipping transport, globally operating firms are faced with having to choose the mode of land transport which provides them with a competitive advantage. The combination of different modes of transport refers to multimodal transport[22].

The port inland modal split depends on hinterland geographical coverage and supply chain preferences and design. Main European port inland transport is dominated by road transport (see Figure 4.6).

Figure 4-6 Modal split at selected European container ports, 2010



Source: Meersman, *et al.* (2011)

However, as road traffic increases and environmental considerations become the main government policy issue, there is a strong tendency to diversify modal options towards rail and barge, which provides better economies of scale as well as being less carbon-intensive per ton/klm. "This is particularly the case of Antwerp and Rotterdam along the Rhine Scheldt Delta which has enabled them to develop barge services that now account for more than 30% of the containers transhipped at the ports. Ports that have grown recently, such as Constanza, Bremerhaven and Zeebrugge have been able to better integrate with hinterland rail connections since on-dock or near-dock facilities were part of the terminal design" (Rodrigue, *et al.*, 2009).

4.4 Aligning transport mode capabilities with supply chain strategies

The proposed framework of Figure 4.1 argued that firms have aligned their strategies with MID including transport strategies. This will be applied to inland transport mode choice. The framework identifies several steps in order to link transport mode choice with supply chain design in the MID environment.

In order to determine transport mode choice factors, the criteria list compiled by Cullinane and Toy (2000) offers a reference list from which a selection is made. The selected criteria which can be explicitly linked to transport mode decision are cost, speed, transit time reliability, characteristics of the good, flexibility, loss/damage, frequency, inventory and sales per year.

The cost / price / rate presents the freight rate of the mode, the real transport cost. Speed is defined as the transit time required for moving goods. Transit time reliability is the ability to deliver a certain good in the prearranged time. Characteristics of the good are considered in two dimensions. First, the physical dimension, which comprises the value in monetary terms, the volume in terms of the amount of the good shipped and the weight of the good, all ranging from low to high. The second dimension is the type of the good which is defined as manufactured good (products that have undergone some form of value added) and commodity (products that have not undergone some form of value added). Frequency of service refers to convenient and flexible scheduling, security to the possibility of goods lost or damaged. The comparison of road, rail and barge transport modes is shown in Table 4.2. This table is illustrative and is obtained from three researches. The advantages – in green cells - and disadvantages – in red cells - of inland transport modes can be clearly allocated through the illustration in this table. Using value and value-to-weight characteristics, products shipped can be allocated to rail/barge transport for those with low value and low value-to-weight and to road transport if the product has a high value and a high value-to-weight ratio.

Table 4-2 Inland transport mode selection criteria

Mode selection factor	Specification	Rail/Barge	Road
Characteristics of the good	Value Weight Volume Value/ weight ratio	Low- medium Low- high Low- high Low	Medium-high Low-medium Low High
Cost	Price/ Rate	Low	High
Speed	Transit time, Terminal time, Transhipment time	Low	High
Transit time		Lower	Higher
Frequency of service	Convenient schedule Flexible schedule	Lower	Higher
Security	Loss and damage	More likely	Less likely

Source: Own compilation based upon Porter (1985, 2000) and Fisher (1997)

Inland transport has a large impact on supply chain strategies; it is the enabler for either an agile or a lean supply chain (Stavrulaki and Davis, 2010; Mason-Jones *et al*., 2000, Naylor, *et al*, 1999).

Lean logistics practices including rail / waterways transport do not meet the requirements for time-sensitive products. Agile supply chain practices includes road transport as it must be flexible and quick and relentlessly focuses on providing a certain level of responsiveness and a high service level (Mason-Jones, *et al*., 2000).

The control of such agile supply chains lies primarily with the manufacturer which also has often direct contact to the customer by minimizing or excluding supply chain intermediaries such as distributors or retailers (Stavrulaki and Davis, 2010). Since the decoupling point is positioned at the manufacturer level, lean practices must be applied upstream from raw material supplier to manufacturer and agile downstream from manufacturer to the customer (Naylor, *et al*, 1999).

Based on this analysis, the holistic strategic fit model has been developed, as illustrated in Figure 4.7. The view taken in this dissertation is that competitive strategy and supply chain strategy reflect the firm's competitive environment which is the determinant of a firm's transport strategy.

Figure 4-7 Holistic strategic fit model

Mode	Product	Competitive Strategy	Supply Chain Strategy	Decoupling Point	Stage in Product life circle	Product life circle	Transportation Requirements	Industry Dynamism
Road	Innovative	Differentiation	Agile	Downstream	Introduction/ Growth	Short	Speed-to-Market Flexibility	High

Mode	Product	Competitive Strategy	Supply Chain Strategy	Decoupling Point	Stage in Product life circle	Product life circle	Transportation Requirements	Industry Dynamism
Rail/barge	Functional	Cost leadership	Lean	Upstream	Maturity	Long	Cost efficiency	Low

The model is based on the idea of strategic fit which means that strategic decision making should be aligned to all stages of decision making: decisions from the business level down to the functional level where transport decisions are made. The model suggests that decision making should be made in the light of a firm's operating environment, thus industry dynamism has an influence on decision making at all strategic levels. As dynamism reflects changing customer preferences and competitor behaviour, product characteristics are the decisive drivers for the level of dynamism. The alignment of the elements of the model determines the level of strategic fit. The degree of strategic fit among these elements affects firm performance. The model also says that if the competitive environment changes, and thus the level of dynamism, a firm's strategic decision making at all levels must reflect these changes.

4.5 Nodal component of GCTS – Container port evolution to commercial cluster

As ports represent the only node in the GCTS, their role in linking modes and attracting more business so as to achieve more business and providing the capacity to serve more of the hinterland is crucial in the GCTS and consequently the supply chain.

A commercial location is a location with augmented comparative advantage elements, logistics and commerce characteristics. The quality, cost, and efficiency of these services influence the commercial location's comparative and competitive advantages. A commercial location has to perform as a gateway and as a transhipment hub. Furthermore, a commercial location should develop services that add value to the cargo by the existence of a concentration of interrelated logistics facilities and firms within or in the vicinity of the port area. This port area must be well integrated into a Free Trade

Zone. This potential value added through the logistics input and the high level of integration with the free trade zone are what will change the competitive position of the port.

Each of the areas in which restructuring and development is needed for a port to evolve into a commercial location and so be in a position to form a cluster are now explored. These call for a different approach to studying port developments and competition. To provide a better understanding of this proposed commercial location, sections 4.5.1 to 4.5.5 discuss its possible requirements and different aspects and effects on the national economy.

4.5.1 Commercial location technical and operational characteristics

A port is depicted as a node in the GCTS because ports represent the only locations in which shippers and GCTS actors could concentrate their commercial and business activities to form a commercial location. To facilitate the needs of shippers and GCTS actors, ports should obtain high-standard technical and operational characteristics.

With the growth of trade and economies of scale associated with large ships, ports are under constant pressure to develop their productivity. A port handling panamax and post-panamax containerships should obtain technical characteristics related to berthing depth, stacking density, crane productivity, dwell time, truck turnaround time and accessibility to land services. A new generation of container port should function far beyond the basic container port with significant expansion in infrastructure, equipment and operational procedures. Ircha (2006) identified how basic ports differ from modern ports. Since a commercial location must be a modern port - such as Antwerp, Rotterdam and Hamburg in Northern Europe. Table 4.3 indicates how a port's technical capability needs to change to adapt to an MID environment and becomes a commercial location.

These improved technical and operational characteristics contribute to the differentiation and competitiveness of a port location, since they provide commercial and logistics preferences for both transport operators and shippers. However, the competitive advantage gained from these is not sustainable. Although port infrastructure and equipment need significant capital investments, their setting is replicable as they involve fairly standard technologies. To gain long term and sustainable competitive advantage from technical and operational upgrades, it is necessary to also have physical infrastructure which provides effective access to the main hinterland and beyond as well as a government trade and transport policy framework which facilitates trade and transport logistics which mainly concern port functions.

Table 4-3 Technical and operational characteristics of basic port and commercial location

	Basic port	Commercial Location
Technical Characteristics		
Berthing depth	12 to 15 meters (40 to 50 feet)	More than 15 meters (50 feet)
Stacking density	1,000 to 1,200 TEUs per hectare	2,000 to 4,000 TEUs per hectare
Ship-to-shore gantry crane productivity	About 20-30 movements per hour	About 40-50 movements per hour
Daily throughput per ship	3,000 to 4,000 TEUs	5,000 to 6,000 TEUs
Dwell time at container yard	About 6 days	About 3 days
Truck turnaround time	About 60 minutes	About 30 minutes
Rail access	In port area	On dock
Operational Characteristics		
Trade facilitation	Modal access (dock, siding, road), unloading areas	Free trade zone, logistical services
Distribution centres	Intermodal lifting equipment, storing equipment	Translating, cross-docking, warehousing, temperature controlled (cold chain)
Storage depot	Yard for empty and loaded containers	Container depot, bulk storage
Container services	Administration, maintenance, access (gates), information systems	Washing, preparation, repair

Source: own compilation based upon Ircha (2006)

As argued in Section 4.2, supply chain material management induces demand for transport in MID because of the new interdependency between manufacturing and retailing[23]. Material management in a supply chain requires a commercial location with extensive global connectivity and hinterland accessibility.

4.5.2 Commercial location and accessibility

In the MID environment, gateways and transhipment ports are critical transport components for connecting internal transport networks to global networks, and therefore a commercial location should perform both functions. The gateway function of a commercial location should not only facilitate the interface between sea and land transport, but also meet several connectivity requirements of supply chains, such as distribution centres, warehouses and even insurance and finance. Gateways would be establishing in a physical location with close proximity to highway junctions, confluence of rivers, seaboards, together with a significant transport infrastructure such as terminals and their links. A gateway is the entrance to and the exit from its hinterland, region, a country, or a continent. It tends to be an intermodal and multimodal entity while a transhipment hub tends mostly to perform transmodal–and transhipment operations. A commercial location would emerge in a geographical location with a high level of accessibility to local, regional and global economic centres. Thus, ports should adapt their geography with increased location flexibility. That can be achieved by expanding and relocating major terminals and distribution centres further away along transport corridors to more peripheral locations with land availability and transport network connection. Transport corridors are connecting gateways to the hinterland. The concepts of centrality and intermediarity are particularly relevant to the emergence of a commercial location given that one is concerned with a location / node as an origin or destination of trade, while the other focuses on a location / node as a transitional location where a transport mode interface is carried out.

Transhipment ports are key elements in the long-distance container traffic and their operation can have a significant impact on container trade flows globally. Transhipment ports function as a global distribution centre from where products are shipped to customers or as a manufacturing facility where semi-finished products are finally assembled and then further delivered to customers. Furthermore, transhipment ports act as midpoint for cargos from and to feeder ports. The practice of using some ports as midpoints is being used more and more in container liner shipping. These midpoints or intermediate hubs make it possible to connect geographically diverse parts of a global shipping network by facilitating hub and spoke operations. Development of a commercial cluster requires both gateway and transhipment port functions.

4.5.3 Commercial location and extra value adding functions

Additionally to modern port technical and operational characteristics and accessibility, a commercial location should comprise a logistics zone in order to provide further added value functions (see Table 4.4).

Table 4-4 Value adding functions in a commercial location

Function	Overview
Processing	Operations on the goods: Includes sorting, packaging, testing, assembling.
Distribution	Operations on the cargo: Consolidation, deconsolidation, transloading or cross-docking.
Customs clearance	Releasing and/or inspecting inbound cargo (Assumed by a national customs authority).
Free trade zone	Imported and domestic goods considered to be outside of the customs territory. Requires bounded transport and bounded warehousing.
Container depot	Handle containers (leased or carrier owned), transfer custody of containers between shippers, storing and servicing/repairing containers.

Source: Adapted from Rahimi, *et al* (2008)

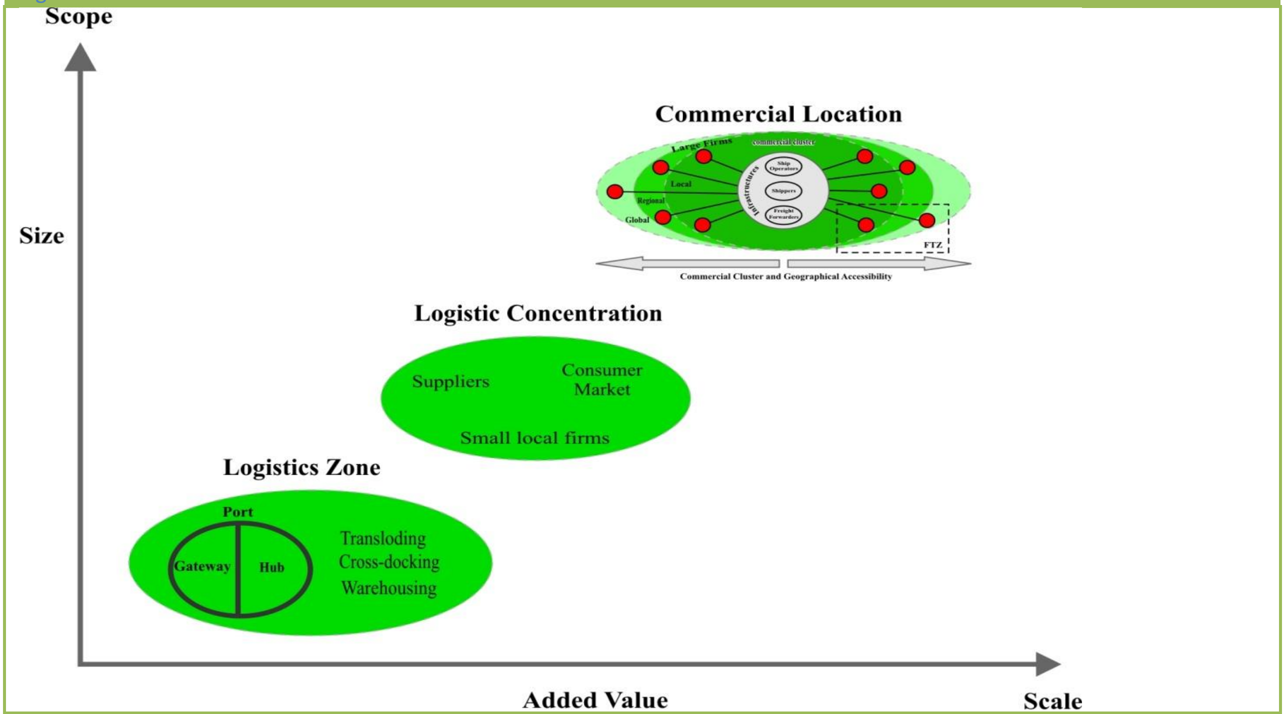
The main value adding elements of a logistics zone should form around gateway and transhipment port operations and functions. The scope and scale of these elements are illustrated in Figure 4.8 which shows the development process that tends to be simultaneous.

In Figure 4.8, a logistics zone develops out of the combination of transhipment ports and gateway ports with modern technical and operational characteristics. In the logistics zone, there is a specialisation in freight movement services and activities such as intermodal terminal operations. These carry out operations such as transloading, mainly in the close proximity to the gateway. The logistics zone instead of limiting itself to transferring freight between shipping and inland transport systems should maintain the whole scale of value added activities associated with global commerce ranging from financing to multimodal and intermodal infrastructures, transloading, cross-docking and warehousing.

The logistics zone develops into logistics concentration as a result of government's policy regarding warehousing and freight distribution activities. These policies provide a specific area for private firms to develop their regional supply chain, distribution and commercial activities. Logistics concentration is the outcome of mutual understanding and joint action of high level government departments and the private sector. It needs deregulation as well as large scale infrastructure investments.

A commercial location evolves from logistics concentration and has value added benefits from port technical and operational upgrades, logistics zone, and logistics concentration accessibility and business environment. This allows for the formation of a network or clusters of different large and small commercial and logistics firms and trade activities in a specific location. These activities comprise warehouses, distribution centres, transport terminals, offices and other services such as utilities, parking space and even hotels and restaurants. These activities need a high level of integration between the firms and distribution centres and higher interconnectivity between transport terminals and the logistics zone together with existence of free trade zone (FTZ) within the location. As mentioned in the introduction to the chapter, most of the commercial cluster elements are port operations and functions. Furthermore, it has been stated that due to the synergy that the network of business activities within the port vicinity would create, the commercial cluster has network effects. This kind of port development are industry-specific logistics and supply chain development, thus attract specific investment which form further port specialization. The policy makers need to support this environment by understanding the requirements of main supply chain players in order promote the effectiveness of the cluster.

Figure 4-8 Commercial location and added value



This setting which consists of large and small firms forms a business network. This business network or commercial cluster provides further level of service flexibility in distribution networks and results in an efficient intermodal freight distribution system which advances supply chain management strategies and even acts as a buffer. This arrangement should provide connections to regional economic areas and also offer direct access to global shipping networks. The development of commercial clusters results in economies of scale since it allows for lower transport costs and reliability, general cluster benefits to be realized and the sharing of the same logistics and commercial facilities and equipment by many firms. Verhetsel and Sel (2009) introduced the concept of "World Maritime cities" in conjunction with concept of "world cities" which initiated by Friedmann (1986). The "World Maritime Cities" mainly focuses on maritime institution and shipping cooperate (companies) concentration within a city. The study categorizes different levels of concentration such as Alfa, Beta and Gamma and based on these categories differentiated the maritime cites to different level of maritime developments. The "Commercial Cluster Concept" focuses on cluster formation based on maritime operational and technical characteristics and differentiates the ports by hub and spoke. The main difference between these two approaches is that, in maritime city approach, city development can change the level of a city maritime level. However, in a commercial location approach, port development is the main determinant of hub and the spoke system formation. In this approach, some ports with significant city developments will remain as spoke, while some others with limited city development can act as a hub, such as Malta. Furthermore, in many cases, shipping and logistics operational development may prevent the city institutional development and vice versa. The above analysis suggests a different approach to understanding port development and competitiveness. Cluster theory considers clusters an important factor in determining competition between nations, regions and industries. Clusters are a collection of interdependent firms which are located in a same area to form a value chain. The application of this way of thinking to logistics and port analysis provides a better understanding of the main elements of a successful port in "Modern Industrial Dynamics". The commercial cluster naturally should form around a container port and consists of firms involved in the different transport, distribution and commercial activities.

4.5.4 Commercial locations and cluster formation

Krugman's (1998) definition of clusters, as discussed in chapter two, describes clusters as comprising linked industries and other entities important to competition[24]. However, this classical view of clusters does not capture the dynamics of modern cluster formation in MID and how differences in business activities of an industry and the industry itself affect competition and regional specialisation.

It does not differentiate between industries and the individual business functions undertaken within industries. To fully understand and explain clusters in MID, it is necessary to disaggregate industry into business activities and redefine cluster formation in terms of business functional activities. This research defines commercial cluster as it comprises all commercial business activities within a supply chain.

As businesses seek to respond to the challenges and opportunities posed by geographical shifts, demand uncertainty and the diversity of global markets in a competitive way, they split business functions, locate and possibly outsource them to where there is a regional comparative advantage and link these locations and firms rather than have all the business functions located in one place. By relocating business functions, firms can convert regional comparative advantage into firm-specific competitive advantage. A firm's overall competitive advantage would be the aggregate of its competitive advantage in the individual functions, which underpins the formation of business function clusters in different locations.

This new concept of a business function cluster as a unit of analysis is better connected with the MID characteristics and the role of government policies. This concept of cluster highlights the importance of competitiveness of every business' functional activity in overall firm's competitiveness.

Financial clusters provide a long-standing example of business function clusters and have been acknowledged in the finance literature. Chan, *et al* (2003) stated that "*Many companies are listed in multiple [stock] markets worldwide, but they are usually traded on the home market where the core business is located. Furthermore, because the business and trading hours overlap in the home market where economic information is released, the home market naturally becomes the most active trading place.*"

This chapter argues that commercial function is distinct from the other functions in that placing this function in a particular location depends on that location having a unique combination of physical and transport infrastructure, specific geographical features and liberalised trade and transport and business environment. Commercial activities would only take place where there is extensive port, logistics, shipping and land transport comparative advantages together with liberalized commercial institutions and structure. This research study also extends the transport and commercial literature by introducing the concept of “commercial clusters” that are formed in unique locations which will be referred to as “commercial locations”. A commercial location has a geographical comparative advantage in transport and commerce. However, these comparative advantage factors by themselves do not give the location or port a competitive edge. To turn the comparative advantage into a competitive edge, there is a need for appropriate government policy which maintains and develops these comparative advantages.

Clusters are important for economic development and the competitiveness of nations. Governments, therefore, can through national and regional policies influence cluster formation and development. In the global economy, sensible macroeconomic policies are necessary for cluster formation but not sufficient. Governments should also produce more incentives at the micro level by understanding the firm’s location requirements. In this context, eliminating barriers that limit cluster formation and facilitating cluster formation and development are important policy issues[25].

In the MID environment, there is an obvious tendency towards a higher level of integration between global transport and commercial systems. To achieve this level of integration, there is a need for further development of intermodal, multimodal and transmodal system together with deregulation and appropriate trade and transport policy to provide new opportunities for shipping, logistics and commercial activities.

A commercial cluster forms in a location that can provide shippers with entire commercial and logistics requirements. In other words, it is the outcome of commercial decisions by commercial actors who are attracted by the ability of the cluster to provide the desired level of logistics and commercial services which add value in terms of customisation, frequency, flexibility, efficiency, effectiveness and accuracy.

Commercial activities need to be located in a region with distribution infrastructures that can maintain trade between numerous partners. In addition to transport infrastructure, such as ports and terminals, and distribution networks, there is a need for logistics services and a transactional environment to support global trade in MID environment.

Logistics services are a complex combination of services for the global circulation of freight that includes performance of distribution, insurance and marketing. The transactional environment comprises the legal, political, financial and cultural environment in which a commercial location operates. This is determined by factors such as exchange rates, regulation, tariffs, manufacturing, and consumer preferences.

4.5.5 Commercial cluster effects and port competition

Cluster effects emphasize competitive advantages gained exogenously through networks rather than from the internal capabilities of an entity. As more business activities depend on outside firms, support services, and local institutions, it becomes more important to locate within a strong cluster to gain benefits that are difficult for an outsider to achieve. In this context, the government's role should be a facilitator rather than director.

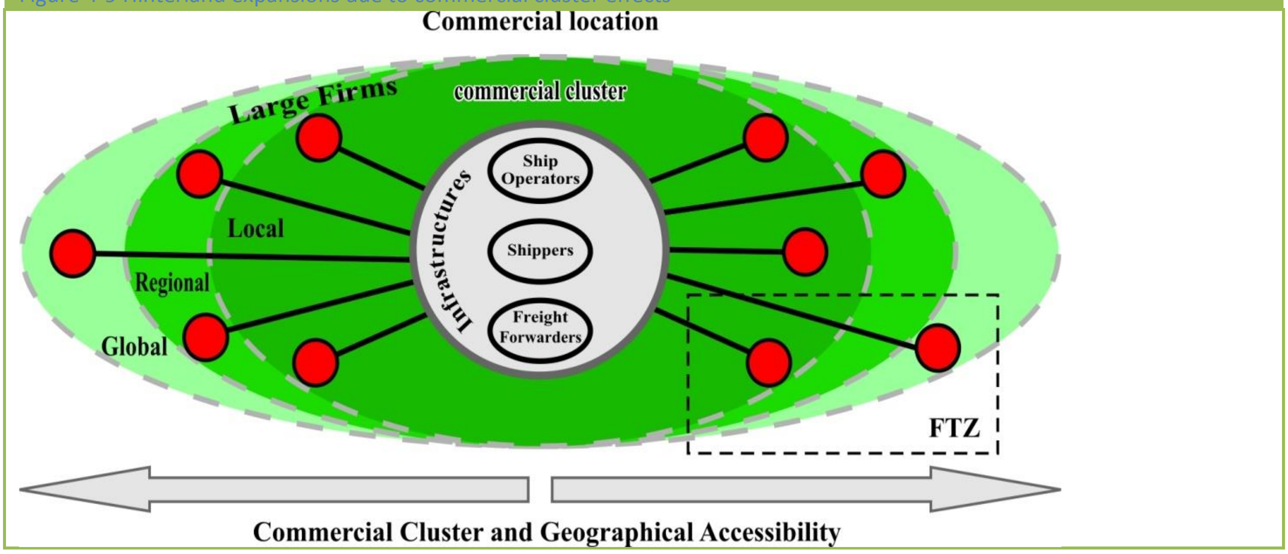
Apart from the logistics and commercial activity concentration that characterizes a cluster, a commercial cluster includes logistics companies and administrative and governing organizations. Figure 4.9 shows how the effect and performance of the commercial cluster depends on the value added generated by the cluster, and is shaped by the interrelationships between the structure of the cluster and its governance.

A particular threat to ports in MID is that ports can be replaced and substituted, not because of limitations in their shipping and transport capabilities but because of requirements to organize the supply chain in a particular way. Some ports may have weak bargaining power as aspects of port choice may not be under the control of the ports. Supply chain concerns therefore can dominate issues such as to how well a port performs. In this case, to increase the bargaining power of a port, it is important to have all components and players in the supply chain located in the port. As port competition intensifies in MID, two associated effects would emerge, which are an enhanced port competitive position and hinterland expansion. The first effect of a commercial cluster is to enhance the competitive position of a port relative to other ports and reduce the threat of a port being substituted. The network effect is the product of synergy between businesses, institutions and factors presented in Figures 4.8 and 4.9. Developments in any of these would have a positive knock-on effect on the others and on the entire cluster.

In this respect, the port competition strategy should shift from attracting physical trade to providing commercial attraction and incentives to businesses in order to form a commercial cluster. A commercial cluster would create a strong synergy in businesses, commerce, technology development, providing components, and human power and information sharing by establishing a network and interacting among companies, universities and research institutes gathered in a certain area.

A second effect is in hinterland expansion. Hinterland expansion does not depend solely on land transport connections and availability but also on the multiplicity of business connections and relationships between the cluster components with the hinterland and global trade. With containerization and the economies of scale that have been achieved in shipping, land transport costs are now relatively much higher than those of sea transport. This difference in cost is an important consideration in supply chain design and port choice. Commercial cluster multiple connections and synergy (network effects) allow the exploitation of complementarities between parts of the supply chain, they can enable a firm to reduce these hinterland costs and the competitive position of the port is enhanced.

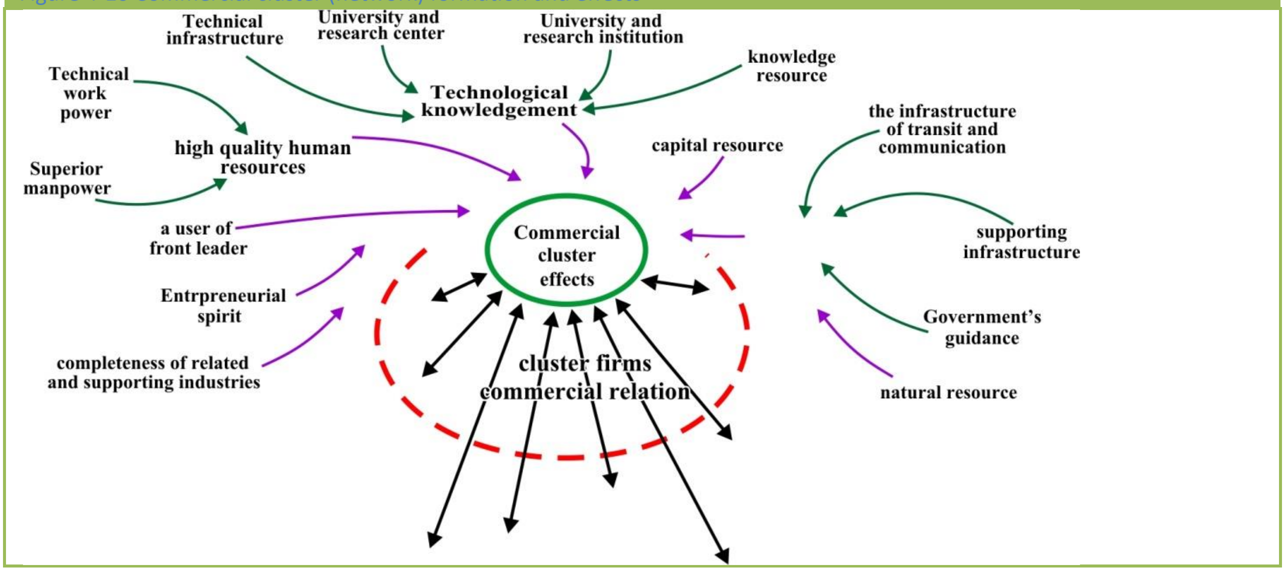
Figure 4-9 Hinterland expansions due to commercial cluster effects



Therefore, the port competition and hinterland expansion not only depends on port connectivity but also on how the businesses in this commercial cluster would expand their supply chain in terms of markets and suppliers – the competition between entire supply chains (Meersman, *et al* (2012) . This is illustrated in Figures 4.9 and 4.10.

Once achieved, cluster (network) effects need to be maintained and sustained, especially in Northern Europe as ports can be substituted for each other due to factor similarities. Furthermore, there are limits to the cluster (network) effect that can be achieved: (a) unique characteristics of rival ports due to the specific location of a port, (b) an inability of the hinterland transport networks linked to a particular port to cope with the level of demand, and (c) city port characteristics and/or other environmental issues would all make it impossible for a port to be substituted.

Figure 4-10 Commercial cluster (network) formation and effects



Source: Adopted from Lin, *et al* (2006)

However, a European port which is seeking to be competitive must have a clear view of key strategic variables. These have been identified in the questions below:

- Where are the new hot spots in the European hinterland?
- Which markets or market segments are being developed?
- What can we offer as logistics solutions for the changing business cases?
- What is competition doing? What is our position?
- How to facilitate the interests of key stakeholders?

- How to attract new potential port users in this changing landscape?
- What drives our existing clients and how to anticipate on these to maintain and make them expand in our port? (Port Technology, 2011)

The port as a standalone business entity would be limited in delivering along these strategic variables while a commercial cluster as a multidisciplinary business network will be able to provide answers to these questions in real time.

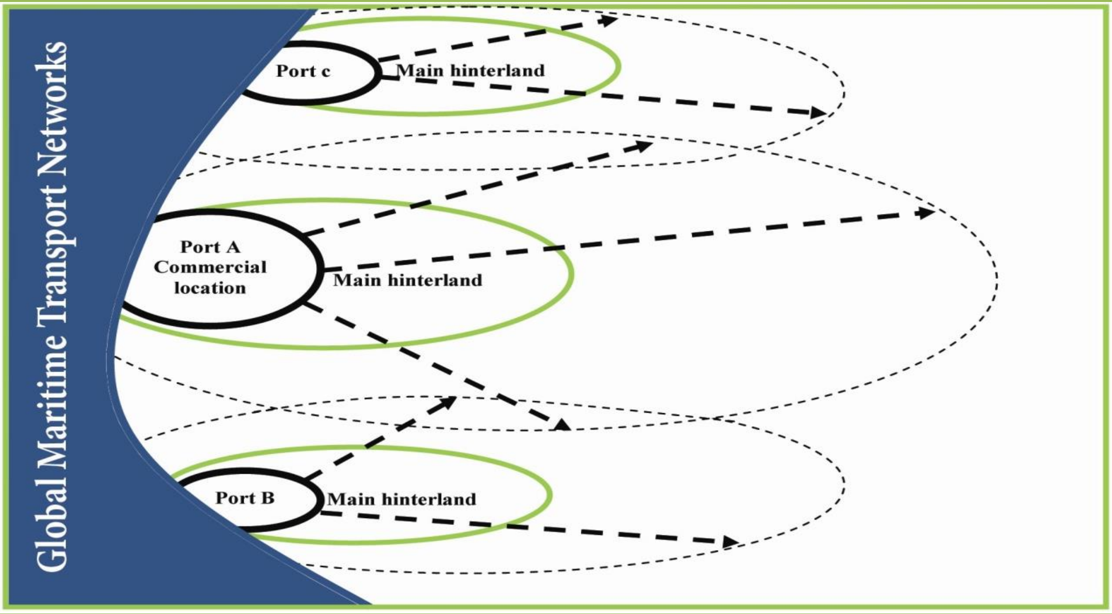
Ports are involved in competition over hinterland and their level of competitiveness depends on the comparative advantage factor relative to other competitors as well as cluster actors connections to hinterland. The development of a commercial location is dependent on the immediate and distant hinterland which could be considered a commercial location for primary and secondary markets respectively as illustrated in Figure 4.11.

As a market becomes more distant, it tends to be less primary and more secondary. Furthermore, a primary market is denser than a secondary market due to overlapping service areas of individual inland terminals, the traffic and accessibility, and the service areas of logistics centres by rail, road and barge. However, the level of density depends on the size of each of the inland service areas, their efficiency, the service frequency, the rates of intermodal shuttle services by rail, road and barge and the scale to which the inland terminal is exploited as a gateway[26]

The secondary market is mainly subject to competition from neighbouring ports where there is an overlap between the areas of markets. This area is called the competition margin. The competitive advantage of a port in the competition margin would be strengthened by developing strong functional links with the cluster as a distribution centre within the immediate hinterland[27]. As a commercial cluster offers business connections that could expand the secondary market, then the boundary of the hinterland will be pushed back, thus expanding its geographical area. Moreover, the competitive advantage of the cluster will lead to an increase in market share as territory in distant locations could be taken away from the hinterland served by competing ports. Since the competitive margins of hinterlands become increasingly indistinct, competition between ports within the same port system gets intensified. Figure 4.11 shows how ports can become connected to the more distant hinterland and so leads to an increase in competition due to cluster effects.

Economic integration such as in the EU intensifies cluster effects by allowing hinterland distribution networks to expand to new regions by allowing free movement of goods, people, service and capital. Before integration distribution networks were designed to service their particular national economies with flows indicative of this configuration. After integration, the configuration of and connections between local and regional distribution networks allow for a more holistic and seamless service in the wider economic area.

Figure 4-11 Commercial cluster effects on hinterland expansion



With economic integration, the structure of distribution networks is modified so as to interconnect regional linkages. While there is a possibility that national trade may decline and transnational trade flows increase, this would depend on the level of trade creation and diversification[28]

4.6 Conclusion

This chapter offered a conceptual framework which identifies the global market mechanism and further port contribution to the economic development. This chapter also categorized the key words used in the subject area of the study by synthesising the relevant literature. Based on the results of chapter three, this chapter helps the thesis to properly classify the evolutionary trend in the global business environment and its impact on ports via the supply chain in order to frame the research question and the aim.

Following introduction of MID, clusters were defined as networks of interdependent and related business functions in order to generate added value. In this definition, the cluster concept spread further than the competitive interdependence and ‘simple’ horizontal networks of firms operating on the same industry group. This business function cluster way of thinking in addition focuses on the importance of vertical relationships between relevant business functions and interdependence in the value chain. This cluster concept therefore provides a different approach to analyse the port issues and is more in line with the MID.

The global production networks as production process now is the conventional wisdom. The priority in globalisation is changing to further integration of the geographical supply, distribution and consumption through complex distribution networks. In such environment, there is a need for transport actors who are not directly involved in production and retailing, taking the responsibility of managing complex logistics networks to connect production to consumption regions, a phenomenon defined under GCTS. That results in further transport and logistics and commercial developments, effective utilization of regional comparative advantages and a transactional environment to support distribution difficulties of global trade. These global developments have significant impacts on the regional and national economy.

As its main theoretical contribution to the literature, this chapter suggests that a port should provide additional value adding elements, by evolving to a commercial location to facilitate formation of a commercial cluster. Formation of a commercial cluster in and around a port would provide an important competitive edge for the port and consequently enhances the regional economy.

To evaluate this hypothesis, there is a need to test and rank the characteristics which attract supply chain actors to a port. These characteristics will be considered modern port demand factors.

This matter will be dealt with in chapter five.

5. CHAPTER FIVE: PORT SELECTION DETERMINANTS AND REGIONAL ECONOMIC DEVELOPMENTS

5.1 Introduction

With the ongoing globalization of production and expansion of consumption and trade, and in view of their strategic role in domestic economic growth, ports are playing an increasingly crucial role as transport nodes in supply chains and as logistics centres. At the same time, port competition is becoming stronger, especially among those vying for the same container flows (van Hassel *et al*, 2014; Meersman *et al*, 2013) and serving overlapping secondary markets and hinterlands.

In an effort to maintain or increase port market share and to secure their place in global trade, governments and/or port authorities are generally keen on enhancing the appeal of their ports by improving their performance in relation to the most influential port choice criteria. They also understand the principle of involving port users' requirements in their development plans. For example, the Port of Hamburg development plan identifies the interests and requirements of businesses and associations and gathers ideas to develop a market-oriented port strategy via a dialogue process (HPA, 2012). The Port of Antwerp has applied a similar procedure through its 'Totaalplan', which has been developed through thematic and mixed private-public working groups, and finalised in 2011 (Port of Antwerp, 2011). This document is the basis for that port's future vision. Port of Rotterdam finally developed its Port Vision in 2011, in close collaboration with regional and national governments, as well as with its private sector (Port of Rotterdam, 2014). Annual progress is being constantly reported.

Although there has been wide research on port selection and more or less consensus in the literature on the relevant key criteria (for example, Pires da Cruz, *et al*, 2013; Aronietis *et al*, 2011; Chou, 2010, 2007, 2002; Tongzon, 2009; Chang, *et al*, 2008; Tongzon and Sawat, 2007; Frankel, 2002; Malchow and Kanafani, 2001; Brooks, 2000; Strenberg, 2000; Thomson, 1998; James and Gail, 1998; Slack, 1985; Hayuth, 1980), it is still worthwhile to score and rank those factors so as to gain insight into their relative importance for specific port areas.

Northern Europe ports[29] offer the most efficient route for container transport into a large part of the central European hinterland. Among them, Antwerp, Hamburg, and Rotterdam are considered in this research as the main competitor alternatives in the field of conventional general cargo and containers. All three ports compete for as large a share as possible of these trades (Meersman, *et al*, 2013). Amsterdam is not considered in this competition circle since it mainly focuses on the bulk market[30]. Among these Northern European ports Antwerp, Hamburg, and Rotterdam are the leading players in the fields of conventional general cargo and containers, and they compete among each other for as large a share as possible in these trades (van Hassel *et al*, 2014; Port Technology International, 2014b; Ng, 2010, 2006).

The aforementioned ports' future development plans emphasise different areas - ranging from port expansion to hinterland connection improvement (Port of Antwerp, 2014; Port of Rotterdam, 2014; HPA, 2012). Given a general scarcity of financial resources, and in order to maintain one's competitiveness and generate the highest possible return, it has been thought that port development budgets should preferably be dedicated to those areas of port operations and functions that influence selection factors the most. A ranking of port choice factors – from the perspective of port users – can thus help planners prioritize investments.

The main research focus in this chapter is on analysing generalized cost, consisting of port charges (port dues, pilot costs, towage and so on), terminal charges and storage cost. The results provide an overall picture of the possible effects of cost changes on creating added value for users and for potential business relocation as a result of the decisions made by port users regarding the port of call for the three ports concerned.

Moreover, the empirical results – specifically the ranking of port players' priorities, and ports' individual scores – provide input for transport policy. Taking due account of these rankings and of each player's share in port utilization, governments and/or port authorities are able to focus investments on the most productive factors. Attracting more firms and greater commercial activity to a port will generate added value for the region and may encourage other businesses to relocate their commercial activities to that region so that they could benefit from network economies.

The rest of this chapter is organized as follows. Section 5.2 compares the characteristics of the three alternative port choices considered in this study. Sections 5.3 and 5.4 are dedicated to the previous studies on applied methodologies and their design, advantages and disadvantages. Application of the methodologies is provided in section 5.5 followed by empirical results and conclusion in sections 5.6 and 5.7 respectively.

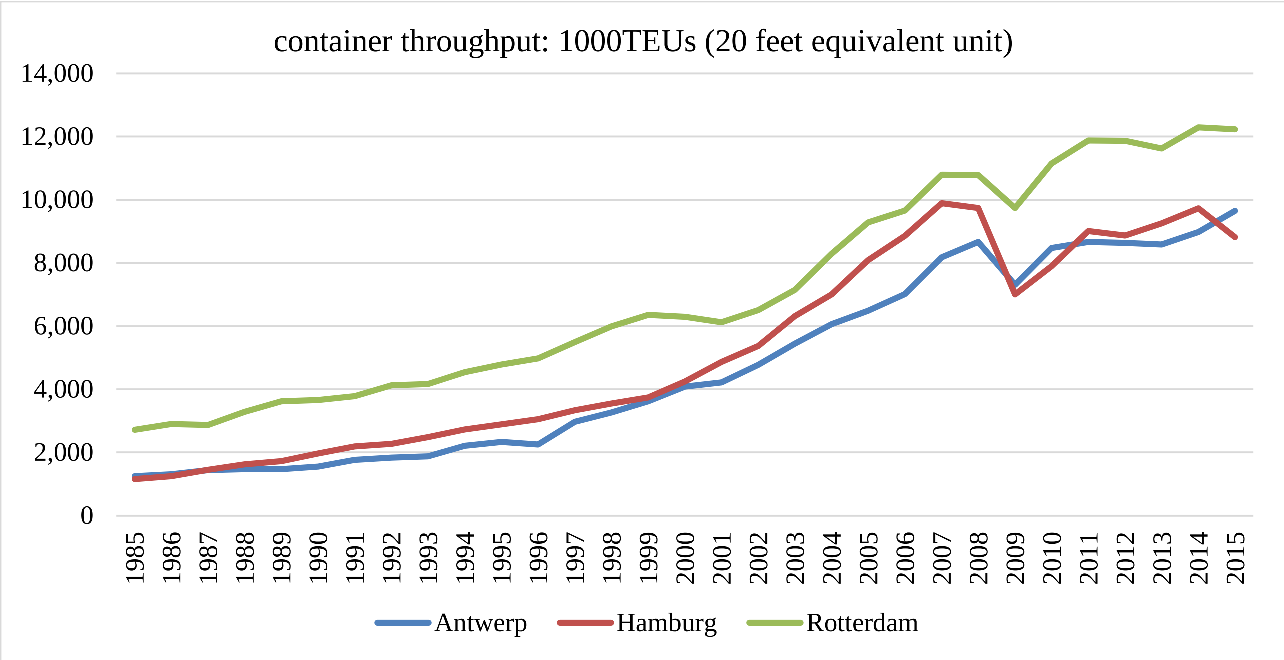
5.2 Alternative port choices: Antwerp, Hamburg, and Rotterdam as the main competitors

This section provides a comparison of these three main European ports in terms of functions and operations. As mentioned above these three ports are considered in the literature as the main North European container hubs (e.g. Wackett, 2014; Meersman, *et al*, 2013; Colliers International, 2013). This research opts to study them as well as the main alternative ports at the next subsections go through the following key issues of these ports: container throughput, hinterland connectivity and accessibility, port locations in respect to the global shipping networks and future development strategies.

5.2.1 Container throughput

In 2000, the port of Antwerp was the tenth largest port in the world with a throughput of 4.1 million TEUs a year, but ten years later it had fallen to the fourteenth place with 8.4 million TEUs. Even though the port has dropped out of the top ten in the global rankings during this ten year period, it overtook the port of Hamburg for the first time, becoming the second European port in 2009 with 7.3 million TEUs a year. In that same year, Hamburg throughputs were slightly less at 7.1 million TEUs. As the growth trends in container throughput for the three ports shown in Figure 5.1 indicate, these ports that are competing closely with each other regarding their throughput for last three decades.

Figure 5-1 throughput of three ports



Source: Own compilation based upon containerization International, 2012, Port of Antwerp (2016), Port of Hamburg (2016), Port of Rotterdam (2016).

5.2.2 Hinterland connectivity and accessibility

Table 5.1 presents an overview of key information about ports' capacity, productivity, and quality of hinterland connection. This date illustrate the operational characteristics of the three Northern-European ports.

Based on the information shown in Table 5.1, it can be observed that many aspects across the three ports are similar and provide grounds for competitive rivalry. However, the modal split in Hamburg is significantly different from that of Antwerp and Rotterdam. While barge transport represents about 43% and 30% of modal connections for Antwerp and Rotterdam respectively, inland waterway represents only 3% of Hamburg port's hinterland transport.

The port of Antwerp, in particular, enjoy benefits due to its inland location 80km down the Scheldt estuary and from the ease and speed of access to the European hinterland, with 6 major motorways no more than 1km from the port. Furthermore, key economic centres in Northern France and Western Germany are less than 400 km away: Paris/Rungis– 357 km; Alsace Lorraine – 347 km; Frankfurt– 394 km; Ruhr Valley– 212 km (Port of Antwerp, 2013).

Table 5-1 Three ports operational characteristics

	Antwerp	Hamburg	Rotterdam
Hinterland connection	➢ Railway: (1,055km) ➢ Highways: 6 ➢ Rivers Seine and Rhine (950 pw) 100 Pipelines	➢ Railways: 3 (304 km) ➢ Highways: 4 ➢ Waterways: 302 short sea connections	➢ Railways: 160 km to Germany ➢ Highways: 6 ➢ Waterway
Modal split (approximate share)	Barge 30% Rail 20% Road 45% Pipeline 5%	Barge 2% Rail 36% Road 62%	Barge 30.2% Rail 11.2% Road 58.6% Pipeline: 1500 km
Container Terminals	**7**	4 (+ 42 multi-purpose)	**28**
Area	13057ha	7250 ha	10500 ha
Quay length	9245m	11200m	8900 m
Capacity (000 TEU)	12,200	9,000	12,000
Cranes	**64**	**76**	**100**
The number of vessel arrivals	15,240 (2011)	9,800 (2010)	33,681 (2011)
Dwell time	5-6 days (2006)	3-4 days	1.7-5 days

Source: Own compilation based upon Port of Rotterdam (2016), Port of Antwerp (2016), Port of Hamburg (2016), Containerisation International (2013)

According to Port of Antwerp (2013), more freight is transported by road (47%) than any other mode. A very considerable amount of cargo is also shipped by barge (30%). The Scheldt is connected to two major European rivers, the Seine and the Rhine; thus 950 barges per week are scheduled to ship goods towards Germany, France, Austria and Switzerland. Only 20% is transported by rail, partly due to lack of capacity although this is being increased. Antwerp has three main rail corridors: (a) towards France (which later divides to the Iberian Peninsula or Italy), (b) to Germany and The Netherlands (and beyond to Austria, Greece and Balkans), (c) towards Poland (split into two sectors, Russia and the Scandinavian countries). Connections outside Europe can use either the Polish or Balkan corridor (Port of Antwerp, 2013).

World port source (2012) specifies that the port of Hamburg has high capacity terminals with a full range of onsite transportation modules which maintain Hamburg’s competitiveness in Northern Europe. It connects the other European ports such as Baltic and Eastern countries via three main transport ways. In railways, three major port railway stations, 90 different rail companies, 375 km of tracks, and 200 international and domestic rail connections facilitate fast, high frequency and reliable transport to and from the hinterland as well throughout Europe. In the road mode, about 80 kms of highway link the port of Hamburg with the neighbouring industrial and international regions. For the hinterland deliveries (less than 150 km), the truck is the preferred choice due to flexibility, cost and urgency. In the waterways mode, barges are an attractive environmental, reliable and less cost-intensive alternative for transporting bulk, dangerous cargo and increasingly containers.

According to the Rotterdam Port Authority, more than 150 million consumers are living within a radius of 500 kilometres of Rotterdam, and 500 million consumers all over Europe with a combined buying power of $600 billion. 58 percent of their hinterland transport throughout Europe should be carried out by truck. The remaining 42 percent must be moved by train and inland barge. About 30% of the goods in the port travel by freight barge to the European market (Port of Rotterdam, 2013).

5.2.3 Port location and global shipping networks

Following the deepening of the Scheldt River in 2010, Ultra Large Container Ships (ULCS) can now access the port of Antwerp. According to the Antwerp Port Authority, the shipping company MSC has had more than 100 ULCS calls at the port, in addition to the different ULCS calls of other ship operators, such as Maersk and Cosco. The port has 300 scheduled services reaching 800 destinations worldwide, of which 20 serve North America weekly (Port of Antwerp, 2013).

Due to its location, Hamburg serves as an important transit point between Central and Eastern Europe. It has been especially successful with cargos servicing the Baltic Sea Region and the Far East due to its water-based interface for the intercontinental trade flows. China is the number one trading partner of the port of Hamburg (Port of Hamburg, 2013).

In terms of hinterland extension, Rotterdam is the ideal port. There are about 500 connections from Rotterdam to more than 1000 ports worldwide (Port of Rotterdam, 2013). A depth of 75 foot guarantees that ultra large vessels can enter in any circumstances. Approximately 34,000 ocean-going vessels and 100,000 inland vessels are estimated in Rotterdam per year. Sea going vessels were 33,681 in 2011, 34,404 in 2010 and 33,352 in 2009 (ibid).

5.3 Previous studies on methodologies

Having outlined the competitive operational characteristics of the three ports, it is evident that understanding the factors that affect port choices of users will provide valuable input for policy formulation and port strategy. Different methods have been used to study port choice ranging from descriptive statistics to discrete choice analysis and the analytical hierarchy approach (AHP). Many studies use Likert scale questionnaires and descriptive statistics to assess the effects of different factors on the port choices of user groups either in single or multiple group studies (Panayides and Song, 2007; Shintani, *et a*l., 2007). AHP is flexible and can be applied to determine the factors that affect the selection of different types of service providers. It also allows for a more detailed analysis as it considers the objective to be achieved at the first level, sets relevant criteria at the second level and then considers the service providers at the third level. Bagchi (1989) applied this approach to analyse factors that affect the selection of carriers. In a study of port competition performance, Tongzon (1995) used AHP to study the factors that contribute to port performance and efficiency for a sample of 23 ports. Discrete choice analysis provides another technique for modelling choice behaviour and has been applied extensively in studies of the demand for transportation.

5.4 Implemented Methodology

Two approaches that have often been applied in various contexts for similar research are the Analytical Hierarchy Process (AHP) and Analytical Network Process (ANP) methods, introduced and developed by Saaty (1977, 1996, 1986, and 2004). AHP provides a comprehensive framework to solve a problem when a decision maker has to choose the best one in a set of competing alternatives that are evaluated under conflicting criteria (Saaty, 1986). It organizes the basic rationality by breaking down a problem into its smaller constituent parts and then calls for only simple pairwise comparison judgments to develop priorities in each hierarchy. AHP consists of three principles: decomposition, comparative judgments, and synthesis of priorities (ibid).

Applications outside ports include travel demand (Banai-Kashani, 1989), land evaluation techniques (Elaalem, *et al*, 2010), environmental issues (Colombo, *et al*, 2006), project management (Al-Subhi

Al-Harbi, 2001; Torfi and Rashidi, 2011), and consumer preferences (Meiβner and Decker, 2009; Kallas, *et al*, 2011).

Applications do exist for port choice selection as well. These include Pires da Cruz, *et al*, 2013; Onut, *et al*, 2011; Chou, 2010; Xiaoqing, 2009; Meiβner and Decker, 2009; Ugboma, *et al*, 2006; Lirn, *et al*, 2004; Song and Yeo (2004), by comparing AHP and CBA for market share predictions, find that AHP significantly outperforms CBA. They also identified five important factors for Asian ports which are cargo volume, port facilities and location, service level, and port costs. Chou's (2010) study of north, central, and south ports in Taiwan reveals that the draught of containership berths, port costs, and efficiency are the most relevant factors for ocean carriers. Ugboma, *et al* (2006) identify seven port selection factors and four Nigerian ports that shippers consider in their decision-making process; their findings suggest that the highest emphasis should be on efficiency, frequency of ship calls, and adequate infrastructure. Pires da Cruz, *et al* (2013) distinguish among port users' and service providers' key port selection factors. Service providers rank the technical factors such as port facilities and channel depth highest while for port users, commercial factors such as vessel turnaround time and intermodal links are more important. Lirn, *et al*'s (2004) findings reveal that both carriers and service providers have similar perceptions of the most important attributes for transhipment port selection. Onut, *et al* (2011) applied AHP to evaluate alternative ports in the Marmara region based on conflicting qualitative and quantitative criteria.

Applications of ANP outside ports include evaluation of different technologies, strategies, and websites' success (Salehi, 2010; Nadali, *et al* ,2011; Ordooabadi, 2012; Eslami Nosratabadi, *et al*, 2012), valuation of land use (Aragonés-Beltrán, *et al*, 2008; Banai, 2010), applications in supply chain management (Zhou, *et al*, 2008), applications in transport mode selection (Tuzkaya and Onut, 2008) and in evaluating technology parks (Eslami Nosratabadi, *et al*, 2013).

In port selection and maritime routing literature, ANP is also applied. (Mclean and Biles, 2008) apply this technique to a study of liner shipping network configuration and operations and in the case of r container port selection studies by Onut, *et al*, 2011 have also used ANP.

Despite this wide scope of application, the procedure followed has remained basically the same.

The advantages of AHP and ANP relate to their capacity to capture a wide range of quantitative and qualitative variables (Banai, 2010; Dantas, *et al*. 2001; Mendoza, *et al*., 1999; Carter, *et al*, 1999; Yoon and Hwang 1995; Jankowski and Richard 1994; Khasnabis and Chaudhury 1994; Carter, 1991; Kasperczyk and Knickel, 2014). Many users favour these methodologies because they can be combined with other approaches such as fuzzy analysis (Carter, 1991; Mendoza, *et al*, 1999; Kurttila, *et al*, 2000; Kangas, *et al*, 2001; Leviakangas and Lahesmaa, 2002; Chou, *et al*, 2003; Mahmoodzadeh and Shahrabi, 2007; Xiaoqing, 2009), and also because of the ease with which they can be applied (Macharis, *et al*. 2004; DTLR, 2001). Moreover, pairwise comparisons of data input is found straightforward and convenient by most users (Kasperczyk and Knickel, 2014). The possibility to check for consistency of judgments across all pairwise comparisons makes AHP and ANP useful and flexible instruments (Saaty, 1986; Ramanathan, 2001). However, the reasons that they are chosen in this study are as followings.

1. AHP and ANP capture a wide range of quantitative/qualitative variables;
2. Predictions can be made with high resolution, site-specific, regional spatial analysis;
3. Limited data could be used to make predictions.

In this research the observations with inconsistency indicator less than 0.1 are included. By calculating the geometric mean of the individual pairwise comparisons, AHP and ANP methods allow extrapolating to group decision making (Zahir, 1999). The geometric mean is used in the current study to explore the group decision out of individuals' judgments. Another important benefit is that AHP and ANP yield rather realistic results for policy makers which are one of the target groups for implementing the results of this research. Moreover, no specific time scale is associated with AHP and ANP and there are no limitations regarding geographical coverage (Kasperczyk and Knickel, 2014).

With regard to input data collection, interviewees may often find the questions vague and confusing and therefore individual responses may not always be scientifically trustworthy. The scale of measures representing the preferences of respondents is not always clear to them. Much has been written on what is the most appropriate scale (see for example Kasperczyk and Knickel (2014), Belton (1986), Belton and Gear (1983), Triantaphyllou (2001), DTLR, 2001)). In the literature, two important criticisms come to the fore. First, it is argued that respondents may find it hard to distinguish on a 9-point scale. For the sake of simplification in this research, the 9-point scale is converted to a five-point one. Second, concern has been raised in relation to rank reversal. Taking care of inconsistency indicators overcomes this drawback of the methodology. Moreover, when applying AHP and ANP to a group, divergent or contrary answers may cancel each other out (Kasperczyk and Knickel, 2014). This research takes care of this by sample-checking answers in person. On the whole, the disadvantages of AHP and ANP do not outweigh their advantages, since these methods promote the understanding of the nature of decision making by creating a framework that is used to define the decision, summarize the information available, prioritize information needs, and elicit preferences and values. Potential drawbacks are taken care of as explained above.

Therefore, AHP and ANP meet the requirements of our research and are able to assign a numerical score to each individual port selection criterion. The next section applies this methodology to the selected ports.

5.5 Application of the AHP and ANP methodologies to the selected ports

The basic procedure for applying the AHP and ANP methodologies in the present research is comprised of three phases, the latter of which is composed of four steps, as represented in the process flow chart of Figures 8.1 and 9.1 respectively (see Appendices 8 and 9).

In phase one, the decision-making problem is decomposed into its components, the goal is defined and alternatives are identified. Extracting the pivotal port call factors from the literature and selecting the most influential ones is an important stage in phase one. Criteria should be pervasive and discriminative. Moreover, they should not be redundant nor confusing. In this respect, Fülöp (n.d.) asserts that '*Decision criteria, which will discriminate among alternatives, must be based on the* *goals. It is necessary to define discriminating criteria as objective measures of the goals to measure how well each alternative achieves the goals*'.

If the number of criteria is large, it may help to group them together in related sets, as this facilitates the process of checking whether the selected criteria are appropriate to the problem (DTLR, 2001). Also, in the context of the present study, which applies a questionnaire survey, reducing the number of questions helps. Moreover, a limited number of questions eases the calculations. No criteria or sub-criteria may however be disregarded as this would result in a research deficiency. For the above reasons, choosing the most appropriate port selection criteria from the multitude of factors mentioned in the literature is a crucial step.

The most commonly cited criteria for port selection in the literature are costs – consisting of port charges (port dues, pilot costs, towage and so on), terminal charges, and storage costs –, operational quality, location, facilities, productivity and efficiency, and reputation. However, different groups of port users may consider different factors in selecting a port. Table 5.2 provides an overview of the most important and the most frequently cited criteria in the literature for each group separately.

Table 5-2 Port selection influencing factors for each group

Decision makers	The main influencing ascribed factors	Less cited factors
Shippers	cost, port operations quality/reputation and port location	frequency of shipping services, speed/time, efficiency, port facilities/infrastructure, port information system, intermodal/ hinterland connections, congestion in port, port services and flexibility (for special cargo).
Ship operators	cost, location, port facilities/infrastructure and port operations quality/reputation	speed/time, efficiency, congestion in port, frequency of shipping service, intermodal/hinterland links, port information systems, information availability, port administration, port services and flexibility for special cargo.
Freight forwarders	efficiency and port operation quality/reputation	cost, frequency, location, speed/time, port information systems and intermodal/hinterland connections.

Source: adopted from Aronietis, *et al.*, 2010

Selected criteria and sub criteria for this research are as following

1. Port capacity (Available berths, cranes, storage, etc., Probability to lose time (while berthing, crossing locks, etc.), Free capacity)

2. Port costs (Port charges (port dues, pilot cost, towage, etc.), Terminal handling charges, Storage cost and dwell time). The cost criterion is the relative cost which is explicit to specific supply chain network, trade, and main market.

3. Port productivity and efficiency (Container yard efficiency, the number of TEU and/or tones handled per crane per hour, Custom efficiency).

4. Quality of hinterland connection (Land cost (Inland transshipment freight rates and other land transport costs associated with the port), International connectivity, Intermodal connectivity (rail, highway, barges)).

5. Geographical location (Proximity to the markets (demand), Distance of shippers from the port (supply))

In the questionnaire design the aim was to remove many details, and thus develop a simple framework to facilitate an easy understanding of the principles for respondents. However, it is envisaged that the assumptions and simplification that made in the questionnaire will not hinder the theoretical and empirical insight and the fundamental conclusion of this research. In this regards "port operations' quality/reputation" did not include in this survey as the author after consulting with experts and the literature assumed the outstanding reputation for Port of Rotterdam over two others. However, it would be more precise for future research to include this factor as well as “reliability” as other influencing factor which is omitted in this research.

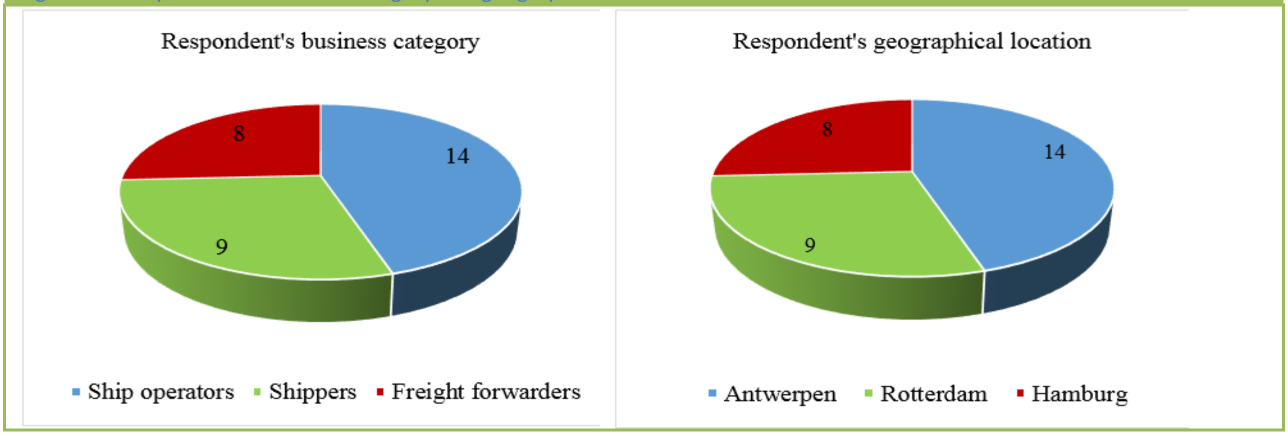
The questionnaire is represented in a tree structure, as is customary in the literature (Appendix 6).

Phase two hierarchizes all components, providing insight into the complicated decision-making process and allowing accurate comparison of the components (Saaty, 1990). To construct the hierarchy, it is essential to bear in mind the problem environment, as this affects the identification of participants associated with the problem, as well as attributes that contribute to its solution (Kasperczyk and Knickel, 2014). Phase three provides a ranking of criteria and of the three ports (see Figures 8.2 and 9.2 in Appendices 8 and 9, which represent the hierarchy in three levels for AHP and ANP respectively). The highest level consists of the question of the decision maker (port selection); the middle level is made up of the criteria; and the bottom level consists of the three alternative ports, Antwerp, Hamburg and Rotterdam.

The data for phases 2 and 3 are collected by means of a structured interview survey with three groups of principal port selection decision makers. The survey was held among carriers (14 responses), freight forwarders (8 responses), and shippers (9 responses). In all, 31 responses were collected. Second, privileged expert assessment of the attractiveness of criteria was recorded by face-to-face interviews and an online survey. The interviewees participating in this research are categorized into three groups: shippers, carriers and freight forwarders located in the ports of Antwerp (14 responses), Rotterdam (9 responses) and Hamburg (8 responses). They were selected randomly from the largest companies in terms of market share. Most of these companies are global operators with a presence in all three ports, but they identify one port as their main location[31]. Respondents are located in and around the ports. Furthermore, it was planned to interview all three of categories in each single port to get comprehensive and reliable results.

Figure 5.2 depicts the distribution of respondents' business category and geographical location.

Figure 5-2 Respondents' business category and geographical location



The respondents were not asked directly about sub-criteria, but it may be assumed that they have taken them into consideration in their judgment regarding the main criteria, as the sub-criteria were mentioned in general when introducing the structured interview. Subsequently, the survey data is used as input data to run the AHP and ANP models. The outcome of the models specifies individual interviewees' priorities regarding selected criteria and sub-criteria, as well as a ranking of the three ports in respect of each criterion. Appendixes 6 and 7 provide the template questionnaires distributed among the respondents for respectively criteria ranking and port ranking. To determine the weight of the factors through pairwise comparison, decision makers must answer the question: 'How preferable is one criterion over the other'? Assigning a relative weight to criteria, ranging from 1 for equal importance to 9 for extreme importance, gives the reciprocal values to the other criterion. When all criteria have been compared, the weights need to be normalized and averaged in order to achieve an average weight for each criterion. A next step consists of the scoring of alternatives with respect to criteria by pairwise comparison. Using the same scale, respondents are asked to answer the question: 'How much do you prefer one alternative over the other in relation to a specific criterion'? (The scales used for pairwise comparisons are illustrated in Table A4.1 in Appendix 4).

Reciprocal values are given to the other alternative. The scores obtained for each of the alternatives need to be normalized and averaged in order to attain the average score. The final computing step is to determine the overall scores of each alternative combining to criteria weights. AHP and ANP methods are applied for each group of respondents separately. When the methods are utilized for a group, their judgments should be combined on the basis of the geometric mean to the judgments (Aczel and Saaty, 1983). The methodology description and the structured model applied in a super decision software environment are provided in Appendixes 4 and 5.

5.6 Empirical results

This section presents the findings from the thirty one port users' responses. The empirical results differentiate between individual port user priorities and preferred port, as well as between aggregate answers for each group. On the one hand, respondents were asked about their ports of call, while on the other, our methodologies revealed their preferences. This provided a comparison of port users insofar as their "preferred port" and "port choice criteria" are concerned.

Moreover, it is indicated in the literature that some port players have more bargaining power to choose a port. Therefore, they have been given a weight which indicates their decision importance in the port of call. The results provide a possibility to compare the ranked criteria in two ways of weighted and un-weighted respondents' answers.

Sections 5.6.1 to 5.6.3 discuss the results from the application of AHP and ANP for all individuals and groups.

5.6.1 Shippers' priorities

With nine valid responses from shippers, the following outcome was obtained. All outcomes were obtained with inconsistency indices less than 0.10. As Table 5.3 shows, Shipper 1 weighed the ports of Rotterdam, Antwerp, and Hamburg by 0.42, 0.33, and 0.25 respectively. As regards the port choice factors, Shipper 1 assigned weights of 0.56, 0.20, 0.17, 0.04 and 0.02 to respectively cost, geographical location, hinterland connection, productivity and capacity. Hence, Shipper 1 considers port costs as the most important factor in choosing a port, while he regards port capacity as the least important factor in making that choice. The stated preferences of the other shippers may be interpreted along the same lines. Table 5.3 and Figure 5.3 provide a summary of shippers' port choice and port choice factor preferences. Table 5.3 indicates that, on average, applying AHP, shippers assign the greatest relative importance to port costs (0.42), followed by geographical location (0.22), quality of hinterland connections (0.22), productivity (0.08), and port capacity (0.05). Rotterdam (0.44) is the shippers' preferred port, followed by Antwerp (0.32) and Hamburg (0.24).

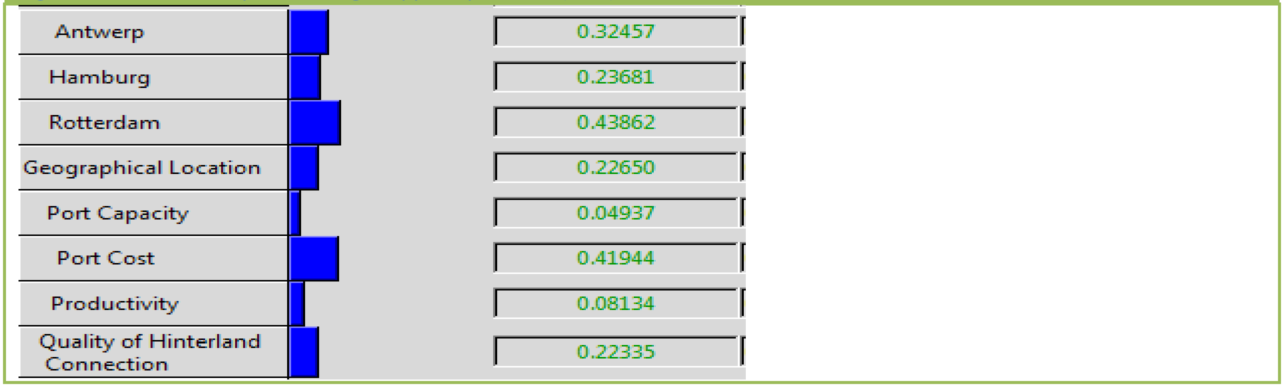
Table 5-3 Shippers' port and port choice factor preferences (AHP)

Company	Ports preferences			Port selection factor preferences				
	Antwerp	Hamburg	Rotterdam	Location	Capacity	Cost	Productivity	Connection
1	0.33	0.25	0.42	0.20	0.02	0.56	0.04	0.17
2	0.17	0.24	0.58	0.19	0.03	0.55	0.05	0.16
3	0.20	0.40	0.40	0.43	0.05	0.20	0.06	0.25
4	0.24	0.20	0.56	0.21	0.04	0.55	0.05	0.15
5	0.28	0.30	0.42	0.27	0.03	0.47	0.07	0.14
6	0.45	0.31	0.24	0.13	0.07	0.35	0.03	0.43
7	0.29	0.11	0.61	0.23	0.04	0.49	0.06	0.17
8	0.12	0.56	0.31	0.18	0.04	0.56	0.07	0.15
9	0.17	0.44	0.38	0.15	0.05	0.48	0.04	0.27
Average	0.32	0.24	0.44	0.22	0.05	0.42	0.08	0.22

Since the business nature of port users is different, the concept of geographical location for each of them is also different. For shippers, the port location concept refers to how well the port is located in their distribution networks of suppliers and consumers. For freight forwarders, it refers to how well the port location contributes to both carriers' and shippers' strategic plans and business, as well as to cost aspects. For carriers, port location relates mainly to where demand (cargo) is located, and how well the port is located in their global shipping network configuration. In this case, for shippers, all three selected ports are located relatively closely to the core European market. However, any questionnaire-based research carries the risk of bias because of prejudice by interviewees. Since the ports under investigation are located within a close proximity and they are competing over the same hinterland, the risk of bias towards the port that users have already chosen for their operations might exist in this research as well. To minimize this risk we interviewed company branches in all three ports as much as possible. To initiate the survey, a longer list of interviewees was considered; however, a few of them either did not respond or did provide non-relevant/complete answers to the questionnaire. It caused the valid responses to be reduced to 31. The expressed reason to avoid answering the questions was its time-consuming procedure. Those that replied found questionnaire and survey interesting and useful as they can consider the final results as a market feedback and their rivals' point of view.

Port capacity is not typically a concern of port users until capacity becomes under pressure and congestion occurs. Instead, port authorities are concerned about capacity from a competition and long-run development point of view. Since the 2008 global economic crisis, which led to a shift of global trade, there has been no real port capacity constraint in this region. The Port of Antwerp had just acquired its Deurganckdock, the Port of Rotterdam had the Maasvlakte II development which just opened, and the Port of Hamburg had started up expansion in its Waltershof area and the Altenwerder and Tollerort terminals. Currently, port congestion problems start to appear in the port region, albeit because of hinterland connections than to terminal capacity itself, implying traffic shifts among them (Port Technology International, 2014a).

Figure 5-3 Criteria and port ranking, shippers' priorities (AHP)



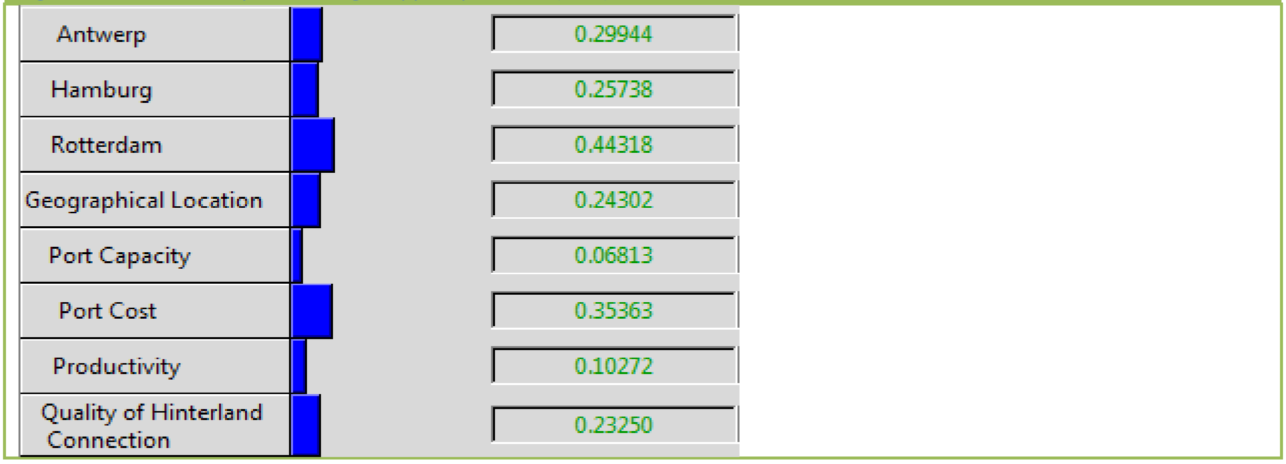
The results of ANP confirm different scores obtained from AHP, for example, cost is weighted 0.45 and 0.44 in AHP and ANP respectively. However, rankings stay the same in both models; cost is ranked as the most important factor in both of methodologies. Table 5.4 and Figure 5.4 depict the shippers' judgments' obtained from ANP.

Table 5-4 Shippers' port and port choice factor preferences (ANP)

Company	**Ports preferences**			**Port choice factor preferences**				
	Antwerp	Hamburg	Rotterdam	Location	Capacity	Cost	Productivity	Connection
1	0.49	0.21	0.29	0.28	0.03	0.44	0.05	0.20
2	0.16	0.28	0.56	0.27	0.05	0.43	0.06	0.18
3	0.17	0.43	0.40	0.44	0.05	0.19	0.06	0.26
4	0.22	0.24	0.54	0.21	0.05	0.43	0.10	0.20
5	0.19	0.42	0.39	0.31	0.04	0.38	0.07	0.19
6	0.39	0.37	0.27	0.15	0.05	0.27	0.03	0.46
7	0.29	0.11	0.59	0.24	0.05	0.39	0.11	0.20
8	0.12	0.57	0.31	0.18	0.04	0.44	0.14	0.20
9	0.16	0.43	0.40	0.25	0.05	0.39	0.06	0.24
Average	0.30	0.26	0.44	0.24	0.07	0.35	0.10	0.23

They indicate that, on average, applying ANP shippers assign the greatest relative importance to port costs (0.35), followed by geographical location (0.24), quality of hinterland connections (0.23) and productivity (0.10), port capacity (0.07). Rotterdam (0.44) is the shippers' preferred port followed by Antwerp (0.30) and Hamburg (0.26).

Figure 5-4 Criteria and port ranking, shippers priorities (ANP)



Except for a little difference between geographical location and connection, the ranking of port choice criteria in both models is same. When AHP is applied, shippers give the same weight to geographical location and quality of hinterland connection, while when applying ANP, they give the higher importance to the geographical location than connection.

5.6.2 Ship operators' priorities

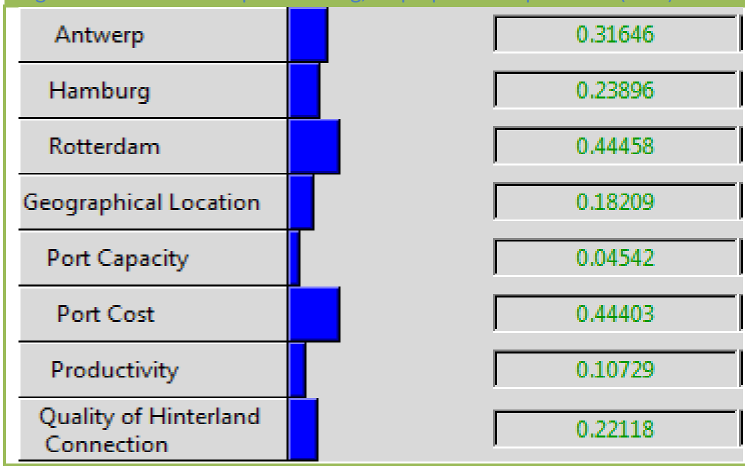
Fourteen valid carrier responses were used. Table 5.5 and Figure 5.5 depict ship operators' judgments regarding port choice factors and port selection when AHP is applied. The table illustrates that carrier 1 assigns weights 0.41, 0.33, and 0.25 to respectively Rotterdam, Antwerp, and Hamburg. The choice factors cost, geographical location, hinterland connection, productivity and capacity are assigned weights of 0.45, 0.27, 0.17, 0.06 and 0.04 respectively. Hence, the results indicate that carrier 1 considers port cost the most important decision factor in selecting a port of call, and port capacity as the least important. The stated preferences by the other shipping companies can be interpreted in the same way.

Table 5-5 Ship operators' port and port choice factor preferences (AHP)

Company	Ports preferences			Port selection factor preferences				
	Antwerp	Hamburg	Rotterdam	Location	Capacity	Cost	Productivity	Connection
1	0.33	0.25	0.41	0.27	0.04	0.45	0.06	0.17
2	0.12	0.20	0.68	0.15	0.03	0.37	0.05	0.39
3	0.51	0.17	0.31	0.16	0.03	0.52	0.06	0.22
4	0.49	0.13	0.38	0.13	0.03	0.56	0.04	0.23
5	0.27	0.16	0.56	0.22	0.03	0.11	0.07	0.56
6	0.45	0.10	0.44	0.10	0.04	0.41	0.30	0.16
7	0.41	0.10	0.50	0.14	0.04	0.48	0.06	0.28
8	0.37	0.34	0.28	0.40	0.03	0.29	0.10	0.17
9	0.36	0.26	0.38	0.28	0.06	0.46	0.04	0.14
10	0.18	0.30	0.52	0.07	0.05	0.44	0.18	0.23
11	o.31	0.41	0.27	0.17	0.03	0.57	0.07	0.15
12	0.21	0.26	0.53	0.06	0.10	0.53	0.08	0.22
13	0.15	0.17	0.67	0.07	0.04	0.45	0.28	0.15
14	0.22	0.19	0.58	0.06	0.03	0.60	0.10	0.19
Average	0.31	0.24	0.44	0.18	0.04	0.44	0.10	0.22

On average, applying AHP, ship operators assign the greatest weight to port costs (0.44), followed by quality of hinterland connections (0.22), geographical location (0.18), productivity (0.10) and port capacity (0.04). Rotterdam (0.44) emerges as the ship operators' preferred port followed by Antwerp (0.31) and Hamburg (0.24).

Figure 5-5 Criteria and port ranking, ship operators' priorities (AHP)



Overall, the findings are in line with those of shippers, be it that port cost is slightly less dominant here, and hinterland connections gain importance. The latter finding most likely has to do with the fact that bottlenecks over time have shifted from the 'wet' port side to the 'dry' port side: terminal gates, intra-port connections and connections with long-distance modes of transport have become the real issue. For the newly developed infrastructure in the three ports, the situation is particularly problematic. In Rotterdam, the Maasvlakte II is built westwards, towards the sea, while the market is located to the east. This means that the entire existing port, with already congested infrastructure, needs to be transversed. In Antwerp, the newest Deurganck dock is located on the Left Bank, where multimodal transport infrastructure is still underdeveloped. Hamburg, finally, features congestion in its conventional network, through increased volumes, sparking the need for expansion, or optimization in the short run (Port Technology International, 2014b). The difference in overall valuation of Rotterdam and Antwerp gets very small in the case of carriers; this implies that both ports are more or less interchangeable. This may explain the nearly immediate traffic shifts between them in case of capacity problems, as illustrated above.

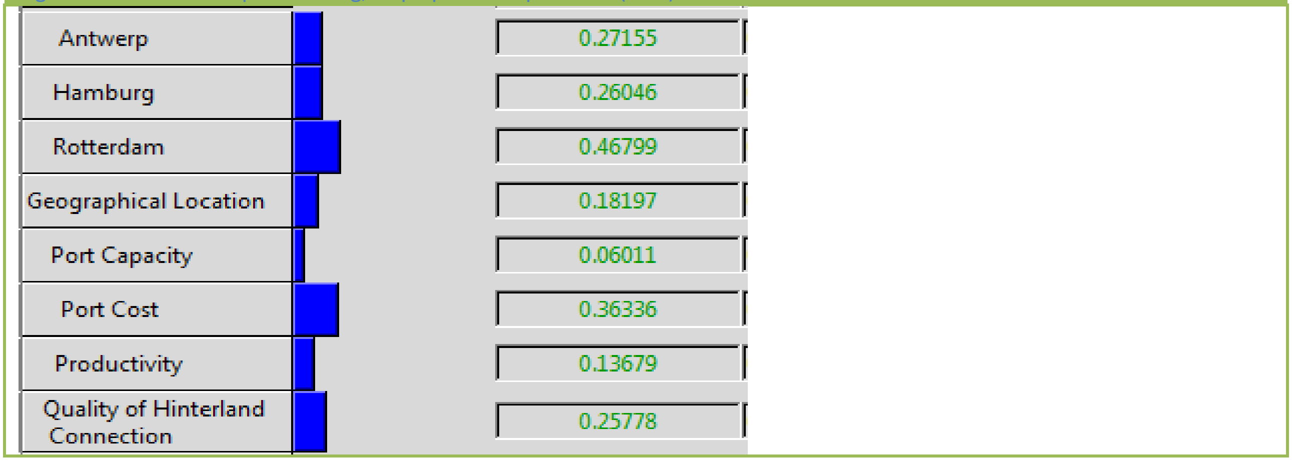
In the next step, ANP is applied for ship operators' judgments. Table 5.6 shows the detailed results for individual answers and Figure 5.6 shows the aggregated result of all ship operators' judgments.

Table 5-6 Ship operators' port and port choice factor preferences (ANP)

Company	Ports preferences			Port selection factor preferences				
	Antwerp	Hamburg	Rotterdam	Location	Capacity	Cost	Productivity	Connection
1	0.29	0.28	0.43	0.24	0.06	0.37	0.10	0.23
2	0.13	0.23	0.65	0.16	0.04	0.31	0.10	0.39
3	0.35	0.19	0.45	0.16	0.04	0.31	0.10	0.39
4	0.39	0.15	0.46	0.13	0.05	0.44	0.10	0.29
5	0.25	0.17	0.38	0.21	0.03	0.11	0.07	0.57
6	0.54	0.11	0.35	0.11	0.06	0.34	0.31	0.18
7	0.35	0.10	0.56	0.13	0.05	0.40	0.14	0.29
8	0.31	0.37	0.32	0.37	0.04	0.25	0.13	0.21
9	0.25	0.27	0.47	0.25	0.08	0.37	0.10	0.20
10	0.18	0.28	0.53	0.10	0.07	0.38	0.17	0.36
11	0.20	0.48	0.32	0.16	0.07	0.44	0.14	0.18
12	0.19	0.25	0.56	0.07	0.16	0.42	0.14	0.21
13	0.15	0.20	0.65	0.11	0.05	0.37	0.25	0.22
14	0.20	0.25	0.55	0.08	0.05	0.46	0.20	0.21
Average	0.27	0.26	0.48	0.18	0.06	0.36	0.14	0.26

When ANP is applied, on average, ship operators assign the greatest weight to port costs (0.36), followed by quality of hinterland connections (0.26), geographical location (0.18), productivity (0.14) and port capacity (0.06). Rotterdam (0.48) emerges as the ship operators' preferred port followed by Antwerp (0.27) and Hamburg (0.26).

Figure 5-6 Criteria and port ranking, ship operators' priorities (ANP)



Comparing the results of AHP and ANP depicts that ranking of criteria is kept same in both models, although the scores are changed. Cost and capacity are given lower score than in AHP's results, while quality of hinterland connection and productivity have received higher scores.

5.6.3 Freight forwarders' group priorities

Eight valid responses from freight forwarders were used. Table 5.7 and Figure 5.7 depict forwarders' judgments regarding port choice factors and port selection when AHP is applied. The table shows that Forwarder 1 assigns weights of 0.44, 0.40, and 0.16 to Rotterdam, Antwerp, and Hamburg respectively. The weights for the port choice factors cost, hinterland connection, productivity, geographical location, and capacity are respectively 0.37, 0.24, 0.14, 0.13, and 0.11. The results indicate that Forwarder 1 considers cost to be the most important consideration in choosing a port, while port capacity emerges as the least important decision factor. The stated preferences of the other freight forwarders may be interpreted along the same lines.

Table 5-7 Freight forwarders' port and port choice factor preferences (AHP)

Company	Ports preferences			Port choice factor preferences				
	Antwerp	Hamburg	Rotterdam	Location	Capacity	Cost	Productivity	Connection
1	0.40	0.16	0.44	0.13	0.11	0.37	0.14	0.24
2	0.52	0.24	0.24	0.14	0.05	0.61	0.07	0.12
3	0.53	0.18	0.28	0.12	0.04	0.62	0.05	0.16
4	0.71	0.09	0.19	0.05	0.08	0.32	0.34	0.20
5	0.69	0.16	0.15	0.11	0.03	0.65	0.05	0.15
6	0.20	0.26	0.53	0.16	0.03	0.48	0.06	0.27
7	0.24	0.16	0.60	0.04	0.04	0.67	0.10	0.14
8	0.20	0.38	0.42	0.05	0.05	0.63	0.10	0.16
Total	0.36	0.24	0.40	0.14	0.07	0.49	0.12	0.18

On average, when AHP is applied, forwarders attach the greatest relative importance to costs (0.49), followed by quality of hinterland connections (0.18), geographical location (0.14), productivity (0.12) and port capacity (0.07). Rotterdam (0.40) emerges as the forwarders' preferred port, followed by Antwerp (0.36) and Hamburg (0.24).

The dominance of cost as a prime selection criterion is clearly in line with the view of shippers. Rotterdam has more of an import orientation. This is also linked to its main connections: Rotterdam has more important connections with Asia than Antwerp, and Asia typically is a producer of many consumables. While, Antwerp has been mainly an export-oriented one, featuring a lot of export- rather than import freight forwarders.

Figure 5-7 Criteria and port ranking in point of view of freight forwarders (AHP)

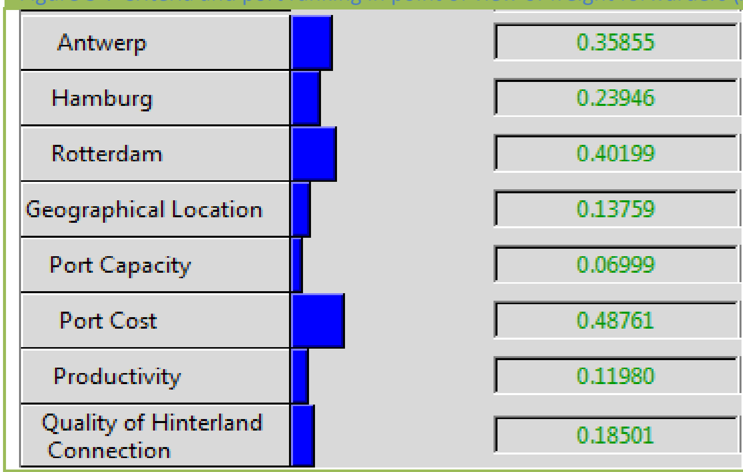


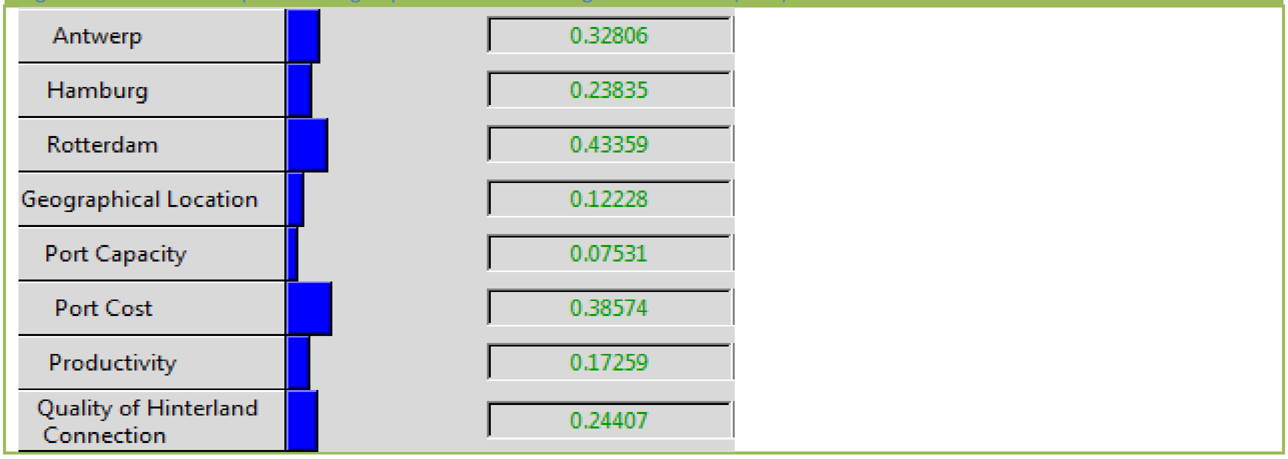
Table 5.8 and Figure 5.8 depict forwarders' judgments regarding port choice factors and port selection when ANP is applied.

Table 5-8 Freight forwarders' port and port choice factor preferences (ANP)

Company	Ports preferences			Port choice factor preferences				
	Antwerp	Hamburg	Rotterdam	Location	Capacity	Cost	Productivity	Connection
1	0.40	0.18	0.42	0.12	0.11	0.31	0.16	0.29
2	0.35	0.24	0.43	0.12	0.07	0.38	0.17	0.24
3	0.32	0.20	0.47	0.12	0.07	0.47	0.13	0.21
4	0.69	0.09	0.22	0.06	0.08	0.27	0.33	0.24
5	0.60	0.25	0.15	0.17	0.05	0.49	0.08	0.20
6	0.17	0.32	0.50	0.17	0.03	0.39	0.07	0.34
7	0.20	0.25	0.56	0.12	0.06	0.50	0.09	0.22
8	0.25	0.34	0.41	0.06	0.07	0.48	0.14	0.24
Average	0.33	0.24	0.43	0.12	0.07	0.38	0.17	0.24

On average, when ANP is applied, forwarders attach the greatest relative importance to costs (0.38), followed by quality of hinterland connections (0.24), productivity (0.17) geographical location (0.12), and port capacity (0.07). Rotterdam (0.43) emerges as the forwarders' preferred port, followed by Antwerp (0.33) and Hamburg (0.24).

Figure 5-8 Criteria and port ranking in point of view of freight forwarders (ANP)



Comparing to the results of AHP, the rankings stay the same; however, cost and geographical location are given the lower scores while connectivity and productivity have received the higher scores. The outcome of software of both AHP and ANP approaches for each individual respondent are provided in appendixes 8 and 9 respectively.

5.6.4 Overall view and summary

Ranked criteria priorities and ranked ports for each group of decision makers are summarized in Table 5.9. There is a difference in port selection criteria and their rankings in different regions of the world because of the differences in regional supply chain characteristics, marketing processes and local economic conditions.

Table 5-9 Ranked criteria priorities and ports: the results of AHP ad ANP

Decision makers	Factor priorities					Port ranking
	1	2	3	4	5	
Ship operators	Port cost	Quality of hinterland connection	Geographical location	Port productivity	Port capacity	Rotterdam Antwerp Hamburg
Shippers	Port cost	Quality of hinterland connection	Geographical location	Port productivity	Port capacity	Rotterdam Antwerp Hamburg
Freight forwarders	Port cost	Quality of hinterland connection	Port productivity	Geographical location	Port capacity	Rotterdam Antwerp Hamburg

To obtain the overall result from all- the vector of all decision makers' priorities- a geometric-mean average scaled answer is used to drive aggregated answers of thirty one respondents. A comparison between the results of AHP and ANP methods is provided (Tables 5.10 and 5.11).

Both models of AHP and ANP methods identified almost similar criteria and alternatives rankings.

Table 5-10 All groups' port and port choice factor preferences

Ports preferences				Port choice factor preferences				
Ports/factors	Antwerp	Hamburg	Rotterdam	Location	Capacity	Cost	Productivity	Connection
AHP	0.33	0.23	0.44	0.18	0.05	0.45	0.10	0.21
ANP	0.28	0.25	0.46	0.19	0.06	0.36	0.12	0.25

As regards port choice factors, all of the supply chain players assigned weights of 0.45 and 0.36 in the AHP and ANP models respectively which indicates its highest importance for all of supply chain players in their port selection decision. Port capacity received the lowest ranking in both models 0.05 and 0.06 in AHP and ANP respectively.

Table 5.11 illustrates the relative importance of alternative port. The results of AHP indicate a 0.44 score for Port of Rotterdam. This is followed by preference ranking for Antwerp (0.33) and Hamburg (0.23). Criteria rankings of both models for each port user group are presented in Table 5.11.

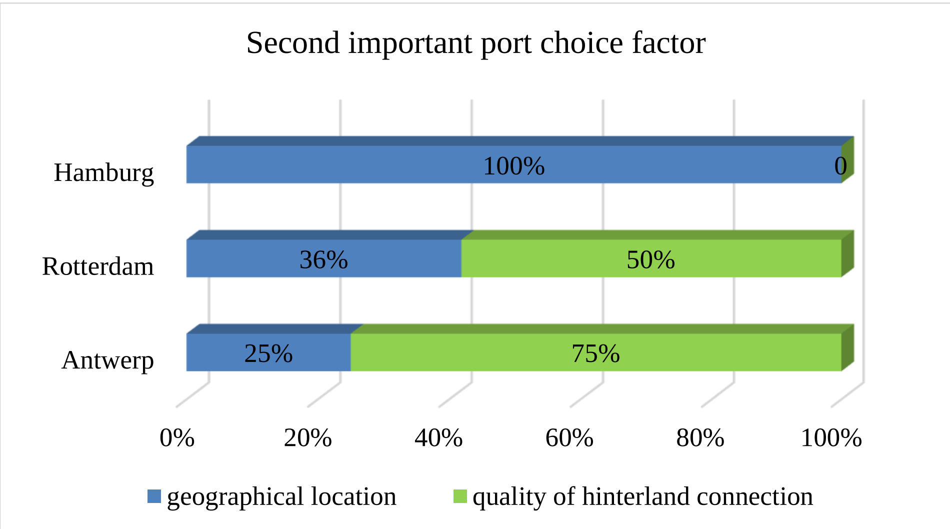
Table 5-11 The comparison of two methodologies' results

Factors/ decision makers	AHP			ANP		
	Ship operators	shippers	Freight forwarders	Ship operators	shippers	Freight forwarders
Geographical location	0.18	0.22	0.14	0.18	0.24	0.13
capacity	0.04	0.05	0.07	0.06	0.06	0.06
cost	0.44	0.42	0.49	0.36	0.35	0.48
productivity	0.10	0.08	0.12	0.14	0.10	0.11
Quality of hinterland connection	0.22	0.22	0.18	0.26	0.23	0.18

For the sample chosen for this study, the cost criterion was found to be the most important attribute for all users (with a score between 0.35 and 0.49) followed by quality of hinterland connection (between 0.18 and 0.26), Geographical location (between 0.13 and 0.24), productivity (between 0.08 and 0.14) and capacity (between 0.04 and 0.07).

Additionally, as Figure 5.9 shows, the results from the models suggest that all the respondents highlighted port cost as the most important criterion for their port selection decision. However, 75% of respondents who chose Antwerp for their first port highlighted the hinterland connection as their second important criterion after cost while 25% identified geographical location as their second criterion after cost. All of the respondents (100%) who chose the port of Hamburg specified the geographical location as the second criterion. Finally, 36% of respondents who preferred the port of Rotterdam as their first port of choice recognized the hinterland connection as the second criterion whereas 56% indicated location was the second important criterion.

Figure 5-9 Second important port choice criteria



An interpretation of these findings is that the main advantage of Hamburg is geographical location, the main advantage of Antwerp is quality of hinterland connection, and Rotterdam has strengths in terms of both hinterland connection and geographical location.

The results of this study are therefore a useful addition to existing literature as a specific regional study in North-European ports in general and Antwerp, Rotterdam and Hamburg as important gateways in particular. The results support and quantify claims in the literature about the considered region, but also qualify certain past perceptions. In this sense, it is confirmed that cost is a prime selection criterion for all actors, albeit to a lesser extent for carriers. This is somewhat contradictory to prevailing thinking, as carriers are the ones paying directly for out-of-pocket port expenses. Apparently, they are able to pass on those expenses to their own customers.

The relative overall similarity between the preferences stated by shippers and carriers could be because of the fact that many shippers apply carrier haulage contracts. Hence, their behaviour is influenced to an important degree by the guaranteed haulage. In this context, port costs, geographical location, and connectivity are important concerns in port selection.

Finally, the relative preference for Rotterdam to Antwerp and to Hamburg does not conform to observed container volumes – where Hamburg surpassed Antwerp in the period 2010-2014 and down again in 2015, in terms of actual container volumes. This preference is not the same for all actors, as illustrated by the behaviour of freight forwarders.

The often-stated importance of ‘capacity’ is clearly qualified. While capacity may be an important issue in other regions around the world that experience capacity constraints, capacity is not an issue in the ports considered here.

5.7 Conclusion

In the modern global business environment, port policy makers should continuously make an effort to understand what factors are influencing port customers’ decision when choosing ports. Businesses seek to respond to the challenges and opportunities posed by geographical shifts, demand uncertainty and the diversity of global markets in a competitive way. Their port choice decision is also influenced by these challenges. The objective of this chapter was to find out to what degree the factors affect port selection.

Results in this chapter can be considered as the main determinants driving the growth of the commercial cluster and port users' priorities in an MID environment, which were discussed in chapter four. Therefore, the results may be helpful in formulating port policies, as they can inform policy makers in making investment decisions by specifying which selection criteria are most crucial in the eyes of the principal groups of port users.

The research by applying different approach and methodology reconfirms the results in the literature and finds that port costs play the most significant role in the port selection process according to all three groups of respondents, followed by location, connectivity, productivity and, least importantly, port capacity. However, there are some discrepancies between respondent groups, with respect to their ranking of criteria, which may be attributed to their respective positions and responsibilities within the supply chain, and the contract of carriage concerned (carrier haulage or merchant haulage). Ship operators, for instance, attach relatively more importance to hinterland connections as they integrate in land-based segments of supply chains. The increased use of carrier haulage may explain the relative overall similarity in preferences.

The findings suggest that, in order for a port to enhance its competitive position, it must contribute primarily to lower overall transport costs, for example, through improved technical and operational expertise. Terminal concessions are a good example of this: making their running times shorter and more flexible, subject to evaluation, should help. In Antwerp, the recently-built Deurganck dock lock combines private construction expertise with public planning and guarantees.

For Hamburg for instance, which gets ranked third overall by all respondents, some more thought should be given to port costs. Hamburg is located further away from the main connecting route between Europe and other continents, and it needs to compensate for this through adapted tariffs. Other important points of attention are keeping hinterland connections up to date and developing the local cargo base, as a way of exploiting maximally the location close to sea.

Factors that would decrease port costs are also to be noted. The relationship between factors such as port capacity, productivity, cost and the nature of the hinterland connection is not a simple one. Costs can fall if time spent and lost in ports is reduced as a result of port capacity being of a high standard due to availability of equipment, berths and storage space. In addition, port cost could also fall because of good connectivity between different modes of transport and efficient international links, smooth custom procedures and well run operations in the container yards. The complex interconnections between port capacity, productivity, cost and hinterland connections are outside the scope of this study. Furthermore, when making port choices, different port users as business decision makers assess these factors individually, rather than on the basis of the complex connections and relationships that could be found between them.

It must also be noted that these conclusions are valid only for the ports under review. In this respect, they reflect the unique characteristics, organization and ownership structures of those three ports. The nature of competition between other ports and their regional characteristics and supply chain structure may result in different factors and different port selection priorities. Hence, further case studies are essential before our findings can assume a more general applicability.

6. CHAPTER SIX: CONCLUSION

This chapter provides conclusions to the thesis. The aim of this study was to examine the consequences of changes in the global business environment and strategic transport infrastructure for business decisions of port users, national and regional competitiveness and economic growth for the case of Belgium. This was done through a detailed examination of the role of port development as an element of strategic transport development. In the process, the thesis addressed a range of different issues, ranging from the nature of contemporary evolution of the business environment, theories of business location decisions, supply chains, port development and growth and cluster formation. Ports infrastructure in Belgium proved to be a suitable context for exploring these issues which are central to the study of contemporary supply chain management and transport policy formulation in Europe. The specific areas of investigation and methodology are presented in three main chapters.

1. Chapter three quantifies the effect of transport infrastructure investment on national economic growth. The results of the chapter prove that in addition to traditional growth stimulating factors, port infrastructure has a positive impact on the Belgian GDP per capita. This implies that besides the traditional direct and indirect impacts of ports on employment and value added, also the growth enhancing potential of port infrastructure should be taken into consideration when evaluating port infrastructure investment plans. The results should however be handled with care because of the rather short time series and the lack of data on some non-transport infrastructure investments.

2. Possible additional value added of a port in the form of cluster effects was explored in chapter four. Chapter four considers whether container port evolution to a commercial cluster promotes national developments by formation of a network of commercial players. The qualitative analysis provided in this chapter forms the conceptual framework of the thesis and gives an explanation for the contribution of ports to economic growth.

3. Based on the explored role of modern ports in enhancing economic growth, chapter five assesses and ranks the factors which improve port attraction for businesses (port users) in the line of

commercial cluster formation. These factors could be considered as investment priorities for policy makers for port developments and associated economy.

This study is unique in its mixed methodological approach which combines theoretical work on clusters and container port development, econometric analysis and the use of a questionnaire survey and the application of structured techniques for analysing decision making. This approach provides a better understanding of the impact of port development on economic growth, the factors underpinning the decisions of different port users and the nature of the competitive environment facing Belgian and surrounding ports, than if a single method has been used. This is because this approach provides valuable insights into the particularities of the transport infrastructure and transport policy in the region.

The implemented growth model. Included the ratio of port infrastructure investment by government to total investment, the length of highways per capita, the ratio of the transport sector to the total deflator, the gross domestic production, the openness ratio, and the gross fixed capital formation. The data covered the period 1990 to 2012.

The results confirm the positive and significant impact of transport infrastructure investment on economic growth in Belgium through several channels- investment gross fixed capital formation, the length of highways per capita, the ratio of port infrastructure investment by government to total investment, and openness ratio of the economy.

During the investigated period, it were the length of the motorways and the port infrastructure investments which had, next to the traditional variables, an impact on GDP per capita but only in the long run. The results indicate that there is a need for a relatively longer time period, say about 5 to 10 years based on macroeconomic literature, for the impact of transport investments to be reflected on GDP. However, openness degree appeared with significant effect in the both long and short time. In addition to the traditional direct and indirect effects of transport on GDP, the wider effects are discussed. These further benefits can come through the network effects formed on the basis of well-developed and designed transport system.

These findings imply that when evaluating transport infrastructure investments in Belgium, these aggregate growth impacts should be taken into consideration. If not, one risks to underestimate the positive contribution of this type of investment to social welfare.

In order to determine whether container port development promotes national developments by the formation of a network of commercial players, the study carefully details how in the globalized business environment the formation of clusters has been geared towards providing an efficient means of fulfilling the supply chain and logistics function. This is achieved by harnessing the benefits of proximity and business networks expansion. The findings of this study show that port development in Belgium can be explained within the proposed conceptual frameworks. Theoretically, the study proposes that the development of commercial clusters in Belgium/Northern Europe is influenced by transport infrastructural changes related to policy changes, transport investments and the more competitive environment, which prevail as a result of globalisation.

It is established, through the literature review, that there is no general theory of supply chain management and container port development which can be used to study the role of clusters in the business location decision in commercial activities and evolution in a dynamic global environment. Given the shortcomings of the existing shipping and logistics literature, a framework based on the concepts of the MID and GCTS was proposed as an adequate theoretical framework within which to conduct this study. In this context, the study makes a number of valuable contributions to the literature on port development and transport in Belgium and Northern Europe. The concepts of MID and GCTS are used to investigate in detail business location decisions and the role of container transport and ports as part of a supply chain in contributing to economic development. The perspectives provided by these paradigms allow for the transport mechanism and infrastructure to be recognized within the framework of the global production process. In particular, the global production process is defined as a very dynamic and spontaneous business environment which dictates the nature of the transport mechanism and transport infrastructure and which plays a major role in its formation and development. In the analysis, it is argued that ports are crucial components of the global transport system. Thus, unlike previous studies, the main focus of the study shifts and is placed on investigating the role of ports in economic development in such a dynamic business environment.

It was also proposed that the flexibility and attractiveness of a port in such a dynamic business environment are the main success factors of the port and subsequently that will impact on the regional economy in a port's location. Crucially, the study brings a different perspective to the literature by the adoption of an approach to analysing ports in a dynamic global environment which frames commercial clusters as a linking element, thereby enabling to analyse the ports in line with MID. Furthermore, the study also evaluated whether container port development promotes national developments by formation of a network of commercial players.

Therefore, the main theoretical argument of this study is that a port should provide additional value adding fundamentals by developing into a commercial location through creating a commercial cluster. The study shows how, with reference to business clusters, one could conceptually synthesise and align firms' supply chain and competitive strategy, with logistics, and in particular container transport, transport infrastructure and government transport policy in a dynamic, globalised environment. In the first step, the conceptual framework introduced the concept of MID environment, which explains the relationship between globalization processes, the changing geography of the world economy, the evolving firm's strategies, and the implications of these for container transport and for government transport policies. This phenomenon changes the way in which container transport operates and its role in the supply chain configuration. GCTS was introduced to explain the value adding elements of the container transport system in global production proses. The business cluster concept was introduced to connect these two concepts. This trend in port development is at the centre of the theoretical approach.

Cluster effects of commercial clusters create competitive advantages gained exogenously through business network expansion rather than from the internal port investment. As more businesses transfer their commercial activities to the commercial location and their businesses expand in terms of both suppliers and market, the commercial location's competiveness is improved. For a small, open economy as the Belgian one, which is strongly integrated in the world economy, ports and commercial cluster can play an important role for its international trade and economic growth. It generates employment and value added directly but also indirectly by spill-overs to up- and downstream sectors. The study's propositions about the vital role of ports in the global transport system and the importance of port dynamism for success together with the study's findings about the significance of port development for economic growth required an investigation to rank the main port attractiveness criteria from the perspective of different port users. The commercial cluster proposed in chapter four specifies that port development and competition in modern times depend on port investment and hinterland connection as well as on the presence of a commercial cluster and network effects. In the light of theoretical contribution, the thesis studied these factors as commercial cluster demand factors and decision making criteria. This is an important contribution to gaining richer insights into explanations for observed strategic choices of different agents that are relevant not just for port selection but also for outsourcing and supply chain design, port competition and transport policy. These results are robust as both the AHP and ANP methods provide similar results for ranked criteria by respondents, although the amount of each criterion weight differs between two models.

Port costs are found to be the most significant factor in port selection for shippers, ship operators and freight forwarders. A ranking of the three ports studied, based on the preferences of different port users, places Rotterdam as the primary choice of port users followed by Antwerp and Hamburg. While the findings are clear about the overwhelming dominance of port costs in influencing port users, they also suggest that operational factors – e.g. handling speed, accuracy, etc. - which feature significantly in affecting competition are hinterland connectivity and location. The finding that hinterland connection is seen as more important than location by users is particularly important in that it highlights the value of the port as part of a transport system. The finding also shows very strong similarities between the preferences of shippers and carriers which indicate that the position of player within a supply chain matters because of the associated responsibilities and implications for bargaining power and controlling costs.

A transport policy should not only seek to foster competitiveness by lowering costs and improving cost efficiency but also seek to foster investment in the infrastructural elements that would enhance and improve hinterland connections.

The results of this section of the study show that productivity and port capacity are ranked as the least influential selection criteria. This does not mean that these issues are not significant in port selection but could reflect the specificities of the Northern-European context, and the fact that for the ports studied, capacity limitation was not an issue of concern for users. Furthermore, even though Hamburg was ranked third, the volume of activity suggests a high degree of substitutability across all three ports studied which underpins the high level of rivalry across the region’s ports. In developing policies and strategies, those responsible for port development should seek to identify and exploit the core competencies of the ports so as to improve their performance as compared to that of their competitors. The results obtained provide information to decision about how investment could enhance port attractiveness.

More specific interpretation for the policy making suggests that transport is a strategic industry and national and regional policy makers are expected to continue to make decisions that will affect competition in ways that provide incentives to improve efficiency. If policy is not developed in a way that takes account of the unique strengths of a port, this could have far reaching consequences. This study indicates that investments in the port should focus on total logistics and supply chain cost minimization elements. It also identifies that port users prefer to select the most cost-efficient port (or container terminal) to save on total logistics costs, not only the port costs. This finding means that the higher the total logistics cost, the more negative the effect on the port user’s selection. Furthermore, the results can be used for formulating port policies as they can inform the policy makers for optimum investment by specifying the main important port criteria from the main port users’ point of view. To enforce the port’s competitiveness position, consequently, the global transport has to become cheaper by improving technical and operational aspects of a port.

Dynamic international business environments are expected to continue to impact on ports and economic growth. In the light of the findings of this thesis, policy makers also need to determine the risks which ports as part of the strategic transport infrastructure are exposed to. Increased competition may make ports that are not able to adapt to the new economic geography, vulnerable. Ports and other physical transport infrastructure and services are subject to market imperfections that require government regulation, especially due to the MID environment which, in contemporary times, has changed the competitive environment of these services, particularly in logistics and supply chain. Making infrastructural services more efficient, therefore, may involve government policy measures and possibly regulatory reforms. These are complementary to trade policies because gains from trade often depend on the quality of transport infrastructure and related services. Transport infrastructural and services are tradable**,** opening up to trade in these services is helping to improve quality and reduce the costs of these infrastructures. This study also can be helpful on this area. Furthermore, links between ports and commercial clusters raise the question of the scope of transport policy as clusters, ports, and the global container system are becoming increasingly integrated. Physical transport infrastructures and transport services can be considered - a public good; therefore government intervention is necessary for obtaining efficiency.

The findings of this study are also of interest to supply chain players such as ship operators, ship owners, charterers, forwarders, global manufacturers and retailers. This study is also of interest to those academics, consultants and other experts who are involved in modelling shipping and port variables. This research examines the priorities of main supply chain players and port users in three main Northern-European container ports. For port managers seeking to serve the needs of different port users, understanding the port users' preferences in port selection is a major factor in deciding how to provide cheaper port services -through careful setting and analysis of the different components of port costs such as port charges, terminal handling charges, storage cost and, dwell time - and how to improve hinterland connections through enhanced international and intermodal connectivity.

For any study, it is impossible to cover all aspects of the research area. Based on the description of the concepts of MID and GCTS adopted here, ports are only one element of strategic transport infrastructure. The requirements of this and study time limitations have imposed a compromise. There are questions left open for further research, and the author suggests some here.

This study is limited to the Northern-European ports of Antwerp, Hamburg and Rotterdam, within this category of ports (container ports with overlapped hinterland). For more comprehensive results, other main container ports need to be added to this research.

Due to lack of data in all variables, the dataset used here is limited to annual data. A bigger data set, if further observations were available, would have led to more robust analysis and results. Moreover, more observations could provide an opportunity to apply a VAR model for comparison and contrast between results.

The conceptual analysis of the research provides a simplified version of the mechanism of the MID and GCTS. This may limit the use of the analysis for other purposes. First of all, the general theoretical framework is a partial equilibrium one. Thus the limitations which generally apply to this type of analysis are also applicable in this case. In addition, trade flow is assumed to be only decided by three parties who also are the regional representatives. This fact limits the reliability of the model. A few other port stakeholders such as banks and trucking companies could have been contacted, but this was impossible giving the time and other limited resources available.

Furthermore, the research has shown that well-designed infrastructure investments in a country may have long-term economic benefits in terms of growth and productivity. However, while such investments can lead to an increase in land values, they also leave an economy susceptible to significant spillovers from the global economy. Belgium's small open and highly integrated economy can make it vulnerable to external shocks. There is a need for further research on potential spillovers to Belgium from various shocks originating in other countries due to its openness and high performance transport infrastructure. A more detailed analysis of potential sources of shocks and channels of transmission to growth needs researching. Accordingly, future work might examine whether, and to what extent trade exposure creates domestic economic volatility; how trade could induce structural adjustment and how trade is associated with the development of the welfare state.

The study specified that in contrast to contemporary thinking that port development may increase job losses from developed countries to emerging economies, there can be a different view that suggests that port clusters generate more business and commercial activities and consequently more jobs. This is a subject of further research.

Considering that investment in infrastructure is high-risk due to the long term capital-intensive nature of infrastructural investment with high sunk costs, the public-private partnership investment model should be researched for port cluster formation.

The significant difference between marginal and average costs creates a time-inconsistency problem as investors always face the problem that they will be "held up", which requires suitable government intervention. The level of government involvement and public-private partnership is an important matter in this area which needs to be considered in future research.

Finally, this study has focused on determining the port selection criteria adopted by three principal port user groups. However, it would be interesting for future research to test the explanatory power of the port choice factors in a complementary way by means of regression models designed to gauge the impact of these factors on port market share and/or throughput. As a further extension, this study may be expanded towards the port service characteristics of the main container trading regions including all relevant decision makers. Also other criteria could be included, which are harder to measure and judge. Reliability and port reputation are concrete examples. In that sense, the concept of 'generalized transport cost' could be used, that is, the total transport cost (including out-of-pocket cost, time cost, reliability and so on.) associated with the logistics chain.

As a result, this study has been able to highlight the key elements of strategic transport infrastructure and specific influences on port development and port usage. Highlighting this feature provided a comprehensive picture of main areas of Belgium's competitive advantage and position which is a key factor in the future transport investment and economic growth of Belgium.

This study also is significant as it contributes to the debate on whether port development may have a negative or positive effect on GDP. However, it is discussed that investment in port infrastructure as such is not effective. It will contribute to the economic growth if the set of specific conditions and addressed variables are hold.

Appendix 1- Summary of port choice criteria and applied methodology in the literature review

Source	Actor	Criteria	Methodology
Slack (1985)	• Shippers • Forwarders	• Number of sailings • Freight rates • Congestion • Intermodal links	• **Survey**
Branch (1986)	• Shippers	• Cost • Nature of traffic • Adequacy of port facilities • Overall efficiency • Industrial relations record	• **n/a**
Bird and Bland (1988)	• Forwarders	• Frequency of shipping service • Port charges • Time • Grouping and freight consolidation • lob problems at ports • Spirit of free enterprise • Delivered price	• **Survey**
Frankel (1992)	• Governmental bodies • Shipping companies • Shippers • Freight forwarders	• Liner companies revenues / costs/fleet size/fleet employment • Cargo volume / value / allocation	• **Analytic hierarchy process**
Murphy *et al.* (1992)	• Large/small shippers • International water carriers • International water ports • International freights forwarders	• Loading/unloading facilities for large/odd sized freight • Large volume shipments • Low loss and damage frequency • Available equipment • Convenient pickup and delivery times • Information concerning shipments • Assistance in claims handling • Flexibility in meeting special handling requirements	• **Survey** • **Univariate analysis** • **Multivariate factor analysis**
Murphy and Daley (1994)	• Purchasing manager (shipper)	• Shipment information • Loss & damage performance • Freight charges • Equipment availability • Convenient pickup and delivery • Claims handling ability • Special handling ability • Large volume shipments • Large & odd-sized freight	• **Survey**
Kumar and Vijay (2002)	• Shipper	• On time performance • Value • Information technology • Customer service • Equipment and operations	• **Analytic hierarchy process**
Mangan *et al.* (2002)	• Decision makers (on ferry choice) in transport companies	• Service availability • Sailing frequency • Risk of cancellation • Fastest overall route • Proximity of ports to origin/destination • Cost • Speed of getting through ports • Suitability for special cargo • Delays • Intermodal/connecting links • Information availability	• **Modelling** • **Survey**
Nir *et al.* (2003)	• Shipper	• Highway travel time (origin: company, destination: port) • Travel cost • Number of available routes • Frequency	• **Survey** • **Revealed preference multinomial logical model**
Lirn *et al.* (2004)	• Shipping lines	• Physical infrastructure (including depth) • Geographical location (proximity to markets, main routes) • Port administration and service to vessels (turn around time) • Carriers cost per call	• **Analytic hierarchy process**

Source	Actor	Criteria	Methodology
Tongzon (1995);(2009), Tongzon and Sawant (2007)	• Forwarders	• Frequency of ship visits • Port efficiency • Adequate infrastructure • Location • Port charges • Quick response to port users' needs • Port's reputation for cargo damage	• **Survey**
Ha (2003)	• Shipping companies	• Information availability on port activities • Port location • Port turnaround time • Facilities available • Port management • Port costs • Customer convenience	• **Survey**
Tiwari *et al.* (2003)	• Shippers	• Ship calls (frequency) • Total TEUs handled at the port • TEUs per berth at the port • TEUs of cargo per crane • Handling volume (thousand tons) per length of quay • Number of routes offered • Port and loading charges	• **Literature review** • **Discrete Choice Analysis**
Malchow and Kanafani (2001)	• Shippers (commodity types)	• Distance • Frequency of sailings • Average size of vessel • Loading/unloading time	• **Discrete choice model**
Song and Yeo (2004)	• Ship owners • Shipping companies • Shippers • Terminal operators • Academics	• Cargo volume • Port facility • Port location • Service level • Port expenses	• **Analytic hierarchy process** • **Experts surveys**
Cullinane *et al.* (2005)	• Shippers (demand trends) • Port authorities (supply)	• Price • Generalized cost • Quality of service • Policy developments	• **Relative competitiveness analysis**
Guy and Urli (2006)	• Shipping companies	• Port infrastructures • Cost of port transit for a carrier • Port administration • Geographical location	• **Multi-criteria analysis**
Ugboma *et al.* (2006)	• Shippers	• Efficiency • Frequency of ship visits • Adequate infrastructure	• **Analytic hierarchy process**
Acosta *et al.* (2007)	• Terminal operators	• Infrastructure • Superstructure • Technology and communications systems • Internal competition • Cooperation of the institutions and companies involved in the port activity	• **Survey**
De Langen (2007)	• Shippers • Forwarders	• Location of port • Efficiency of cargo handling • Quality of terminal operating companies • Quality of equipment • Quality of shipping services • Information services in port • Good reputation to damage/delays • Customer focus • Connection to hinterland modes • Personal contacts in port	• **Survey**
Shintani *et al.* (2007)	• Shipping companies	• Costs • Empty container distribution	• **Algorithm-based heuristic analysis**
De Martino and Morvillo (2008)	• Port authorities • Shippers • Forwarders • Shipping companies	• Quality of the entire port: infrastructure, links to transport systems, terms of services • Value is generated by joint effort of port actors in the satisfaction of clients' needs	• **Literature review**
Grosso and Monteiro (2008)	• Forwarding companies	• Connectivity of the port • Cost and Port Productivity • Electronic information • Logistics of the container	• **Literature review** • **Survey**

Source	Actor	Criteria	Methodology
Leachman (2008)	• Importers	• Transportation costs • Alternative routes • Door-to-door transit times • Shipments pooling • Lead times of container movement	• **Economic optimization model**
Meersman *et al.* (2008)	• Shipping companies • Terminal operating companies • Port authorities	• Port hinterland connection capacity	• **Analysis of expected trends**
Wiegmans *et al.* (2008)	• Container terminal operators	• Port physical and technical infrastructure • Geographical location • Port efficiency • Interconnectivity of the port (sailing frequency of deep-sea and feeder shipping services) • Reliability, capacity, frequency and costs of inland transport services by truck, rail and barge (if any). • Quality and costs of auxiliary services such as pilotage, towage, customs, etc. • Efficiency and costs of port management and administration (e.g. port dues). • Availability, quality and costs of logistic value-added activities (e.g. warehousing). • Availability, quality and costs of port community systems. • Port security/safety and environmental profile of the port. • Port reputation (satisfactory ranking in benchmarking studies).	• **Interviews** • **Literature review**
Karlaftis *et al.* (2009)	• Shipping company	• Distances between ports • Demand • Supply • Service time	• **Modelling**
Sanchez, *et al* (2011)	• Service providers	• Cost • Effectiveness (Time efficiency, Delays in loading/unloading containers, Customs procedure, Port authority policy and regulations, Dedicated terminals and facilities for transhipment, Speed in responding to liners' new demands and requests) • Quality of port infrastructure and super infrastructure in container handling • Supporting industries (e.g., warehousing, insurance, etc.) • IT and advanced technology • Geographical location • Frequency in damage • Accessibility of the port • Quality of other services (e.g., pilotage, towing,and mooring). • Availability of professional personnel in port. • Preference of shipping lines' clients/shippers. • Relations between port operator and shipping lines. • Port marketing efforts by port authority. • Reputation of port within the region.	• Survey • ANOVA
Onut *et al* (2011)	• Llogistic firms	• Cost • Location • Hinterland economy • Efficiency physical features of port	• **Fuzzy ANP**
Panayides and Song (2012)	• Container shipping lines	• The port ’ berth capacity, flexibility, and average length of ship service. • Cost (including terminal cost, cargo handling, etc.) • Connectivity • Frequency of departures and freight loss. • Efficiency • Capacity (container storage, container yard, etc.) • Reliability	• Survey
Pires da Cruz, *et al* (2013)	• Port users • Service providers	• Port facilities • Channel depth • Vessel turnaround time • Intermodal links	• **AHP**

Source	Actor	Criteria	Methodology
Sayareh and Rezaee Alizmini (2014)	• Shipping companies • Experts of port operations	• Working time, • Stevedoring rate, • Safety, • Port entrance, • Sufficient draft, • Capacity of port facilities, • Operating cost, • Number of berths, • Ship chandelling, • International policies	• Questionair and Delphi technique. • Technique for Order Preference to Similarity by Ideal Solution (TOPSIS) • AHP

Source: Own complained based on Aronietis, *et.al.*, 2010

Appendix 2- Johanson cointegration test results

Sample (adjusted): 1991 2012
Included observations: 22 after adjustments
Trend assumption: Linear deterministic trend
Series: LNGDPCAP LNINVGDP LNOPEN LNP_INV LNDEF
Lags interval (in first differences): 1 to 1

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.932106	109.4035	69.81889	0.0000
At most 1 *	0.702585	50.22783	47.85613	0.0294
At most 2	0.419964	23.55002	29.79707	0.2201
At most 3	0.291007	11.56741	15.49471	0.1789
At most 4 *	0.166300	4.001403	3.841466	0.0455

Trace test indicates 2 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.932106	59.17571	33.87687	0.0000
At most 1	0.702585	26.67780	27.58434	0.0650
At most 2	0.419964	11.98261	21.13162	0.5494
At most 3	0.291007	7.566006	14.26460	0.4245
At most 4 *	0.166300	4.001403	3.841466	0.0455

Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegrating Coefficients (normalized by b'*S11*b=I):

LNGDPCAP	LNINVGDP	LNOPEN	LNP_INV	LNDEF
147.5511	-69.89903	-112.5860	-14.04257	26.91608
-32.21489	34.43634	37.23048	12.10532	-26.08051
-30.92248	14.51971	33.28359	-2.803095	-7.108914
34.00423	15.02114	-25.95928	6.416616	-13.98058
-132.2751	19.08413	109.9460	11.49259	-31.02568

Unrestricted Adjustment Coefficients (alpha):

D(LNGDPCAP)	0.003462	-0.004876	-0.007107	-0.001085	0.000880
D(LNINVGDP)	0.020105	0.008552	-0.006269	-0.001960	0.001098
D(LNOPEN)	0.017349	-0.008886	-0.006548	-0.000216	-0.003341
D(LNP_INV)	0.009330	-0.069788	0.042353	-0.013003	0.028396
D(LNDEF)	0.036122	-0.027606	0.003773	0.010132	0.014394

1 Cointegrating Equation(s): Log likelihood 262.2010

Normalized cointegrating coefficients (standard error in parentheses)

LNGDPCAP	LNINVGDP	LNOPEN	LNP_INV	LNDEF
1.000000	-0.473727	-0.763030	-0.095171	0.182419
	(0.02278)	(0.00747)	(0.00678)	(0.01373)

Adjustment coefficients (standard error in parentheses)

D(LNGDPCAP)	0.510781				
	(0.48741)				
D(LNINVGDP)	2.966444				
	(0.59944)				
D(LNOPEN)	2.559798				
	(0.66393)				
D(LNP_INV)	1.376684				
	(4.91431)				
D(LNDEF)	5.329894				
	(2.02037)				

2 Cointegrating Equation(s): Log likelihood 275.5399

Normalized cointegrating coefficients (standard error in parentheses)

LNGDPCAP	LNINVGDP	LNOPEN	LNP_INV	LNDEF
1.000000	0.000000	-0.450522	0.128149	-0.316722
		(0.06606)	(0.04468)	(0.09796)
0.000000	1.000000	0.659680	0.471410	-1.053645
		(0.13719)	(0.09278)	(0.20342)

Adjustment coefficients (standard error in parentheses)

D(LNGDPCAP)	0.667848	-0.409869
	(0.46124)	(0.23798)
D(LNINVGDP)	2.690945	-1.110789
	(0.51502)	(0.26572)
D(LNOPEN)	2.846069	-1.518658
	(0.58459)	(0.30161)
D(LNP_INV)	3.624882	-3.055401
	(4.23035)	(2.18262)
D(LNDEF)	6.219229	-3.475578
	(1.76567)	(0.91099)

3 Cointegrating Equation(s): Log likelihood 281.5312

Normalized cointegrating coefficients (standard error in parentheses)

LNGDPCAP	LNINVGDP	LNOPEN	LNP_INV	LNDEF
1.000000	0.000000	0.000000	-0.133902	-0.390662
			(0.15039)	(0.24977)
0.000000	1.000000	0.000000	0.855121	-0.945377
			(0.22785)	(0.37840)
0.000000	0.000000	1.000000	-0.581662	-0.164122
			(0.31835)	(0.52870)

Adjustment coefficients (standard error in parentheses)

D(LNGDPCAP)	0.887615	-0.513061	-0.807811
	(0.37635)	(0.19350)	(0.30068)
D(LNINVGDP)	2.884799	-1.201814	-2.153751
	(0.46270)	(0.23790)	(0.36967)
D(LNOPEN)	3.048558	-1.613738	-2.501996
	(0.53678)	(0.27599)	(0.42885)
D(LNP_INV)	2.315215	-2.440444	-2.239008
	(3.97544)	(2.04400)	(3.17613)
D(LNDEF)	6.102561	-3.420797	-4.969092
	(1.79604)	(0.92345)	(1.43492)

4 Cointegrating Equation(s): Log likelihood 285.3142

Normalized cointegrating coefficients (standard error in parentheses)

LNGDPCAP	LNINVGDP	LNOPEN	LNP_INV	LNDEF
1.000000	0.000000	0.000000	0.000000	-0.463581
				(0.08208)

0.000000	1.000000	0.000000	0.000000	-0.479708
				(0.17037)
0.000000	0.000000	1.000000	0.000000	-0.480874
				(0.13625)
0.000000	0.000000	0.000000	1.000000	-0.544565
				(0.33613)

Adjustment coefficients (standard error in parentheses)

D(LNGDPCAP)	0.850727	-0.529357	-0.779649	-0.094672
	(0.38285)	(0.19565)	(0.30526)	(0.04806)
D(LNINVGDP)	2.818159	-1.231252	-2.102877	-0.173798
	(0.46704)	(0.23867)	(0.37239)	(0.05863)
D(LNOPEN)	3.041218	-1.616980	-2.496392	-0.334219
	(0.54961)	(0.28087)	(0.43822)	(0.06900)
D(LNP_INV)	1.873044	-2.635770	-1.901449	-1.177979
	(4.03635)	(2.06267)	(3.21828)	(0.50672)
D(LNDEF)	6.447105	-3.268596	-5.232122	-0.786994
	(1.79224)	(0.91588)	(1.42900)	(0.22500)

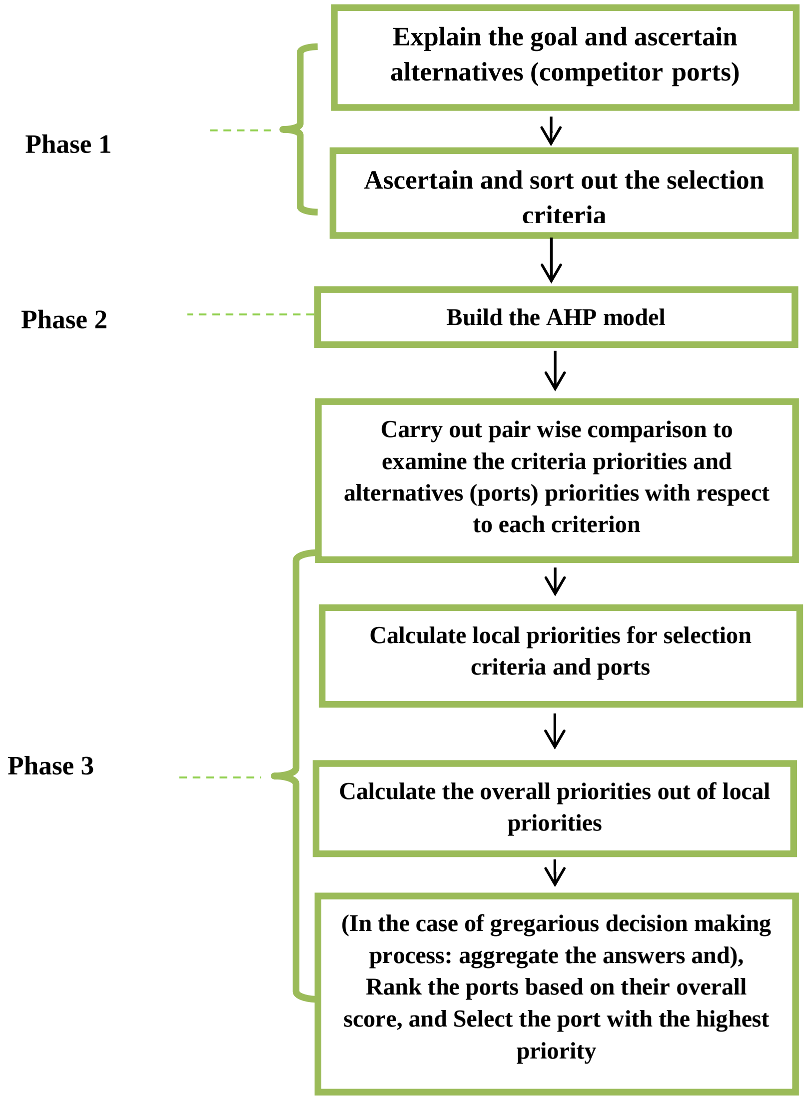
Appendix 3- Reference to Fuzzy ANP applications according to their themes

Theme			No	Reference No	Field
Selection			1	Dag˘deviren & al, 2010	Strategic management
			2	Ahmadvand, Bashiri, & Alighadr, 2010	Project management Critical path
			3	Lin, Lee, & Wu, 2009	Strategic management
			4	Ayub, Md, & Md, 2009	Human Resource Management
			5	Lin R. H., 2009	Supplier selection
			6	Boran & Kerim, 2010	Supplier selection
			7	Kang, Amy H, & CY, 2010	Supplier selection
			8	Razmi & et al., 2009	Supplier selection
			10	Sun, *et al*, 2009	Supplier selection
			11	Pang, 2009	Supplier selection
			12	Önüt & et al., 2011	Supplier selection
			13	S.Vinodh & et al., 2011	Supplier selection
			14	Ayag & R, 2011	New product development (NPD) environment concept selection
			15	Bi & Jin-yu, 2008	Production Line Selection
			16	Tuzkaya, Gülsün, Kahraman, & Özgen, 2009	Material handling equipment selection
			17	Onut & et al., 2009	Selection of the suitable material handling equipment (MHE)
			18	M.L, Lin, & Chiu, 2008	Marketing (selection of different competitive priorities)
			19	Li.Chunhao, Sun, & Du.Yuanwe, 2008	Outsourcing ,third-party logistics (3PL)
			20	Tuzkaya and Önüt, 2008	Transportation-mode selection
			21	Sadi-nezhad & et al., 2008	Scheduling of production in FMS (flexible manufacturing systems)
			22	Yazgan, 2010	Dispatching rule in FMS (flexible manufacturing systems)
			24	Büyüközkan & Çifçi, 2011	Supplier Selection
Evaluation			25	Dag˘deviren & al., 2010	Strategic management
			26	Gao, 2010	Project Management Performance
			27	Sun & Bi, 2008	Knowledge management
			28	Qu & et al., 2009	Support plan
			29	Li, 2009	Supply chain management (SCM)
			30	Zhou, *et al*, 2008	Supply chain management
			31	Chen, 1999	Innovation support system
			32	LIN & HSU, 2008	New service development
			33	Promentilla & et al., 2008	Prioritization of remedial countermeasures
			34	Razmi.Jafar & al., 2009	ERP readiness
			35	Luo & et al., 2010	Virtual Research Center
			36	Lee & al., 2010	Strategic management
			37	Etaati & al, 2010	Software Evaluation (Iso/IEC)
			38	Tseng, Divinagracia, & Divinagracia, 2009	Sustainable production indicators
			39	Sadi-Nezhad & et al., 2010	E-learning
			40	Chang & Horng, 2011	Knowledge-Based Management
			41	Chou, 2003	Web site quality
			42	Daneshvar & Erol, 2010	Department Selection
			43	Guneri & M. Cengiz, 2009	Select a location for shipyard
Location selection			44	WEI & WANG, 2009	Distribution center location
			45	Wu, Lin, & Huang-Chu, 2009	Porter’s diamond model
ANP with QFD			46	Liu & Wang, 2010	QFD
			47	Lin, Cheng, Tseng, & Tsai, 2010	Environmental production requirements
			48	Kahraman & al., 2006	Product technical requirements
Forecasting			49	Dag deviren & al., 2008	Safety management
			50	Mikhailov & Mdan G, 2003	Decision Support System
Decision making			51	Wong, 2010	Outsourcing ,third-party logistics (3PL)
			52	Nuhodzic & et al., 2010	Organization structure

Appendix 4- The AHP process and structure

The basic procedure to carry out the relevant AHP methodology to present research consists of three phases and seven steps which are shown in the process flow chart of Figure A4-1.

Figure A4-1 process flow chart for port selection by AHP methodology

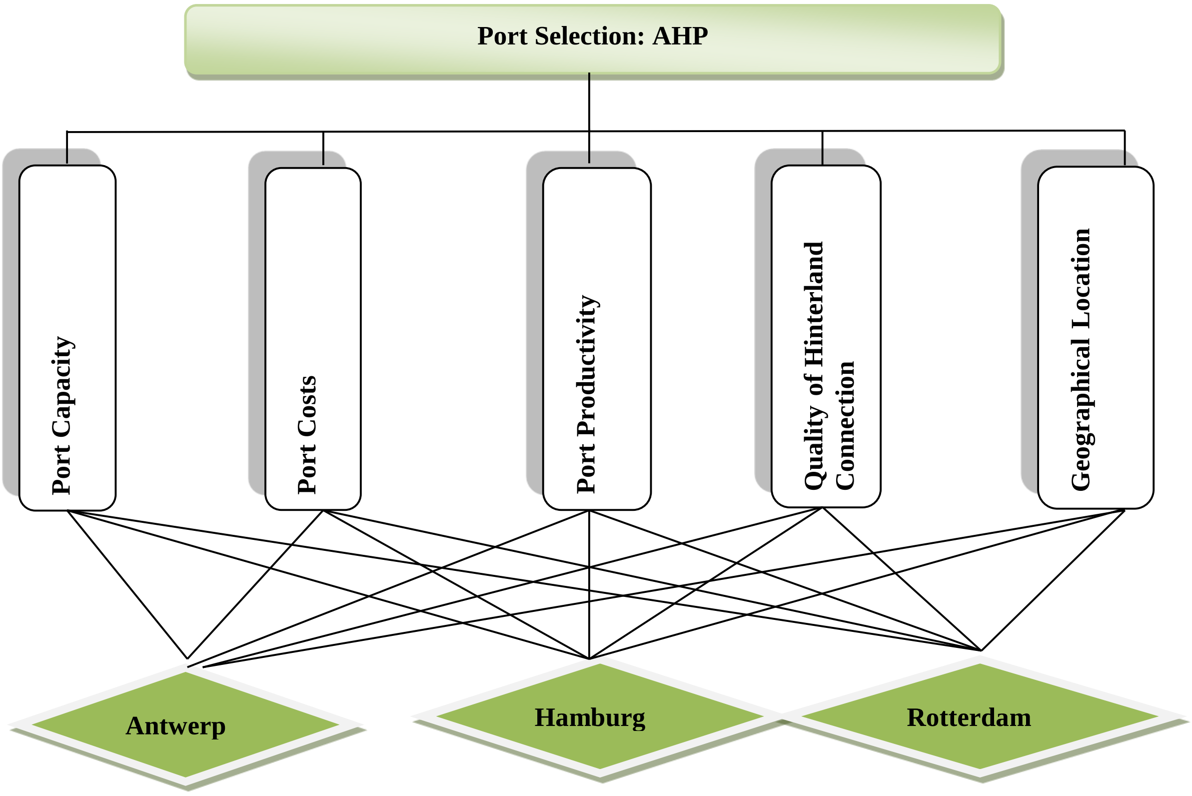


Phase one consists of decomposing the decision making problem to its staples, define the goal and identify the alternatives. This comprises goals at the uppermost level, criteria/sub-criteria at the intermediary level, and the alternatives at the lowermost level.

Phase two sets all staples in a hierarchy giving a view of complicated decision making process and helps comparing the components together accurately (Saaty, 1990). To construct the hierarchy, bearing in mind the environment of the problem is vital since it affects the identification of participants associated with the problem and attributes which contribute to the solution (Kasperczyk and Knickel, n.d.).

Figure A4-2 illustrates the hierarchy in three levels. The upmost level shows the question of the decision maker: port selection, the level in the middle shows the criteria – capacity, cost, productivity, hinterland connection, and location- and the bottom level consists of alternatives – the ports of Antwerp, Hamburg, and Rotterdam.

Figure A4-2 Constructing AHP for port selection goals



Phase three consists of four steps:

- Carry out the pair wise comparisons to examine the criteria priorities and alternatives' (ports) priorities with respect to each criterion.
- Calculate local priorities for selection criteria and alternatives (ports).
- Calculate the overall priorities out of local priorities.
- Aggregate the answers, rank the ports based on their overall scores, and rank the ports regarding their obtained prominence.

To weigh the factors by pair wise comparison, decision makers answer the question "how preferable is one criterion over the other one?" Assigning the relative weight to criteria, ranging from 1 for equal importance to 9 for extreme importance, gives the reciprocal values to the other criterion.

The next step is scoring alternatives with respect to criteria by pair wise comparison. Respondents answer the question "how they prefer one alternative over the other one regarding the certain criterion?" The used scales for making pair-wise comparisons are illustrated in Table A4-1. Reciprocal values are given to the other alternative. Obtained scores for each alternative need to be normalized and averaged to find the average score.

The final calculating step is finding the overall scores of each alternative combining to criteria weights.

Table A4-1 scale of relative importance

Intensity of relative importance	Definition	Explanation
1	Equal importance	Two factors contribute equally to the objective.
3	Moderate importance of one over another	Experience and judgment slightly favour one factor over another.
5	Essential or strong importance	Experiment and judgments strongly favour one factor over another.
7	Demonstrated importance	An factor is strongly favoured and its dominance is demonstrated in practice.
9	Extreme importance	The evidence favouring one factor over another is of the highest possible order of affirmation.
2,4,6,8	Intermediate values between the two adjacent judgments	When compromise is needed
Reciprocals of above non-zero numbers	If a factor has one of above numbers assigned to it when compared with a second factor, then the second factor has the reciprocal value when compared to the first.	
Rational	Ratios arising from the scale	If consistency were to be forced by obtaining n numerical values to span the matrix.

Source: Saaty, 1986

The Analytical Hierarchy Process (AHP) method is applied for each individual and each group of respondents separately. In the next stage, AHP is utilized for aggregate answers of all respondents and groups, in weighted and un-weighted ways. When answers are weighted, ship operators, shippers, and freight forwarders are given the importance degree of influencing whole system of port choice three, two, and one respectively.

When AHP is utilized for a group, their total judgments should be calculated by using the geometric mean to the all answers (Aczel and Saaty, 1983).

Figure A4-3 The applied AHP structure in the super decision software environment

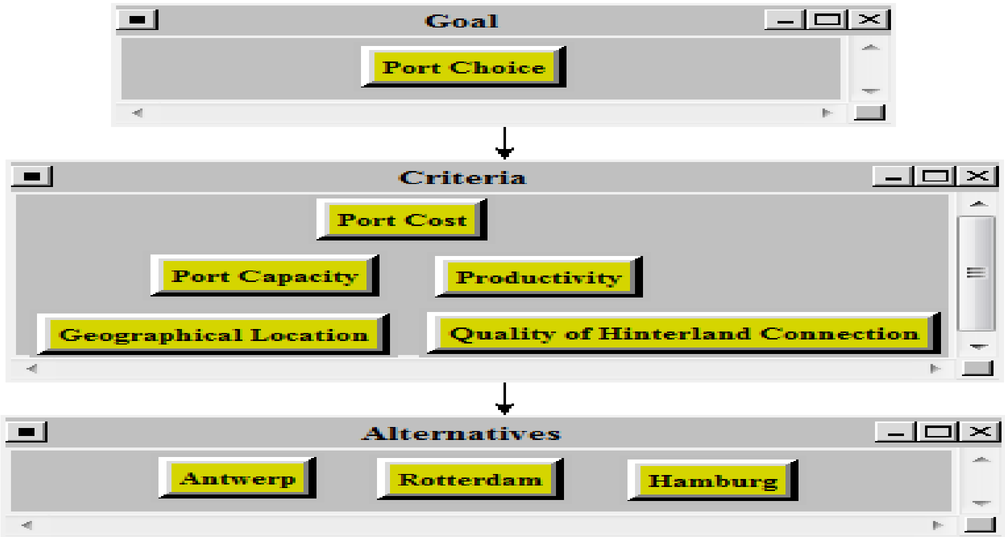


Figure A4-3 illustrates the applied structured model in the super decision software environment. This structure is shared between all individuals (thirty one respondents) and groups (three groups), but each one has its own priorities.

A4-1 Pair wise comparisons and judgment scales

Two sets of questionnaires are distributed to evaluate the criteria priorities with respect to port selection and port selection with respect to criteria. The following formula gives the number of generated questions:

Q (n,2) = n(n-1)/2 (A4-1)

Where Q is the number of questions and n refers to the number of attitudes to be evaluated. Having five criteria to be evaluated by respondents generates ten questions for the criteria priorities' questionnaire and fifteen questions for the port choice questionnaire.

A4-2 Consistency

If the matrix is perfectly consistent, the transitivity rule (8-2) holds for all comparisons.

$$a_{ij} = a_{ik} . a_{kj} \quad \text{(A4-2)}$$

Since the real world can be inconsistent, the case of perfect consistency in pair wise comparison matrices occurs rarely. Therefore, a consistency test must be checked to acquire a minimum inconsistency (equation 8-3).

$CI= (\lambda_{Max} - n)/ (n-1)$ (A4-3)

where λ_{Max} is maximal eigenvalue[32].

The consistency ratio is driven by equation (8-4).

CR=CI/RI (A4-4)

Where *RI* is the random index.

The acceptable consistency of the matrix is considered for the *CR* less than 10%. In addition to Saaty (1977), some other researchers (Alonso, 2006; Tummala and Wan, 1994; Forman, 1990; Lane and Verdini, 1989) have suggested simulations with different numbers of matrices which are similar to the indices carried out by Saaty. Table 8-2 shows the random indices calculated by Saaty (1977).

Table A4-2 random indices from Saaty

n	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*
RI	*0*	*0*	*0.58*	*0.9*	*1.12*	*1.24*	*1.32*	*1.41*	*1.45*	*1.45*

Those answers which appeared with inconsistency indices higher than 0.1 and must be redone by interviewees or dropped. Generally, there are five reasons that generate inconsistency: 1) Mistakes a simple lack of concentration, 2) lack of knowledge or being uncertain, 3) human nature, 4) discrete scale, and 5) capped scales. Usually in the real world facing inconsistence answers is unavoidable. To deal with this situation a number of solutions are considered: 1) avoiding more than 9 criteria to compare, 2) making a proper hierarchy, made by elements which are not extremely different in priority, and finally 3) eliminating contradictions. The later one, specifically, may make conform-looking results. One should bear in mind that this is a part of methodology and reflects anyway the view of respondents which are limited in the geographical and time scope. The other reason that may bring the impression of the conform-looking result is that the criteria chosen to apply to this methodology is once before investigated and selected; in this study there exist a general consensus over the most cited port selection factors by respondents based on the literature review. However, we dropped one contradicted answer from a shipper which reflected the least importance for port cost.

A4-3 Aggregation

The last step is to determine the global priority by synthesizing local priorities, using the equation (A4-5).

$$p_i = \sum_j w_j . l_{ij} \quad \text{(A4-5)}$$

Where p_i presents global priorities of the alternatives, l_{ij} presents local priority, and w_j stands for weight of the criterion j. Collecting individual questionnaires, the final answers to construct the final pair-wise comparison need to be obtained by agglomeration. Following formula is used:

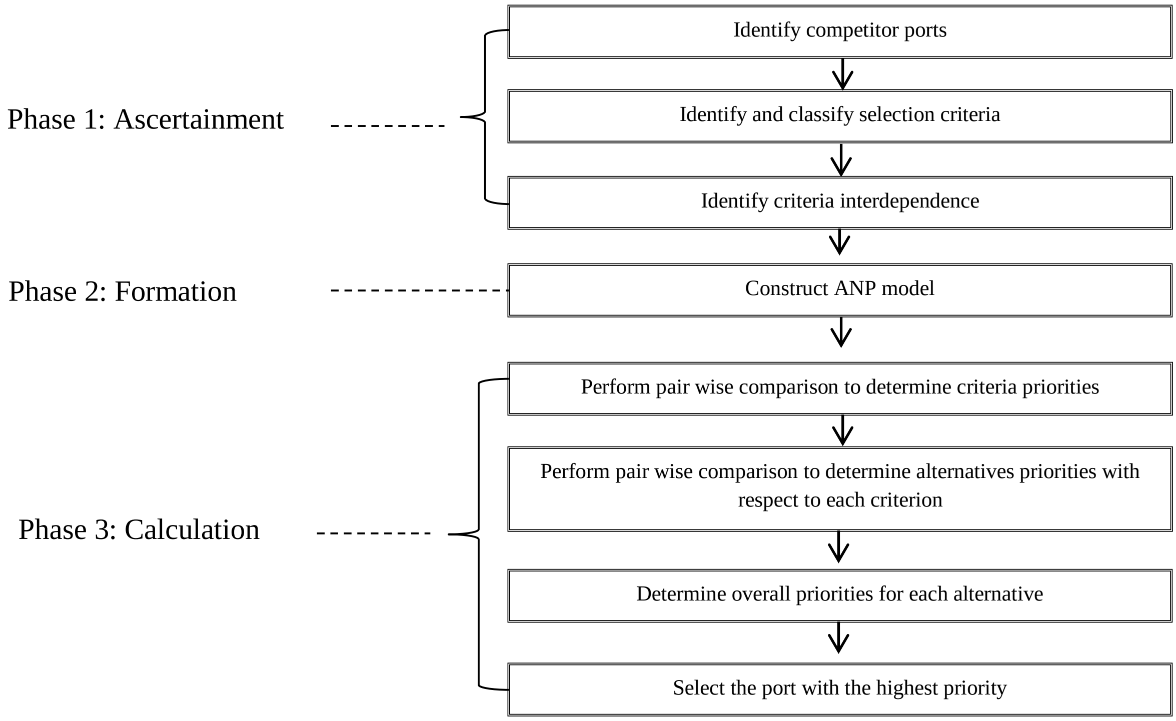
$$\overline{A} = \frac{1}{n}(A_1 + A_2 + ... + A_n) \quad \text{(A4-6)}$$

AHP have several advantages and disadvantages over other MCDM method. A summary of them are addressed in the following section.

Appendix 5- The ANP process and structure

The basic procedure to carry out the relevant AHP methodology to present research consists of three phases and eight steps which are shown in the process flow chart of Figure A5-1.

Figure A5-1 process flow chart for port selection by ANP methodology



ANP consists of an additional stage which interrelates port cost criterion with other criteria. The rest of ANP process and structure is similar to AHP (see Figure A5-2 and A5-3).

Figure A5-2 Constructing ANP for port selection goals

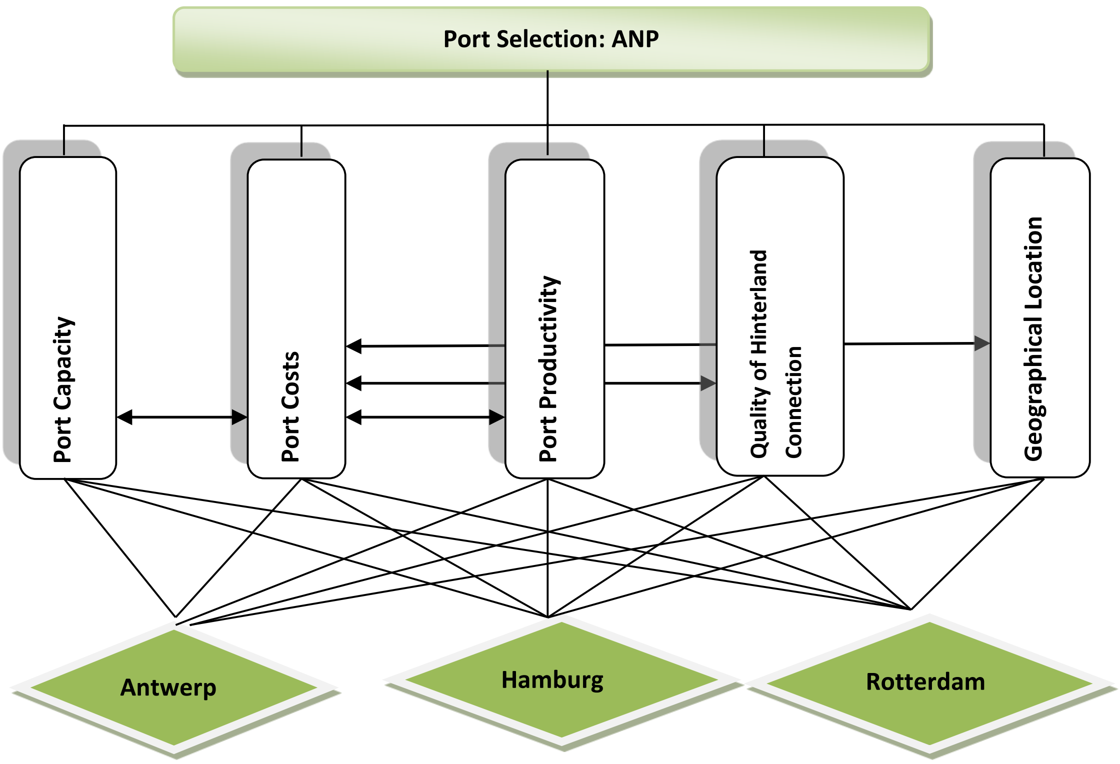
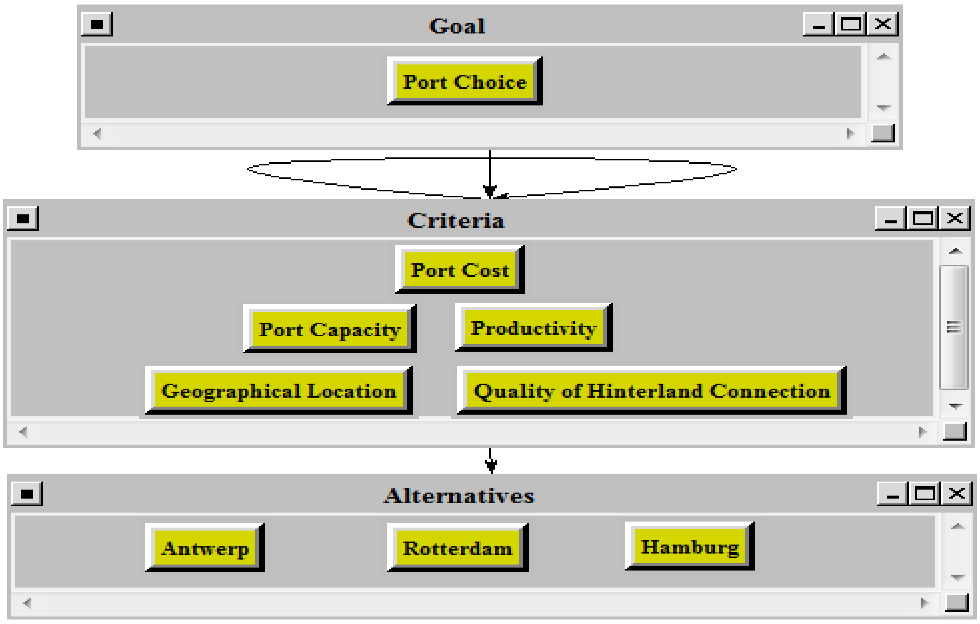


Figure A5-3 The applied ANP structure in the super decision software environment



The network of ANP is represented in a matrix form. The matrix is composed by listing all nodes vertically and horizontally. Each non-zero element of the matrix represents the connection and weight from one node (columns header) to other node (row-header) of the network.

This matrix is called super matrix. The so found priorities are arranged as column vectors in the super matrix. This matrix is then normalized i.e. the sum of all columns is scaled to 1. The whole model is synthesized by calculating the "limit matrix". The limit matrix is the weighted super matrix taken to the power of K+1, where k is arbitrary number. The element 35 of the matrix e.g. represents the connection and weight from cost to geographical location (see Figure A5-4).

Appendix 6- Questionnaire 1: Factor Priority

Questionnaire for determining **factor priorities** in port and shipping services by shippers, freight forwarders and ship-operators.

Part 1: Introduction

The purpose of this survey is to investigate your opinion about five factors related to the competitiveness of container transport system in a way of pair comparison. Following factors are extracted from literature:

1. **Port capacity**
   - ✓ Available berths, cranes, storage, etc.
   - ✓ Probability to lose time (while berthing, crossing locks, etc.)
   - ✓ Free capacity
2. **Port costs**
   - ✓ Port charges (port dues, pilot cost, towage, etc.)
   - ✓ Terminal handling charges
   - ✓ Storage cost and dwell time
3. **Port productivity**
   - ✓ Container yard efficiency
   - ✓ The number of TEU and/or tones handled per crane per hour
   - ✓ Custom efficiency
4. **Quality of hinterland connection**
   - ✓ Land cost (Inland transshipment freight rates and other land transport costs associated with the port)
   - ✓ International connectivity
   - ✓ Intermodal connectivity (rail, highway, barges)
5. **Geographical location**
   - ✓ Proximity to the markets (demand)
   - ✓ Distance of shippers from the port (supply)

You are requested to represent how important each factor is for you to select a port/shipping line with its corresponded figure.

How to weight your choice:

Number “1”: represents the absolute attraction of the “left” choice,

Number “3”: represents the slightly attraction of the “left” choice, Number “5”: shows the equal attraction of both ports concerning the attributed factor.

Number “7”: represents the slightly attraction of the “right” choice,

and number “9”: represents the absolute attraction of the “right” choice.

The numbers between are representatives of relative preferences.

An example:

Q: When comparing **port capacity** with **port cost**, which factor is more important in your port choice?

(when **port capacity** has **absolute** importance):

Port capacity 1(•) 2( ) 3( ) 4( ) 5( ) 6( ) 7( ) 8( ) 9( ) **Port cost**

(when **port capacity** has **strongly** importance):

Port capacity 1( ) 2( ) 3(•) 4( ) 5( ) 6( ) 7( ) 8( ) 9( ) **Port cost**

(when **port capacity** has **slightly** importance):

Port capacity 1( ) 2( ) 3( ) 4(•) 5( ) 6( ) 7( ) 8( ) 9( ) **Port cost**

(when you are **indifference** between **port capacity** and **port cost**):

Port capacity 1( ) 2( ) 3( ) 4( ) 5(•) 6( ) 7( ) 8( ) 9( ) **Port cost**

(when **port cos**t has **slightly** importance):

Port capacity 1( ) 2( ) 3( ) 4( ) 5( ) 6(•) 7( ) 8( ) 9( ) **Port cost**

(when **port cos**t has **strongly** importance):

Port capacity 1( ) 2( ) 3( ) 4( ) 5( ) 6( ) 7(•) 8( ) 9( ) **Port cost**

(when **port cos**t has **absolutely** importance):

Port capacity 1( ) 2( ) 3( ) 4( ) 5( ) 6( ) 7( ) 8( ) 9(•) **Port cost**

Part 2: General question

1- Which of the following best describe the organization you are representing?

( ) Shipping company

( ) Exporting/ Importing company

( ) Manufacturing company

( ) Retailer

( ) Freight forwarder

2- How many container you trading annually

( ) Under 500 ( )500-1000 ( )1000-2000 ( )Over 2000

3- Which of the following ports is your main European trading port?

( )Antwerp ( )Hamburg ( )Rotterdam ( )Others

4- How much increase in your total transport costs due to imposing toll roads by governments (either at destination or origin) may alter your current port and shipping networks utilizations.

( ) 0- 0.5% ( ) 0.5% - 1% ( ) 1%- 1.5% ( ) 1.5% - 2%

Appendix 7- Questionnaire 2: Port Choice

Questionnaire for determining **port and shipping network selection** by shippers, ship-owners, and freight forwarders.

Part 1: Introduction

The purpose of this survey is to investigate your opinion about the port and shipping network selection regarding the main criteria related to the competitiveness of container transport system in a way of pair-comparison. In this study three ports would be considered; Port of **Antwerp**, Port of **Rotterdam**, and Port of **Hamburg**.

An example:

Q: Which port would you chose concerning the "**port capacity**"?

(when you chose **absolutely** Port of **Antwerp**):

Antwerp	1(•)	2( )	3( )	4( )	5( )	6( )	7( )	8( )	9( )	**Hamburg**

(when you chose **strongly** Port of **Antwerp**):

Antwerp	1( )	2( )	3(•)	4( )	5( )	6( )	7( )	8( )	9( )	**Hamburg**

(when you chose **slightly** Port of **Antwerp**):

Antwerp	1( )	2( )	3( )	4(•)	5( )	6( )	7( )	8( )	9( )	**Hamburg**

(when you are **indifference** between Port of **Antwerp** and Port of **Hamburg**):

Antwerp	1( )	2( )	3( )	4( )	5(•)	6( )	7( )	8( )	9( )	**Hamburg**

(when you chose **slightly** Port of **Hamburg**):

Antwerp	1( )	2( )	3( )	4( )	5( )	6(•)	7( )	8( )	9( )	**Hamburg**

(when you chose **strongly** Port of **Hamburg**):

Antwerp	1( )	2( )	3( )	4( )	5( )	6( )	7(•)	8( )	9( )	**Hamburg**

(when you chose **absolutely** Port of **Hamburg**):

Antwerp	1( )	2( )	3( )	4( )	5( )	6( )	7( )	8( )	9(•)	**Hamburg**

Appendix 8- the outcome of software when AHP is applied

ship operators, AHP

1

Antwerp	0.32940
Hamburg	0.25392
Rotterdam	0.41668
Geographical Location	0.27058
Port Capacity	0.04451
Port Cost	0.44687
Productivity	0.06386
Quality of Hinterland Connection	0.17417

2

Antwerp	0.11926
Hamburg	0.19876
Rotterdam	0.68198
Geographical Location	0.15560
Port Capacity	0.03085
Port Cost	0.36713
Productivity	0.05432
Quality of Hinterland Connection	0.39209

3

Antwerp	0.51425
Hamburg	0.17192
Rotterdam	0.31383
Geographical Location	0.15975
Port Capacity	0.03418
Port Cost	0.52400
Productivity	0.05675
Quality of Hinterland Connection	0.22531

4

Antwerp	0.48736
Hamburg	0.13063
Rotterdam	0.38200
Geographical Location	0.12916
Port Capacity	0.03056
Port Cost	0.55986
Productivity	0.04746
Quality of Hinterland Connection	0.23297

5

Antwerp	0.32940
Hamburg	0.25392
Rotterdam	0.41668
Geographical Location	0.27058
Port Capacity	0.04451
Port Cost	0.44687
Productivity	0.06386
Quality of Hinterland Connection	0.17417

6

Antwerp	0.11926
Hamburg	0.19876
Rotterdam	0.68198
Geographical Location	0.15560
Port Capacity	0.03085
Port Cost	0.36713
Productivity	0.05432
Quality of Hinterland Connection	0.39209

7

Antwerp	0.41054
Hamburg	0.09342
Rotterdam	0.49605
Geographical Location	0.14030
Port Capacity	0.03494
Port Cost	0.48743
Productivity	0.05757
Quality of Hinterland Connection	0.27976

8

Antwerp	0.37390
Hamburg	0.34678
Rotterdam	0.27932
Geographical Location	0.40678
Port Capacity	0.02818
Port Cost	0.28774
Productivity	0.10875
Quality of Hinterland Connection	0.16854

9

Antwerp	0.36342
Hamburg	0.25895
Rotterdam	0.37763
Geographical Location	0.28630
Port Capacity	0.05865
Port Cost	0.45993
Productivity	0.04991
Quality of Hinterland Connection	0.14521

10

Antwerp	0.18511
Hamburg	0.29254
Rotterdam	0.52235
Geographical Location	0.07456
Port Capacity	0.05832
Port Cost	0.44675
Productivity	0.18481
Quality of Hinterlan Connection	0.23556

11

12

Antwerp	0.31587
Hamburg	0.41612
Rotterdam	0.26801
Geographical Location	0.17046
Port Capacity	0.03464
Port Cost	0.57107
Productivity	0.07272
Quality of Hinterlan Connection	0.15111

Antwerp	0.21272
Hamburg	0.25673
Rotterdam	0.53055
Geographical Location	0.06115
Port Capacity	0.10242
Port Cost	0.53571
Productivity	0.07949
Quality of Hinterlan Connection	0.22123

13

Antwerp	0.15019
Hamburg	0.17355
Rotterdam	0.67626
Geographical Location	0.07425
Port Capacity	0.04079
Port Cost	0.45297
Productivity	0.27659
Quality of Hinterlan Connection	0.15539

14

Antwerp	0.22235
Hamburg	0.19062
Rotterdam	0.58703
Geographical Location	0.06347
Port Capacity	0.03115
Port Cost	0.60377
Productivity	0.10821
Quality of Hinterlan Connection	0.19340

all

Antwerp	0.31646
Hamburg	0.23896
Rotterdam	0.44458
Geographical Location	0.18209
Port Capacity	0.04542
Port Cost	0.44403
Productivity	0.10729
Quality of Hinterlan Connection	0.22118

Shippers, AHP

1

Antwerp	0.32911
Hamburg	0.25216
Rotterdam	0.41873
Geographical Location	0.20182
Port Capacity	0.02921
Port Cost	0.55868
Productivity	0.04013
Quality of Hinterland Connection	0.17015

2

Antwerp	0.17397
Hamburg	0.24605
Rotterdam	0.57998
Geographical Location	0.19655
Port Capacity	0.03393
Port Cost	0.55467
Productivity	0.05538
Quality of Hinterland Connection	0.15947

3

Antwerp	0.19935
Hamburg	0.39949
Rotterdam	0.40115
Geographical Location	0.43876
Port Capacity	0.04416
Port Cost	0.20604
Productivity	0.05494
Quality of Hinterland Connection	0.25610

4

Antwerp	0.23699
Hamburg	0.19757
Rotterdam	0.56544
Geographical Location	0.21232
Port Capacity	0.03383
Port Cost	0.55364
Productivity	0.05374
Quality of Hinterland Connection	0.14648
Port Choice	0.00000

5

Antwerp	0.28143
Hamburg	0.30610
Rotterdam	0.41248
Geographical Location	0.26798
Port Capacity	0.03356
Port Cost	0.47710
Productivity	0.07275
Quality of Hinterland Connection	0.14861

6

Antwerp	0.45338
Hamburg	0.31140
Rotterdam	0.23522
Geographical Location	0.13290
Port Capacity	0.05686
Port Cost	0.34873
Productivity	0.02982
Quality of Hinterland Connection	0.43168

7

Antwerp	0.28521
Hamburg	0.11354
Rotterdam	0.60124
Geographical Location	0.23196
Port Capacity	0.03882
Port Cost	0.48991
Productivity	0.06687
Quality of Hinterland Connection	0.17244

8

Antwerp	0.12178
Hamburg	0.55914
Rotterdam	0.31908
Geographical Location	0.18000
Port Capacity	0.03386
Port Cost	0.56161
Productivity	0.07655
Quality of Hinterlan Connection	0.14798

9

Antwerp	0.17501
Hamburg	0.44305
Rotterdam	0.38193
Geographical Location	0.15102
Port Capacity	0.05126
Port Cost	0.48546
Productivity	0.04341
Quality of Hinterlan Connection	0.26885

all

Antwerp	0.32457
Hamburg	0.23681
Rotterdam	0.43862
Geographical Location	0.22650
Port Capacity	0.04937
Port Cost	0.41944
Productivity	0.08134
Quality of Hinterlan Connection	0.22335

Forwarders, AHP

1

Antwerp	0.40529
Hamburg	0.16140
Rotterdam	0.43331
Geographical Location	0.12767
Port Capacity	0.11397
Port Cost	0.37239
Productivity	0.13903
Quality of Hinterland Connection	0.24695

2

Antwerp	0.52326
Hamburg	0.23837
Rotterdam	0.23837
Geographical Location	0.14366
Port Capacity	0.05139
Port Cost	0.61207
Productivity	0.06762
Quality of Hinterland Connection	0.12525

3

Antwerp	0.53039
Hamburg	0.18560
Rotterdam	0.28401
Geographical Location	0.12502
Port Capacity	0.03854
Port Cost	0.62597
Productivity	0.05303
Quality of Hinterland Connection	0.15744

4

Antwerp	0.71244
Hamburg	0.09137
Rotterdam	0.19619
Geographical Location	0.05486
Port Capacity	0.08189
Port Cost	0.32013
Productivity	0.33988
Quality of Hinterland Connection	0.20324

5

Antwerp	0.68799
Hamburg	0.16187
Rotterdam	0.15014
Geographical Location	0.11282
Port Capacity	0.03012
Port Cost	0.65092
Productivity	0.05563
Quality of Hinterland Connection	0.15050

6

Antwerp	0.20220
Hamburg	0.26587
Rotterdam	0.53194
Geographical Location	0.15784
Port Capacity	0.02650
Port Cost	0.48205
Productivity	0.06078
Quality of Hinterland Connection	0.27284

7

Antwerp	0.24052
Hamburg	0.16149
Rotterdam	0.59799
Geographical Location	0.04569
Port Capacity	0.04569
Port Cost	0.67419
Productivity	0.09124
Quality of Hinterlan Connection	0.14319

8

Antwerp	0.19789
Hamburg	0.38059
Rotterdam	0.42151
Geographical Location	0.04936
Port Capacity	0.05312
Port Cost	0.62758
Productivity	0.10487
Quality of Hinterlan Connection	0.16508

all

Antwerp	0.36047
Hamburg	0.23057
Rotterdam	0.40895
Geographical Location	0.11446
Port Capacity	0.07082
Port Cost	0.48909
Productivity	0.14235
Quality of Hinterland Connection	0.18327

Appendix 9- the outcome of software when ANP is applied

ship operators, ANP

1

Antwerp	0.29325
Hamburg	0.27690
Rotterdam	0.42985
Geographical Location	0.24275
Port Capacity	0.05796
Port Cost	0.36526
Productivity	0.10264
Quality of Hinterland Connection	0.23139

2

Antwerp	0.12841
Hamburg	0.22251
Rotterdam	0.64908
Geographical Location	0.15763
Port Capacity	0.04089
Port Cost	0.31019
Productivity	0.10295
Quality of Hinterland Connection	0.38834

3

Antwerp	0.35468
Hamburg	0.19156
Rotterdam	0.45376
Geographical Location	0.16118
Port Capacity	0.06169
Port Cost	0.41522
Productivity	0.07957
Quality of Hinterland Connection	0.28234

4

Antwerp	0.39112
Hamburg	0.14729
Rotterdam	0.46159
Geographical Location	0.12675
Port Capacity	0.04971
Port Cost	0.43742
Productivity	0.09749
Quality of Hinterland Connection	0.28863

5

Antwerp	0.25267
Hamburg	0.17061
Rotterdam	0.57672
Geographical Location	0.21705
Port Capacity	0.02878
Port Cost	0.10911
Productivity	0.07055
Quality of Hinterland Connection	0.57450

6

Antwerp	0.54248
Hamburg	0.11255
Rotterdam	0.34497
Geographical Location	0.11214
Port Capacity	0.05758
Port Cost	0.33911
Productivity	0.30980
Quality of Hinterland Connection	0.18137

7

Antwerp	0.34959
Hamburg	0.09458
Rotterdam	0.55583
Geographical Location	0.13365
Port Capacity	0.04610
Port Cost	0.39191
Productivity	0.13846
Quality of Hinterland Connection	0.28987

8

Antwerp	0.30941
Hamburg	0.36706
Rotterdam	0.32353
Geographical Location	0.37337
Port Capacity	0.03729
Port Cost	0.25155
Productivity	0.12973
Quality of Hinterland Connection	0.20806

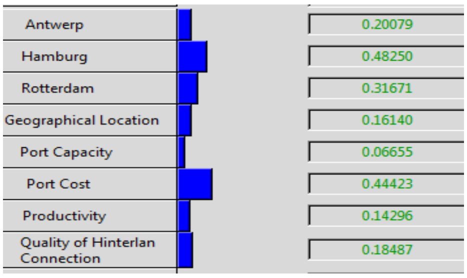
9

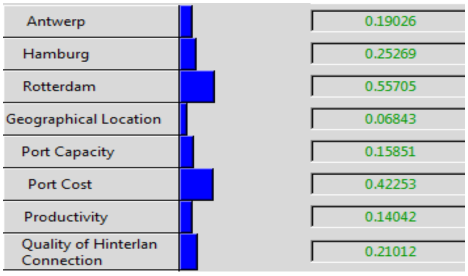
Antwerp	0.25173
Hamburg	0.27288
Rotterdam	0.47540
Geographical Location	0.25033
Port Capacity	0.07845
Port Cost	0.37394
Productivity	0.09826
Quality of Hinterland Connection	0.19903

10

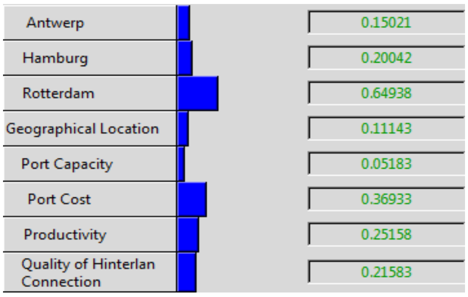
Antwerp	0.18391
Hamburg	0.28219
Rotterdam	0.53390
Geographical Location	0.10359
Port Capacity	0.05633
Port Cost	0.36518
Productivity	0.17012
Quality of Hinterlan Connection	0.30479

11 12

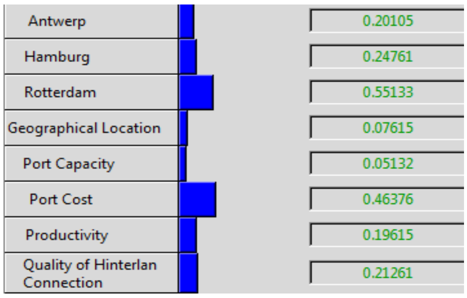

Antwerp 0.20079
Hamburg 0.48250
Rotterdam 0.31671
Geographical Location 0.16140
Port Capacity 0.06655
Port Cost 0.44423
Productivity 0.14296
Quality of Hinterlan Connection 0.18487


Antwerp 0.19026
Hamburg 0.25269
Rotterdam 0.55705
Geographical Location 0.06843
Port Capacity 0.15851
Port Cost 0.42253
Productivity 0.14042
Quality of Hinterlan Connection 0.21012

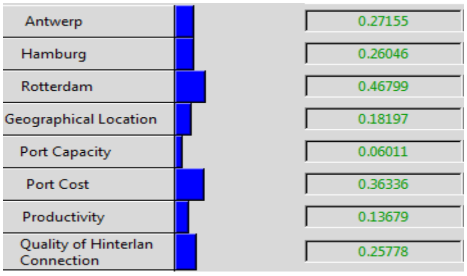
13


Antwerp 0.15021
Hamburg 0.20042
Rotterdam 0.64938
Geographical Location 0.11143
Port Capacity 0.05183
Port Cost 0.36933
Productivity 0.25158
Quality of Hinterlan Connection 0.21583

14


Antwerp 0.20105
Hamburg 0.24761
Rotterdam 0.55133
Geographical Location 0.07615
Port Capacity 0.05132
Port Cost 0.46376
Productivity 0.19615
Quality of Hinterlan Connection 0.21261

all


Antwerp 0.27155
Hamburg 0.26046
Rotterdam 0.46799
Geographical Location 0.18197
Port Capacity 0.06011
Port Cost 0.36336
Productivity 0.13679
Quality of Hinterlan Connection 0.25778

Shippers, ANP

1

Antwerp	0.49307
Hamburg	0.21509
Rotterdam	0.29184
Geographical Location	0.27752
Port Capacity	0.03444
Port Cost	0.43670
Productivity	0.05359
Quality of Hinterland Connection	0.19775

2

Antwerp	0.15667
Hamburg	0.28565
Rotterdam	0.55768
Geographical Location	0.27537
Port Capacity	0.04729
Port Cost	0.43424
Productivity	0.06408
Quality of Hinterland Connection	0.17902

3

Antwerp	0.16870
Hamburg	0.43733
Rotterdam	0.39396
Geographical Location	0.44331
Port Capacity	0.05107
Port Cost	0.18680
Productivity	0.06085
Quality of Hinterland Connection	0.25798

4

Antwerp	0.22107
Hamburg	0.23737
Rotterdam	0.54156
Geographical Location	0.21473
Port Capacity	0.04721
Port Cost	0.43361
Productivity	0.10425
Quality of Hinterland Connection	0.20020

5

Antwerp	0.19453
Hamburg	0.41674
Rotterdam	0.38873
Geographical Location	0.31023
Port Capacity	0.04318
Port Cost	0.38521
Productivity	0.06715
Quality of Hinterland Connection	0.19423

6

Antwerp	0.36445
Hamburg	0.36833
Rotterdam	0.26722
Geographical Location	0.15020
Port Capacity	0.05560
Port Cost	0.29696
Productivity	0.03257
Quality of Hinterland Connection	0.46467

7

Antwerp	0.29510
Hamburg	0.11105
Rotterdam	0.59385
Geographical Location	0.24534
Port Capacity	0.05086
Port Cost	0.39351
Productivity	0.11274
Quality of Hinterland Connection	0.19754

8

Antwerp	0.11616
Hamburg	0.56828
Rotterdam	0.31555
Geographical Location	0.17898
Port Capacity	0.03951
Port Cost	0.43848
Productivity	0.14363
Quality of Hinterlan Connection	0.19940

9

Antwerp	0.16533
Hamburg	0.43520
Rotterdam	0.39947
Geographical Location	0.25536
Port Capacity	0.05241
Port Cost	0.39064
Productivity	0.06432
Quality of Hinterlan Connection	0.23727

all

Antwerp	0.29944
Hamburg	0.25738
Rotterdam	0.44318
Geographical Location	0.24302
Port Capacity	0.06813
Port Cost	0.35363
Productivity	0.10272
Quality of Hinterlan Connection	0.23250

Forwarders, ANP

1

Antwerp	0.39743
Hamburg	0.17781
Rotterdam	0.42476
Geographical Location	0.12314
Port Capacity	0.11425
Port Cost	0.31394
Productivity	0.15842
Quality of Hinterland Connection	0.29026

2

Antwerp	0.35121
Hamburg	0.32439
Rotterdam	0.32439
Geographical Location	0.12808
Port Capacity	0.06181
Port Cost	0.46865
Productivity	0.13865
Quality of Hinterland Connection	0.20281

3

Antwerp	0.32409
Hamburg	0.20703
Rotterdam	0.46888
Geographical Location	0.11800
Port Capacity	0.06956
Port Cost	0.47675
Productivity	0.12808
Quality of Hinterland Connection	0.20761

4

Antwerp	0.68793
Hamburg	0.09087
Rotterdam	0.22119
Geographical Location	0.05831
Port Capacity	0.08378
Port Cost	0.27596
Productivity	0.33716
Quality of Hinterland Connection	0.24480

5

Antwerp	0.60017
Hamburg	0.24741
Rotterdam	0.15242
Geographical Location	0.17545
Port Capacity	0.04619
Port Cost	0.49109
Productivity	0.08338
Quality of Hinterland Connection	0.20388

6

Antwerp	0.17271
Hamburg	0.32600
Rotterdam	0.50129
Geographical Location	0.17254
Port Capacity	0.03057
Port Cost	0.38843
Productivity	0.06924
Quality of Hinterland Connection	0.33923

7

Antwerp	0.20153
Hamburg	0.25131
Rotterdam	0.54716
Geographical Location	0.12202
Port Capacity	0.05971
Port Cost	0.50422
Productivity	0.09377
Quality of Hinterlan Connection	0.22027

8

Antwerp	0.24698
Hamburg	0.33655
Rotterdam	0.41647
Geographical Location	0.06579
Port Capacity	0.06865
Port Cost	0.47768
Productivity	0.14580
Quality of Hinterlan Connection	0.24208

all

Antwerp	0.32806
Hamburg	0.23835
Rotterdam	0.43359
Geographical Location	0.12228
Port Capacity	0.07531
Port Cost	0.38574
Productivity	0.17259
Quality of Hinterlan Connection	0.24407

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[1] For further discussion see chapter 2, section 2.3 supply chain design and formation.
[2] According to Porter (1990), inward FDI is ‘not entirely healthy, and while in a later publication (Porter, 1998) it is acknowledged that FDI can contribute to the development of a cluster, it is suggested that this will occur only if foreign-owned firms ‘make a permanent investment in achieving a significant local presence’.
[3] Representing for each of the 275 municipalities where place of production is located grouped data. These data comprise age, sex, educational qualification, industry, and year.
4 Solow growth model, Trans-log function, and Cobb-Douglas
[5] The general argument is that the environmental impacts of ports are air and water pollution, dredging, aquatic nuisance species, loss of wildlife habitat, public access to coastal resources, and land use issues (Fawcett, 2004).
[6] Growth, i.e., getting larger, is a more modest consequence. Development implies a dual structural shift: a new social and technical environment or a new set of economic opportunities emerges, and the pattern of relationships between the environment and social actors changes. Specialized commercial agriculture, the industrial revolution, and the globalization of production are all developmental consequences that would not have been possible without sustained improvements in transportation systems (Lakshmanan and Chatterjee, 2005).
[7] From 1970 to 2010 the value of exports has grown by a factor of 48 times if measured in current dollars, while GDP increased 22 times and population increased 1.8 times (Rodrigue, *et al*, 2009).
[8] External factors such as knowledge spill-over and labor market externalities, which provide more availability and high quality of training for workers, increase returns and, consequently, stimulate agglomeration.
[9] Rietveld and Bruinsma (1998), Lakshmanan (2010), Mikelbank and Jackson (2000), Adkin (1959), Garrison, *et al* (1959), Mohring (1961), Taffee and Gauthier (1973), Boyce and Allen (1974), Knight and Trygg (1977), Lerman, *et al* (1978), Dyett, *et al* (1979), Aschauer (1989).

[10] The adequate sample size for multiple regression models can be calculated by rule of thumbs or formula. For example Milton (1986) provided the following formula and table:

$$n = K + 1 + \frac{t^2(1-R^2)}{\Delta r^2}$$

Where K is the number of variables in the final model, taking into account anticipated R^2.
Sample size determination for multiple regression studies: significant test for Beta coefficient at the 0.05 level (t=2)

		Δr^2				
R^2		0.001	0.005	0.01	0.02	0.05
	0.10	3601+k	721+k	361+k	181+k	73+k
	0.20	3201+k	641+k	321+k	161+k	66+k
	0.30	2801+k	561+k	281+k	141+k	57+k
	0.40	2401+k	481+k	241+k	121+k	49+k
	0.50	2001+k	401+k	201+k	101+k	41+k
	0.60	1601+k	321+k	161+k	81+k	33+k
	0.70	1201+k	241+k	121+k	61+k	25+k
	0.80	801+k	161+k	81+k	41+k	17+k
	0.90	401+k	81+k	41+k	21+k	9+k

Source: Milton, 1986
However, in the VAR models the degree of freedom (the number of data points minus the number of parameters to be estimated) is even less since they involve the estimation of many parameters. For example, having 6 variables in the model of this study and 4 lags, the total of (6×6×4) + 6 = 150 parameters are estimated. This lowers the degree of freedom of the regression.
[11] Since measuring the accessibility is complex and requires a wide range of data and information, the length of infrastructure is used to represent the accessibility.

[12] Variables are listed as following:

- Gross Domestic Product, (1970-2012), volume USD, collected from OECD.
- Import of goods and services, (1970-2012), volume USD, collected from OECD.
- Export of goods and services, (1970-2012), volume USD, collected from OECD.
- Productive capital stocks (1970-2012), collected from OECD.
- Gross fixed capital formation (1970-2012), collected from OECD.
- Length of motorways in terms of kilometre (1970-2010), collected from OECD.
- Transport sector deflator index (1970-2012), National bank of Belgium.
- Total economy deflator index (1970-2012), National bank of Belgium.

- Port infrastructure investment by government (1989-2012), collected from OECD.
- Total employment growth (1970-2012), collected from OECD.
- Total population growth, (1970-2012), collected from OECD.
- Transport infrastructure investment and maintenance spending (1995-2012), collected from OECD.
- Length of other roads in terms of kilometre (1970-2010), collected from OECD.
- Navigable inland waterways in terms of kilometre, (1990-2012), collected from OECD.
- Railway - length of lines in terms of kilometre, (1970-2009), collected from OECD.
- Railway - length of tracks in terms of kilometre, (1993-2009), collected from OECD.
- Economically active population, (1983-2012), collected from OECD.
- Labour productivity of the total employment, (1970-2012), collected from OECD.
- Education – the number of high educated individuals, (1987-2012), OECD.

[13] Other variables are tried as well for the best model and they are ignored since they did not provide a significant coefficient in the final model (for example Labour productivity of the total employment, total employment, total employment growth, etc.). Also the extracted variables total investment to GDP and total investment per capita provided very similar results, the first one is chosen for this model.

[14] Including Flemish maritime ports (Antwerp, Ghent, Ostend and Zeebrugge), the Liège port complex, and the port of Brussels.

[15] The estimations are based on the analysis of their economic, social, and financial situation. The analysis of financial results involves a study on return on equity, liquidity and solvency ratios and financial health model developed by the Bank.

[16] These include a shift in the forces driving demand, the speed of delivery and the reduction in the level of operational defects.

[17] Dynamism comprises aspects of change such as (a) rate at which products become outdated, (b) rate of change in taste and preferences of customers, (c) rate of innovation of new products and services and, (d) rate of emergence of new challenges from competitors Ward *et al*. (1995) and Chi *et al*. (2009).

[18] Other major drivers of change such as competition and customer preferences have been a direct result of globalization and technological innovations (Alagse, 2011).

[19] Basic quality: attributes that are often unnoticed by customers and taken for granted when fulfilled but result in dissatisfaction when not fulfilled. Attribute fulfilment does not result in satisfaction. ‘If you do not get the basics right, all else may fail’ (Shahin, 2004). An example would be a coffee machine that complies with the basic requirements of making coffee.

[20] There are differences between infrastructures in different countries, shipping industry provides connection between these infrastructures by different ship sizes, therefore, shipping industry forms semi-homogenous global transport infrastructures.

[21] A common carrier obligation was imposed on liners in U.S. trades by the 1916 Shipping act, but was heavily reduced by the Ocean Shipping Reform Act of 1998 (Reitzes and Sheran, 2002), which allowed confidential contracting with individual shippers.

[22] Combined transport is a transport in which the major part of the European journey is carried out by rail, inland waterways or sea and in which any initial and/or final leg carried out by road are as short as possible. This definition shows a higher level of detail in specifying a hierarchic order of use of the modes of transport. Rail, inland waterways or sea have to be the longest part of the journey, while road constitutes the initial and final leg of the trip. Combined transport implies a precise selection of transport modes with a reduction of road use. Multi-modal transport is a carriage of goods by at least two different transport modes. Among the definitions given, this is the most general, and takes in consideration just the need to have at least two modes of transport, without any particular specification, not even for the loading unit. (UN/ECE, ECMT, EC, UN, 2001) Previous to the above mentioned definitions are the description of intermodal transport given by the European Commission and the United Nations. According to the European Commission, COM (97) 243 Final of 29/5/1997: Intermodality is characteristic of a transport system that allows at least two different modes to be used in an integrated manner in a ‘door-to-door’ transport chain... Intermodality clearly is not about forcing a specific modal split. However, by improving the connections between all modes of transport and integrating them into a single system, intermodality allows for a better use of rail, inland waterborne transport and short sea shipping which, by themselves, in many cases do not allow a door to door delivery (Grosso, 2011).

[23] The demand for container transport is not only derived from final demand for products but also induced by material management requirements of the supply chain. It also can be argued that the demand for container transport that is induced by material management requirement is the dominant driver of the demand for container transport.

[24] “Clusters encompass an array of linked industries and other entities important to competition. They include, for example, suppliers of specialized inputs such as components, machinery, and services as well as providers of specialized infrastructure. Clusters also often extend downstream to channels or customers and laterally to manufacturers of complementary products or companies related by skills, technologies, or common inputs. Many clusters include governmental and other institutions. Finally, foreign firms can be and are part of clusters, but only if they make permanent investments in a significant local presence.” (Krugman 1998).

[25] In the Competitive Advantage of Nations theory, Porter (1990) explains the significance of clusters and emphasises why governments need to take account of it in policy. Porter's theory states that "nations gain significant competitive and economic advantage where concentrations of firms (clusters) exist in home markets of similar or related industries. Cluster location relationships help produce beneficial advantages such as knowledge spillover, ease of access to skilled labor, and assembly of the inputs of production, and competitive pressures to innovate and increase productivity". Stuchtey (2000) argues that the government should enable cluster development by providing an educated skilled workforce and physical infrastructure.

[26] The immediate hinterland (or fundamental hinterland) illustrates an area where the terminal has a dominant, if not an exclusive, share of the flows. It is traditionally the core market area of the terminal where accessibility is the highest. It is possible for other terminals to compete over the main hinterland, but this is likely to be done at a notable disadvantage or in the case where a terminal offers a very poor level of reliability.

[27] The competition margin represents an area where a terminal can be competing with other terminals. The competitiveness becomes a matter of differential accessibility, costs and quality and reliability of service.

[28] Trade creation and diversion is related to the formation of economic integration first introduced by Jacob Viner (1950) in which trade flows are redirected from non-member states to member states or created between member states due to the formation of a free trade area or a customs union.

[29] Hamburg, Bremen, Amsterdam, Rotterdam, Antwerp, Ghent, Zeebrugge, Dunkirk, and Le Havre.

[30] "*Over the last decades Amsterdam managed to increase market shares in North-West Europe in bulk markets (e.g. doubling its liquid bulk share to 8.6% over 2003-2010) Amsterdam is a major hub for petrol, steel and cacao. Rotterdam showed a remarkable rebound in container traffic shares since 2006 (from 32.5% in 2006 to 35.1% in 2010). Over 2004-2011, Rotterdam sustained its position as second most central cargo hub in the world, after Singapore, using a variety of maritime connectivity measures*" (Stevens, 1999).

[31] They are listed as following: Alianca Belgium, ANTTREX Shipping NV, BASF, Burger logistic Services NV, China Shipping agency, CMACGM, DB Logistics, DHL, Evergreen Belgium Shipping Agency, Gosselin Group, Hanjin Shipping Co LTD., Hapag Lloyd, Heineken Nederlands Supply, John T. Essberger& Deutsche Afrika-Linien, Kuehne+Nagel, Lanxess, Maersk line, MSC Belgium, Nike CSC, P&G, Toyota Motor Europe NV/SA and Volvo Logistics.

[32] An eigenvector of a square matrix A is a non-zero vector V that when multiplied by A, yields the original vector multiplied by a single number λ; that is $AV = \lambda V$. The number λ is called the eigenvalue of A corresponding to V.