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The Seine Nord Europe canal – a growth opportunity for the Port of Rotterdam?

by

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Abstract

The natural evolution of sea-ports brought by the introduction of the container has lead to an environment of increasing inter-port competition for serving contestable hinterlands. The ports in the Hamburg – Le Havre range have been one of the most fiercely competing ports as virtually all of them are serving the same hinterland – mainland Europe. Every port has developed its hinterland connections and is trying to gain access to as many freight corridors as possible using different modes of hinterland transport and national governments have made tremendous investments in infrastructure projects to facilitate the flows of cargo.

One such infrastructure project is the planned construction of the Seine Nord Europe canal. Essentially connecting the river Seine to the Europe’s main waterway network, it will enable the ports of Rotterdam, Antwerp, Zeebrugge and Dunkirk to access the Ile-de-France region by barge. It is expected that fierce competition will develop for the newly-accessible hinterland and the Port of Le Havre will lose its nearly monopolistic position.

This thesis is exploring the future market situation in the Ile-de-France after the Seine Nord Europe will be opened, taking the perspective of the Port of Rotterdam. The overall market potential of the region has been determined using a regression tool with past data and estimations of future explanatory factors. After, a scenario analysis with cost data has been used to evaluate the competitiveness of barging on the route from the Port of Rotterdam to Ile-de-France compared to the currently used mode – trucking. Finally, a more holistic perspective has been taken, appraising the potential competitiveness of the Port of Rotterdam in Ile-de-France through adopting a supply chain perspective.

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Chapter 1 Introduction

Since Adam Smith's *The Wealth of Nations* economists have been obsessed with economic growth and the ever-lasting paradigm has been how to achieve higher levels of economic expansion. Leading politicians of countries and regions, senior managers of corporations and smaller companies and individual economic actors all strive for growth and think of different strategies to achieve it.

Trade is undoubtedly one of the best known ways to achieve economic growth and various trade theories have been developed. The first notable contribution is from David Ricardo and his theory of comparative advantage, which argues in favour of regional specialization in the product that each region is comparatively best at. Ricardo proved that trade between the specialized regions will make every one of them better off and increase the overall consumption possibilities for them. In 20^{th} century the Heckscher-Ohlin-Samuelson model was created, which essentially complicated Ricardo's theory and allowed for more than one factor of production, but only confirmed the validity of Ricardo's conclusions. However, both these theories assumed costless trade and no transport costs, which in reality is never the case for physical goods.

World trade of merchandise goods in 2009 accounted to $12,178 billion and transportation costs incurred for that trade were $700 billion (both at export values) (WTO, 2010). The value of transportation alone implies that these costs should not be excluded from any economic analysis and that the transportation sector deserves its share of attention. Moreover, trade has exhibited tremendous growth both at a regional and global level. Two of the main causes of this growth have been the development of new technologies and the ever decreasing costs of transportation. According to UNCTAD (2010) currently 90% of world trade is sea-borne and not surprisingly sea-borne trade has been steadily growing in the last two decades. The most significant growth, however, can be observed in the containerized cargo sector.

The predecessor of the container ship – the general cargo ship – operated in a much less efficient manner than its newer counterpart. The cargo in these old ships was stored on movable decks and had to loaded and unloaded by hand or by highly inefficient equipment. The cargo itself was kept in all kinds of different packages – bags, pallets, cases, boxes, barrels, crates or any other depending on its nature. Ships were staying in ports for weeks or even months, depending on the port location and efficiency (Talley, 2000). Ports had high labour requirements, most of which was low-skilled and workers were hired daily on an ad-hoc basis, depending on the current requirements. Automation was hardly possible due to the different requirements of each type of cargo and cargo throughput in the ports was generally low.

At this era of port development ports hardly competed among themselves and each port enjoyed a natural monopoly of its geographical location. The hinterlands were captive and further distribution was not an issue as shipments were generally smaller and not speed sensitive, since cargo had already spent months travelling and staying idle on the ship waiting to be handled. Ports were subsidized by national governments, because it was argued that they possessed too many positive externalities to be left to the private sector, such as generating high levels of employment and facilitating regional economic development and growth. Ports were developed in the vicinity of locations with big production and consumption potentials, such as Rotterdam, downstream on the river Rhine, which penetrated one of the most industrialized and densely populated regions of Europe – the Ruhr region – or Liverpool, close to the highly industrialized Manchester region. In that time many ports were *"badly run, disorganized, bureaucratic, inefficient and expensive; a shipowner's nightmare and worst enemy"* (p. 326, Haralambides, 2002). The reason that ports were able to maintain such conditions and still attract cargo was their monopolistic position – trade barriers between countries were forbidding the use of ports in neighboring nations and, most importantly, underdeveloped hinterland infrastructure proved to be a big bottleneck for inter-regional flows of cargo from competing ports.

The introduction of the container in 1950s and its wider adoption from 1960s onwards proved to be a radical innovation for trade and the maritime shipping industry. Its introduction was spurred by the idea of the American trucker Malcolm McLean to standardize the cargo package so the cargo itself has to be handled only twice – at its origin when it is loaded into the container and at its destination when it is being unloaded (Talley, 2000). The container increased the handling capacity of the ports even in its early introduction – the benchmark for conventional cargo in Rotterdam before the introduction was 14 tons per hour with 1.25 tons per man-hour and in the early days of the adoption when ships used their own gear to load and offload containers off their deck the new benchmark increased to 22 tons per hour with 5 tons per man-hour (Ulco Bottema, pers. com. February 2011). All kinds of conventional cargo started to be loaded in containers and dedicated container ships and later container terminals started to appear in different routes and locations around the world. While the introduction of the container enabled cargo to be unloaded much faster, it also allowed automation of the handling processes, as the standardized containers could be handled by new universal container cranes. Although the adoption of these cranes by the ports was not instantaneous, it allowed ships to stay at ports far lesser and service times to be estimated with much greater accuracy and reliability, thus contributing to the emergence of reliable schedules. Last but not least, the increased speed of handling in ports allowed for the bigger scale of the ships themselves and therefore the observed growth in the transported quantities of goods.

The developments at ports caused by the introduction of the container were even more dramatic. First of all, ports slowly started to reduce their low-skilled labour force and demanded fewer workers with skills to operate the terminal handling equipment. Ports were becoming more capital intensive and more efficient in handling cargo. Most importantly, the introduction of the container has facilitated the easier hinterland distribution of the cargo. The container only has to be placed on a transport vehicle for hinterland distribution and then could be transported easily to any location connected to the port by appropriate infrastructure. Essentially, this contributed to the footloose nature of the cargo, which could now select any port along the coastline that makes the final destination accessible. These developments led ports to lose their monopolistic positions and start competing for cargo in contestable hinterlands. Ports started to compile portfolios of services both to destinations overseas and in the hinterland, using different modes of transport – road, rail or barge.

In the new competitive environment ports became much more aware of their opportunities and threats to growth and market share position. In Europe, the growing economies, the flourishing production capacities and increasing wealth along with the increased investments in infrastructure contributed to the sharp increase in trade, both within the continent and overseas. The signing of the Treaty of Rome in 1957 (Anon 1), which was the beginning of the European Economic Community (EEC), and its later multifold enlargement created a free trade zone within Europe, further boosting the opportunities for European ports.

Big industrial clusters were developed in the hinterland, mainly along waterways. It is not surprising that the strongest European industrial regions in the 1970s and 1980s were undoubtedly in the Ruhr region along the Rhein and in the south of France, along the Rhone. These waterways were needed, because of the nature of the growth industries in that time – a lot of raw materials were needed, mostly transported in bulk, and river transport is most suitable for their supply. These waterways have become strong hinterland corridors and the ports which had immediate access to them have gained a strong position compared to their competitors.

The ports in the Hamburg – Le Havre range seized the opportunity of the new cargo flows associated with increased production and trade and managed to capture parts of the growth both through setting up services to various locations overseas and constructing appropriate infrastructure to the hinterland. The increasing trade with North America after the Second World War, the boom in the petrochemical sector in 1970s and 1980s and finally the emergence and growth of containerization, which started in the early 1980s and is thought to have slowed down with the start of the economic crisis in 2008, have contributed to the rapid development of these Northern European ports. The repositioning of production capacities to China and South-East Asia has also played a role in the increasing traffic through these ports. The result for the range in 2008 was a 46.4% of total container traffic in all ports in Europe accounting to a total of 38,141,000 TEUs (Eurostat, 2011). This growth was achieved organically – through growth in the economies that the ports were serving and their increased demands for transportation services – both imports and exports.

The growth has also brought the emergence of the hub-and-spoke concept and the emergence of mainports. The ever-increasing sizes of ships and their desire to call at less ports in both end of their routes has resulted in increasingly concentrated cargo flows through fewer and fewer ports, which have been increasing their capacities continuously to accommodate the growing demands. Terminals were designed for high shares of transshipment, as it was expected that the increasing ship size was to bring a high demand for feeder services and more moves along the quay walls. However, customer demands for faster transit times and more reliability have shifted the calling trends of shipping lines to multi-porting – calling at multiple ports, discharging smaller batches of containers and distributing the cargo towards the hinterland. The plans to expand the previous designated mainports have gone through and it remains uncertain whether these new capacities will be utilized at a sufficiently high level to advocate the investments that have been made.

The recent developments have considerably reduced the growth projections of the Western Europe economies and thus of the expected cargo throughput in the ports in Hamburg – Le Havre range. Moreover, ports in the Mediterranean and the Baltic have been developed to accommodate the potential growth in the new members of the European Union. Those factors along with the planned increases in the capacities of the North European ports, such as the Maasvlakte 2 development in Rotterdam and the Container Terminal 4 in Bremerhaven, are threatening to bring a decreasing growth and market share to the ports in Hamburg – Le Havre range and to lead to overcapacity. Therefore, the attention has now been focused on strengthening positions in the current markets and accessing new emerging markets as an instrument for further growth.

Port of Rotterdam established itself as the leading port in the Hamburg – Le Havre range and respectively in Europe ever since it was reconstructed after the Second World War. Its favorable geographic position in the heart of European economic activity and accessibility both from the sea and from the hinterland has been a natural factor for the leader status of Rotterdam. The availability and deep hinterland penetration of all three modes of hinterland transport to and from the port is another important success factor. Especially the direct connection to the river Rhine has been crucial. Barging services to different river ports have facilitated the much needed diversification of hinterland transport options – providing a cheap and environmentally-friendly alternative to the road transport. Finally, along with the excellent hinterland accessibility, the great natural depths of the port basin have become a major cause for shipping companies to set up services from Rotterdam to virtually any part of the world, enabling the port to offer a wide portfolio of overseas destinations to its users. Considering these factors, in 1980s the Dutch government adopted a policies aiming to transform the Netherlands into a 'Distribution country'. According to Kuipers (2002) there were five elements of this decision: the development of Port of Rotterdam and Schiphol airport to what was referred as 'mainport'; the central position of the Netherlands in the European production and consumption regions; the emergence of European Distribution Centres (EDCs) and the objective to attract them within the Netherlands; the advanced state and large market share of the Dutch logistics and transportation industry and the large employment it has generated within the country; and finally the political support for these function and extensive investments in infrastructure facilitating the flow of cargo to strategic locations. These policies have created a legacy for the Port of Rotterdam of a unique market position and a natural advantage over its competitors and have helped it to retain its leadership position in the highly turbulent market environment in the beginning of 21^{st} century. The bottom line is a throughput of 11,145,804 TEU in 2010 accounting for a market share in the Hamburg – Le Havre range of 29.9% (Port of Rotterdam Authority, 2011).

The 'Distribution country' policy of the Dutch government provided high investment capacity for Port of Rotterdam. Moreover, the Rotterdam Port Authority was corporatized in 2004, which has led to its ability to also attract external investment capacities and also contributed to its financial stability. Several infrastructure projects were developed either with support or through 100% financing by the Dutch government. The most notable ongoing project is the planned port extension Maasvlakte 2. It involves land reclamation and preparation of the land for commercial use by terminals and connection to the available hinterland infrastructure. Maasvlakte 2 will extend the existent port land by 1000 ha or about 20% and will involve several big container terminals. The first three terminals which are planned are an extension of the existent Euromax terminal, a brand new APM terminal with a planned capacity of 4.5 million TEU by 2014 (Anon 2) and a DP World terminal called Rotterdam World Gateway with a planned capacity of 4 million TEU by 2013 (Anon 3). The almost doubling of the container throughput capacity by 2014 will leave the port with large overcapacity, which at the time of planning was thought to be absorbed by the fast-growing trade flows of the economies served by the port. Although, the plans of introduction of new capacity have been updated to a step-wise introduction to reflect the market environment, the current slowdown in economic activity and the unstable growth in production and consumption of the Western European economies have questioned the optimistic projections about the port capacity expansion, which by the way exceeds the 2010 throughput of the second biggest port in the Hamburg – Le Havre port range.

The highly probable overcapacity will inevitably cause financial problems not only for the new terminals, but also for the existing ones in the port, and might even extend to other ports in the range. The declining returns on investments in the terminals and the high share of automation are likely to create destructive competition among the terminals and some of them might even have the destiny of the Ceres Paragon Container Terminal in Amsterdam, which stands empty with no services to and from it. The trend of terminal automation which has accelerated in recent years will further harm the terminals, as it will greatly decrease their operational flexibility. The terminals have invested into a certain level of equipment which has a useful economic life of 20 or more years and laying it up or underutilizing it will inevitably bring capital losses to the terminals. In this potentially dreadful market environment ports have started to look at opportunities to serve new emerging markets or serve existing market differently. They have tried to penetrate markets previously served by their competitors by facilitating the set-up of hinterland services by different modes, as well as entering the inland terminal market by acquiring inland terminals and thus becoming competitors with their previous partners. For example, the Port of Antwerp has set up a shuttle train to the Munich region by bundling the flows of their different terminals and acting as a facilitator (Helen De Wachter, pers. com. June 2011). Port of Rotterdam on the other hand has again benefited from the Dutch governmental support. The government has developed a cargo dedicated rail track to the German border called Betuweroute. Completed in 2007 with an estimated cost of 4.7 billion Euro it is supposed to connect the Port of Rotterdam with the inland tri-modal Port of Duisburg in Germany (Anon 4). However, the part of the track in Germany is not completed yet, so its daily capacity of 150 trains cannot be fully utilized. Although the project suffers greatly from a cost-benefit analysis perspective, its estimated break-even point being far in the future, the rail track will provide competitive advantage to the port when completed (Hesse, 2008). Port of Rotterdam have also acquired a share in some terminals in Duisburg, hoping to increase the competitive position of the port in the region. These actions by port authorities and governments aim to benefit the port users by expanding the port network to access new markets or traditional markets by new means.

A new infrastructure project similar to the Betuweroute is being developed in the North of France and has captured the attention of four ports from the Hamburg – Le Havre range with its prospect for them to access new hinterlands with great economic potential and high demand for goods. The Seine Nord Europe canal is a proposed inland waterway canal between the river Seine basin and the Scheldt in Belgium, essentially connecting the Seine to the European inland waterway network and giving it access to the Rhein-Main-Danube corridor. The 107 kilometres long canal between Compeigne and Aubencheul-au-Bac in France has been identified as a priority project in the Trans-European Transport Networks (TEN-T) and is designed to allow the passage of convoys carrying up to 4400 tons of cargo. The canal, which will connect 3 French regions to the European inland waterway network – Picardie, Ile-de-France and Haute-Normandie – will include 4 logistical platforms on it and is expected to be opened in 2015. The most notable consequence of this new infrastructure is the inland waterway accessibility of the Paris agglomeration from Europe's two biggest ports – Antwerp and Rotterdam.

Ile-de-France, the French region consisting of Paris and its agglomeration, is the second smallest mainland region of France (excluding islands) but is the most densely populated. An area of 12,012 km^2 housing a population of 11,694,000 inhabitants Ile-de-France region has the highest regional contribution to the national GDP – a regional account of 552 billion Euros in 2010 (INSEE, 2011). The river Seine passes right through Ile-de-France before it flows into the English Channel and there is a considerable traffic flow to and from the Ports of Le Havre and Rouen to the Paris region, where a few inland ports are situated. Three inland ports are most notable as they have specialized container facilities and are growing rapidly – 13.4% in container volumes in 2010 (Ports de Paris, 2011a). These ports are comparable to size to the biggest inland cluster of ports in Europe – the tri-modal inland terminals in Duisburg – and collectively they had an annual throughput of over 300,000 TEU in 2009. The ports' plans to increase their terminal capacity to 600,000 TEU by 2015 will make it a very attractive location for the ports of Antwerp and Rotterdam which will by then be able to access it by barge through the Seine Nord Europe canal and try to set up services and gain market share.

This thesis is going to examine the new market situation created in the Ile-de-France region and its particular effect on the Port of Rotterdam. The main question to be answered is:

What is the potential for Port of Rotterdam of capturing a part of the Paris and Northern France market due to the Seine Nord Europe development?

To limit the complexity of the problem at hand, this study is going to limit its attention only to trade in containers. Furthermore, several sub-questions are posed to have a better structure of the problem and obtain a comprehensive representation of the situation:

- **What is the regional market potential?**
- **How competitive is the barge transport compared to road transport on the route from Port of Rotterdam to Port of Gennevilliers?**
- **What strategy should Port of Rotterdam adopt to improve its competitiveness in the new market?**

First of all, a background of the theoretical and economic environment is presented to gain an insight into the examined situation. Second, a methodology for the evaluation of each of the research sub questions is presented systematically. In the fourth chapter of this thesis the regional market potential for years 2015 and 2020 is predicted to evaluate the importance of developing a barging network to the region. In the following section, the competitiveness of barging compared to trucking is examined on the route to evaluate the feasibility of the use of barges to supply the Ile-de-France region from the Port of Rotterdam. The sixth chapter takes a more holistic approach and evaluates the competitive positions of the ports against each other in order to identify key factors for Port of Rotterdam on which it will have to concentrate in order to be able to gain a stable and considerate market share in the region. Finally the paper ends with a summary of the results and a conclusion, also giving some strategy recommendations already identified before.

Chapter 2 Economic background

Port business in Northern Europe is going through turbulent changes of the environment in which it is conducted. The rapid expansion of trade mainly resulting from containerization and the emergence of global supply chains has greatly influenced the factors of port competitiveness, attractiveness and profitability. The concentration of cargo flows in the leading ports along with the concept of intermodality, discussed later, have greatly extended the hinterlands served by each port, causing them to overlap and consequently forcing ports to offer superior services in terms of reliability, cost-effectiveness and timeliness (OECD, 2009). Moreover, the evolution of ports from pure gateways to nodes in global supply chains (Robinson, 2002) has shifted the port selection criteria from port performance to overall supply chain performance, taking into account the transport services provided to and from the port. In fact, less efficient ports and more distant are often preferred to close and efficient competitor ports if the hinterland services from the former are superior in terms of cost and reliability. This fact is not surprising, given that the cost per kilogram per km is 5 to 30 times higher for hinterland transport than for maritime transport, depending on the mode (Notteboom, 2008).

The growth in traffic and distribution demands have burdened port operation and required expansions both in port and hinterland infrastructure. Local constraints connected to land availability and negative environmental externalities put a limit on port expansion. Moreover, the increasing importance of hinterland transport has made congestion and high distribution cost the biggest enemy of every port. Most of the leading European ports have already encountered heavy road congestion in their immediate hinterlands, greatly hampering their reliability of distribution. If these ports are ambitious to keep growing, they have to deal with the local constraints while also ensuring excellent accessibility to major consumption and production markets in their hinterland. To tackle the issues at hands these ports have adopted the concept of *"port regionalization"* (Notteboom and Rodrigue, 2005).

Port regionalization is the natural transition of a port into a regional logistics integrated entity. The ports "*expand their hinterland reach … through a number of market strategies and policies linking them more closely to inland freight distribution centers*" (p. 298, Notteboom and Rodrigue, 2005) with an initial objective to achieve "*higher levels of integration with inland freight distribution systems*" (p. 302, Notteboom and Rodrigue, 2005). Essentially, ports use corridors to access inland terminals and use them to distribute cargo to locations around those terminals. The ports face several challenges and must ensure that several conditions are present if port regionalization is to be successful.

First of all, a reliable and cost efficient corridor must be present from the port to the inland terminal. This corridor essentially resembles high-quality uncongested and possibly high volume infrastructure, which would ensure a timely and cost-efficient cargo transfer between the port and the inland terminal. Most often this infrastructure is either a rail-road or inland waterway, because roads generally do not fulfill the requirements for a corridor. However, there have been some examples of inland terminals served exclusively by road transport such as the French 'road stations' developed in the 1970s (Notteboom and Rodrigue, 2009). Failure of that corridor would harm the accessibility and connectivity of the port to that particular inland terminal, leading to deteriorating service and low competitiveness in the particular market.

Second, the inland terminal should act as a cargo bundling point and consolidation and deconsolidation center. If the port does not possess enough cargo for a dedicated shuttle train or barge to a single location, an inland terminal often bundles demand from neighboring locations. The port can also use a single transport vehicle to bundle flows to several inland terminals close to each other and these terminals can consolidate their cargo into a single transport unit so that they can utilize the unit and achieve economies of scale in transportation. This concept is more common in barging than in rail. If an inland terminal or a group of terminals does not possess such characteristics, their inclusion into the port network would not add value to the port services, as the port would better off use direct delivery to serve the needs of the adjacent regions.

Last but not least, the presence of broader logistics zones around inland ports is favorable for the development of strong connections to the port. These zones attract activities and businesses related to the cargo in the inland port that would locate near the sea-port if the land-prices and land-availability there were lower. Such activities include, but are not limited to, low-end and high-end value-adding logistics services, ranging from packaging and labeling to final assembly and component additions, distribution centers, forwarders etc (Notteboom and Rodrigue, 2009). Distribution centers in particular are set up by cargo users with the purpose of storage and logistics value-added activities. Such distribution centers usually require availability or cheap land, as they are space intensive and do not earn high returns per square meter, central locations in terms of consumer markets and proximity to major infrastructure for cargo delivery. Sites near inland terminals usually satisfy all the requirements of these facilities and they are often established in their immediate vicinity, creating logistics clusters and demand for large cargo flows through the inland terminal. While not entirely necessary, the existence of such broader logistics zones around inland ports greatly improves the probability of success of the network are real drivers for port regionalization.

This paper focuses on the attempts of Port of Rotterdam towards higher port regionalization through extending its hinterland network towards the inland ports along the Seine in the Paris region and accessing in by barge through the newly constructed corridor of Seine Nord Europe canal.

Oxford Dictionary defines a barge as "*a long flat-bottomed boat for carrying freight on canals and rivers, either under its own power or towed by another*" (Anon 5). Barges are the biggest inland transportation vehicles. A typical barge carries around 1500 tons of cargo, but push convoys which carry as much as 15000 tons are possible, if the waterway capacity is sufficient for them. The average speed of 12 kilometers/hour harms the competitiveness of barge transport for time sensitive cargoes and the infrastructure for barges is inland waterways, which usually have very limited penetration. Regions with natural waterways have an advantage and are often also suitable for the expansion of the waterway network by the digging of canals, but dry regions or such regions with low river capacities cannot accommodate barge transport at all. While roads and even railroads have a much higher penetration of the hinterland, the waterways are mainly congestion free as they are highly underutilized for the means of transportation. Another important advantage is that while trucks have restrictions for driving hours during the day, barges are running 24 hours along the day and 7 days the week. In Europe the growth of traffic volumes between regions has been increasing, putting a high burden on the already congested road network. Moreover, the railroad network is prioritized for passenger transport and there are generally few cargo dedicated railroad tracks. This fact partly offsets the disadvantages of slow speed and low penetration of barges, as it contributes to their reliable schedule. While barges can hardly compete with rail and especially with road transport when it comes to speed of delivery, they have a strong advantage in the cost structure. As barges transport large quantities of cargo, the costs of transportation become negligible per ton-kilometer. Barge transport generally has high fixed and low variable cost, as the cost of transshipment is high and the costs per kilometer are low. That is why barges become very competitive when cargo has to be transport over big distances, such as from the Port of Rotterdam to Upper Rhine. Last but not least, barge transport is environmentally friendly, as the emissions per ton are generally low. This characteristic is becoming increasingly important with the recent raise in environmental awareness among the public and essentially policy makers, as emissions are already taxed in road and rail transport and inclusion of the barge transport under emission taxing schemes is on the way.

The European Union controls CO_2 emissions by implementing the so called policy of Emission Trading Schemes (ETS). The policy itself concentrates on the big polluters – power plants, oil refineries and chemical factories, steel industry and the transport sector – and operates by distributing emission allowances among them and allowing them to trade these allowances on an open market. National governments are the responsible bodies for allocating allowances to the different industries and they are also in charge of ensuring that companies conform to their respective amounts of allowed emissions. If companies exceed their allowed emissions, they are obliged to pay a penalty depending on the amount of their excess and the market price of emissions. This flexible penalty system has been set up to discourage companies to make a trade-off between cost of penalty and the price of emission rights and to stimulate all of them to take part in trading those emissions market on the created market (Walenski, 2010).

Barge transport is the only mode that is not yet included into the ETS, as road transport already pays a tax included in the fuel and truck owners also pay an annual tax dependant on the environmentally friendliness of their vehicles and rail transport is taxed through the power plants, which produce the electricity for it. However, protests and lobbying from the other two modes are intensifying and they are calling for a level playing field, which would eventually mean introduction of barging into ETS. It is likely that this is going to be done analogically as in road transport, by charging a fixed rate over the price of the fuel. However, even if an emission trading cap is introduced, the ultimate result would be an increase in the cost of barging, so for the purpose of the following analysis, the type of charge is irrelevant – the highlight is on the final outcome.

Barges were traditionally used to transport bulky cargoes. In Europe, their main use before the introduction of the container has been the transportation of coal and different types of ores mainly along the Rhine. Their high capacity and the nature of the bulk cargoes being mainly time-insensitive have made them perfect for inland transportation of natural resources from the Ruhr mines to plants using those resources as an input. Another traditional use has been the transportation of both liquid and dry bulks mainly from the Port of Rotterdam towards its hinterland. Before the introduction of the container general cargo was hardly ever carried on board of barges. The slow and costly manual loading and unloading process and the difficulty of automation as well as the need of transshipment, because the last leg of the journey is mostly to be made by road, greatly reduced the effectiveness of barges for transporting general cargo. However, the packaging of general cargo goods in containers partly eliminated those problems and paved the way to what has been defined as intermodal transport.

The term *intermodal transport* is defined by the European Conference of Ministers of Transport *et al.* (2003) as "*movement of goods (in one and the same unit or vehicle) by successive modes of transport without handling of the goods themselves when changing modes*". Essentially, intermodal transport is transport of containers by more than one mode without handling the goods in the container during the transportation. Figure 1 represents a simple intermodal transport chain, the pre- and post-haulage made by truck and the main leg done by barge. A complex modern intermodal chain, for example between a garment factory in India and a distribution centre of a major clothes retailing chain in Europe, would involve packaging the goods in a container at the factory in India, transporting the container by truck to a near dry port after which the container would be put on a train and moved to the nearest deep-sea port, say Chennai. At the port the container would be loaded on a feeder vessel to Singapore where it would be transshipped to a bigger ship and transported to Rotterdam. When the vessel reaches the ECT Delta Terminal, the container would be further transshipped to a barge and transported to an inland port somewhere along the Rhine, picked up by a truck from that terminal and shipped to its final destination where the container would be opened to retrieve the goods. Such a complex intermodal chain would never be possible if the goods were not packed in a container and had to be handled every time they change the transport mode. The general cargo transport chain involving a deep-sea leg was most frequently the one shown in Figure 1, but the main transport leg was performed by a deep-sea vessel, rather than barge.

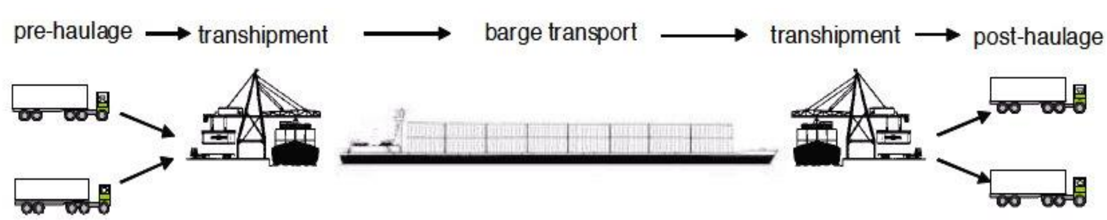

Figure 1: Intermodal Transport **Source: Konings (2009)**

The introduction of the container has greatly increased the competitiveness of the rail and barge transport in the market for transportation of finished and semi-finished products. The transportation of the goods within a single packaged body facilitated the fast transfer of that body between different modes of transport and created space for better cooperation between the modes. In the case of barge transport, the container created a scope for combination of the benefits of that transport, such as low cost and low emissions and added the advantage of flexibility as trucks could easily collect and distribute the cargo to the inland port where the barge is served (Konings, 2009). However, one important condition should be satisfied in order for the benefits of barge transport to be present – a sufficiently large cargo flow has to be present to fill the capacity of a barge, because underutilizing a barge greatly reduces the economies of scale in transportation and therefore the eliminates the advantages of the mode. The increase in over-seas imports and the concentration of these into a few deep-sea ports in Europe has ensured that stable and significant traffic flows exist to numerous destinations in inland Europe, so barge and train services were started to a number of inland ports in the vicinity of consumption, production and distribution centers. Another necessary condition for the successful use of intermodal transport is the sufficient distance that is travelled by either barge or train, so that the cost savings on the transport itself can offset the additional costs of handling the containers. Several studies have been done on the issue of the exact distance that is efficient for the introduction of barge intermodal transport, producing results with disturbingly high deviations. Van Klink and Van den Berg (1998) have determined the biggest distance of 500 kilometers, Cardebring *et al*. (2000) stated that the minimal distance is slightly lower at 400 kilometers, the Dutch Ministry of Transport (Ministry of Transort, Public Works and Water Management, 1994) estimated that the distance for a service with pre- or post-haulage directly involving deep-sea transport to be 100 kilometers, and Machari and Verbeke (2001) did a case study for the Port of Antwerp and concluded that the minimal necessary distance making intermodal transport viable is 95 kilometers. While clearly the researchers have made essentially different assumptions and used different data, these results stand to show the difficulty of concluding the optimal distance of intermodal transport.

Although transportation of containers by barge in Europe has recently become attractive due to different EU policies supporting its growth, its historical development has not been as smooth. The river Rhein has been the main artery where barging has developed and while today this mode is also spread towards other waterways and regions, the Rhine still remains the main corridor for waterway transport. The first barge container transport was of primarily empty containers between Rotterdam and locations on the upper (Basel and Strasbourg) and middle Rhine (Mannheim and Karlsruhe) (Van Driel, 1993). Soon after, in 1968, the first river container terminals were opened in Mannheim, Basel and Strasbourg. However, barge transport of containers remained very limited and didn’t surpass the annual volume of 10,000 TEU until 1975 (Notteboom, 2007). The growth in maritime container transport in the following years, leading to the concentration of containers in certain ports, such as Rotterdam and Antwerp, facilitated the set-up of barge liner services and consequently the establishment of barge transport as a reliable transportation mode for containers. The development of more inland container terminals along the Rhein led to growth in traffic over the river increasing more than ten-fold for 10 years from 20,000 TEU in 1976 to 210,000 TEU in 1985 and then 800,000 TEU in 1995 (Notteboom, 2007). At the same time the traffic in the two biggest barge ports in Europe reached 1.15 million TEU in Rotterdam and 675,000 TEU in Antwerp.

At that time a new trend became apparent in the barge transportation market in Northern Europe – the emergence of inland terminals outside of Rhein basin. The large network of inland waterways in the Netherlands, Belgium and also reaching Northern France and Luxembourg proved to be favorable for the development of a dense inland terminal network. While by 1990 there were only 2 terminals operating outside the Rhine, by 2002 their number has risen to 43, of which 5 in Northern France and Luxembourg, 12 in Belgium and 26 in the Netherlands (Notteboom, 2007). These developments drew the attention of other regions that had the opportunity to develop barge transport and terminals also started to appear along the Rhone and Seine, which is essentially the field of interest of the current paper.

Figure 2: European Inland Waterways Map **Source: www.binnervaart.be**

	(million tkm)		
	Road (1)	Rail (2)	Inland water-ways (3)
EU-27	:	442 738	144 953
Belgium	36 174	8 572	8 746
Bulgaria	17 742	4 693	5 436
Czech Republic	44 955	15 437	33
Denmark	16 876	1 866	-
Germany	307 547	115652	55652
Estonia	5 340	5 943	:
Ireland	12668	103	-
Greece	28 890	786	-
Spain	211 895	10 475	-
France	173621	40627	8673
Italy	179 411	23 831	:
Cyprus	963	-	-
Latvia	8 115	19 581	:
Lithuania	17 757	14 748	:
Luxembourg	8 400	279	279
Hungary	35 373	9 874	1 831
Malta	:	-	-
Netherlands	71 566	6 984	35656
Austria	29 075	21 915	2003
Poland	180 742	52043	202
Portugal	35 808	2 549	-
Romania	34 269	15 236	11 765
Slovenia	14 762	3 520	:
Slovakia	27 705	9 299	899
Finland	27 805	10 777	:
Sweden	35047	23 116	-
United Kingdom	171 477	24 831	:

Figure 3: Hinterland Transport Statistics by Country **Source: Eurostat (2010)**

In 2008 inland waterway transport in EU-27 countries accounted to a total of 145 billion ton-kilometers corresponding to a market share of 5.9% of total transport (Eurostat, 2010). The inland waterway network in Europe (Figure 2) has a total length of 52,000 km, the longest networks being in the countries France (14,900 km), Germany (7,500 km), the Netherlands (5,000 km) and Belgium (1,570 km) (De Vries, 2006). These countries are also the leading in the waterway transport, with the exception of France (Figure 3). The explanation for this is that while France has the largest network of inland waterways, most of them are only able to accommodate relatively small vessels. However, France has been developing its capacities and investing in inland terminals, mainly in 3 regions – Lille, Paris and along the Seine and Lyon and along the Rhone. For the purpose of the current analysis, the attention is going to be set on the Seine and the terminals that are developed along it.

Barging for containers along the Seine has mainly been between the deep-sea Port of Le Havre and the inland port of Gennevilliers in Paris, while a few other inland terminals have recently also emerged, the most notable of which Bonneuil-sur-Marne, Limay and Evry. The Port of Le Havre has raised its attention towards inland shipping and is promoting the development of services towards its biggest hinterland market – Ile-de-France. The modal share of barging in Le Havre has been growing from 1.3% in 1998 through 4.8% in 2003 and has reached 9% in 2009 with a planned development of 12% in 2015 (Notteboom, 2007; Port of Le Havre Authority, 2010). This steady increase since the start of the first barge service along the Seine in late 1994 indicates that the inclusion of barging as a mode of hinterland distribution from the port has been successful and Le Havre has entered the regionalization phase of its development.

The inland ports have successfully played their respective roles in the network and they have also drawn attention to expanding logistics clusters around them. The river Seine acts as a reliable natural corridor between Le Havre and the inland ports. The distance between the deep-sea port and the inland platforms is approximately 200 kilometers, which makes barge transport competitive to road transport and ensures that the use of the canal is cost-efficient. The spatial vicinity and groupings of individual ports provides a good base for cargo bundling in case flows are not sufficient to fill individual shuttles to every terminal. Most importantly, the inland terminals have acted as catalysts of logistics cluster formations around them and have created a steady demand for inflows or outflows of cargo. This is hardly surprising given that the region of Ile-de-France concentrates and economic output of 552 billion Euro within an area of 12,012 km^2 and several logistics zones are needed in order to accommodate the trading and distribution demands of the 11,694,000 inhabitants. In fact, the first dedicated logistics zones in Europe were created near Paris in the 1960s, Sogaris and Garonor. These logistics zones still exist today, Sogaris even having expanded to 3 new locations in the Ile-de-France region, and they are the only logistics zones in France that are members of the European Association of Freight Villages. The website of the association defines a freight village as "*a defined area within which all activities relating to transport, logistics and the distribution of goods, both for national and international transit, are carried out by various operators*" (Anon 6). The existence of such areas around inland terminals can add as a cluster engine for a logistics cluster and place high demands for cargo flows, consequently enhancing the growth of these inland terminals. Moreover, there are 9 'plateformes logistiques', specially defined zones for logistics activities by the French government, housing distribution centers of various companies and logistics providers – Aventis, L'oreal, Carrefour, Samada Motorcycles, Armand Thiery, Hays Logistics, ND Logistics, Tibbett & Britten and others. This clustering of logistics zones and distribution centers is a very favorable factor for the port regionalization that Le Havre has achieved in this region.

The inland port of Gennevilliers is the largest and most important in the Ile-de-France region. Since the start of its first container operations in 1994, it has grown to be become the inland hub for the whole region (Figure 4). Its current barge handling capacity is estimated to be over 100,000 TEU per year and the waterway volume in 2008 amounted to 76,874 and at 2010 it reached 107,957 TEU (Ports de Paris, 2011b). The port is a developed tri-modal platform, also serving rail and road, and the rail traffic is even more substantial than the barge, but barge-rail connections are still underdeveloped. The port has also started initiatives to attract related businesses to its vicinity so it can strengthen its leading position in the region and facilitate growth. In May 2005 a business incubator was established with the objective to attract companies in logistics, international trade, e-commerce and transport-oriented industries. The Port of Gennevilliers also plans to increase its riverside handling capacity by installing a new gantry crane. The planned terminal capacity in 2015 amounts to 200,000 TEU (Ports de Paris, 2011b).

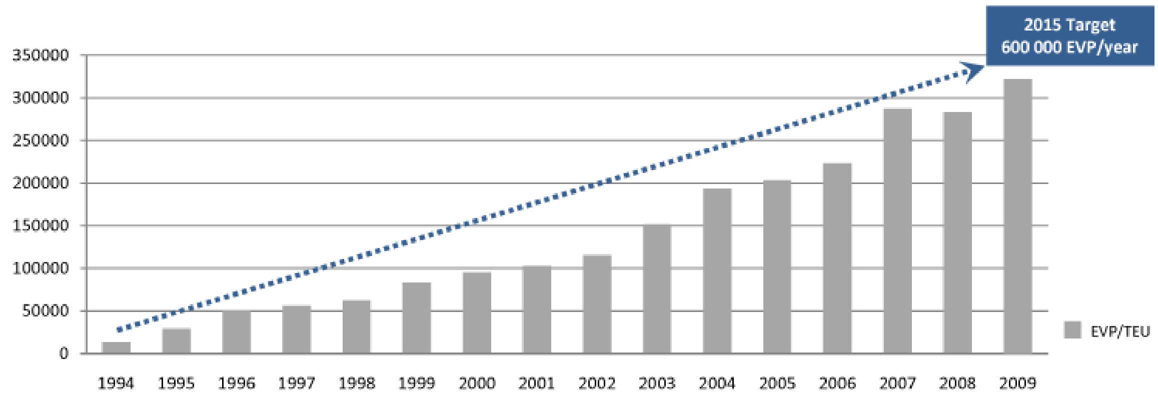

Figure 4: Port of Gennevilliers Throughput **Source: www.paris-terminal.com**

Three other inland ports in the Ile-de-France region are offering container handling options, but their share in the total amount of transported containers is marginal compared to the Port of Gennevilliers. The Port of Limay is situated in the west part of the region and is the first inland port when arriving from Le Havre. It currently has an estimated container capacity of 15,000 TEU and in 2010 total traffic amounted to 11,443 TEU (Ports de Paris, 2011c). An area of 2 ha adjacent to the current terminal is reserved for an extension, resulting in an additional capacity of 30,000 TEU. Twenty companies in the sectors of metallurgy, automobiles, grain, pulp and paper industries have storage and distribution facilities in the vicinity of the terminal, but not all of them are using the container traffic through it. The Port of Bonneuil-sur-Marne is situated 8 kilometers east of Paris and handled 5,955 TEU in 2010 (Ports de Paris, 2011c). It is also a tri-modal platform, but its rail services are very limited and do not handle any containers – traffic of 94,239 tons of rail cargo in 2010 compared to 1,115,039 tons by barge. The port offers land for storage, industrial and logistics activities and already some companies are established in it – Carnatio, Bergerat-Monnoyeur Cofrafer, Lafarge Cement and so on. The Port of Evry is situated upstream the Seine, 25 kilometers east of Paris and its recently developed container terminal has a capacity of 10,000 TEU. Opened in August 2010, the terminal managed to achieve 1,643 TEU, but has a much bigger potential (Ports de Paris, 2011c). Companies such as Toys 'R Us, Carrefour, Danone and Bellows have expressed interest in developing sites close to the Port of Evry and it is likely that at least a part of them will establish facilities in its business-dedicated 2.9 ha area.

Port of Le Havre has a natural monopoly in serving the Ile-de-France region that is typical of an earlier period of port development. Its monopoly is not a result of superior service, but of the presence of natural infrastructure for inland transport – the river Seine. However, a recent development threatens its dominance in the region and paves the way for other major seaport in its range to enter the market of inland shipping along the Seine. If an established seaport operating services on the Rhein and in Belgium and Northern France wants to set up a new service to the Seine, the barges operating the service would have to pass through the existing Canal du Nord connecting the two river basins. The current size restrictions for barges passing through the canal are 650 tons and it has proven a bottleneck for trade and cargo flows on this north-south axis. A newly developed project, the Seine Nord Europe canal plans to relieve the created bottleneck, by allowing push convoys as big as 4,400 tons to pass through the canal, while enabling far more substantial cargo flows over inland waterways between the Seine basin and the main waterway network in Europe.

The new Seine Nord Europe canal (Figure 5) with an estimated overall project cost of 3,173.2 million Euro is going to be 106 kilometers long, 54 meters wide and with a depth and air draft of respectively 4.5 and 7 meters. Barges will pass through 7 locks and sail past 4 inland terminals as they sail all the way from Compiegne to Aubencheul-au-Bac (Biet et al., 2008). Each of the new terminals will include a logistics zone accounting to a total of 311 ha of new space for business activities. The largest of the platform – Cambrai-Marquion – is forecasted to handle 60,000 TEU by 2020, making it an attractive location for sea-ports to expand their hinterland networks. Barge traffic on the canal on the other hand is expected to increase three- to four-fold until 2020 (Nautes, 2011). Moreover, it is going to connect existing and planned distribution centers and production sites of various companies to existing markets and give them a more environmentally-friendly and reliable way to handle their imports and exports, also changing their transportation patterns. These companies include, but are not limited to Renault, Toyota, BASF, ArcelorMittal, Carrefour, Roquette, Bonduelle and many others (Nautes, 2011).

Figure 5: Seine Nord Europe canal **Source: www.vnf.fr**

To recover the huge investment cost the development committee has considered an innovative concept for inland shipping that has already been widely applied to road infrastructure development. Discussions are being held as to whether to charge an infrastructure cost to all barges that pass through the canal and six organizations (The European Commission, VNF, RFF, SPW, Wenz and the Ministry of Transport of the Netherlands) have conducted a study about internalizing all external costs on the Paris-Amsterdam corridor (European Commission et al., 2011). While their conclusion is that taking such actions would achieve the objectives of decreased congestion and pollution and more efficient load of the vehicles, there is an inherent risk that charging an infrastructure for barge infrastructure will cause a shift of cargo flows back on the roads and undermine the success of the Seine Nord Europe project. It remains to be seen whether this policy is going to be introduced and the effects it will actually have on the transport market.

The inland terminal developments associated with the Seine Nord Europe project will increase the demand for waterway services to the Seine region and along the canal and create an opportunity for the ports that are connected to the inland waterway network to plug into that region. The position of Le Havre into the market will no longer be of a natural monopolist, but of a dominant player, which is the least spatially distanced from the region. In other words the Seine Nord Europe canal will create an interesting opportunity for the ports of Rotterdam and Antwerp to extend their port regionalization networks into the Ile-de-France region and foster their leading positions in the Hamburg – Le Havre range.

Chapter 3 Methodology

To answer the posed research question, specific methodologies are developed for each sub-question and they are set out hereafter.

3.1. Market Potential

Market potential for a region is always cargo specific, especially when it comes to importing or exporting goods. Australia has great potential in exporting coal and iron ore, but their regional potential of exporting containers is relatively low. On the other hand, Germany's dry bulk fields are almost depleted and the extraction of natural resources from them is relatively expensive, so they don't have a potential in exporting bulk cargoes, but their industry has great potential of exporting high-quality manufactured goods in containers and the large internal market with great purchasing power demands a lot of imports, making it one of the most attractive markets for countries exporting manufacturing production, such as China and the countries in South-East Asia.

For the purpose of the current paper, regional market potential is going to be defined as demand for transport services of containers along the inland waterways – both importing and exporting. To measure this potential, it is most convenient to look at the container traffic in the inland waterways terminals in the region. This traffic depends on a number of factors such as annual regional GDP, number of inland terminals, their annual water-side capacities, and number of services to these terminals per week. To determine the regional potential in the future, a regression with past data is going to run, the factors mentioned earlier set as explanatory variables and the water-side traffic through the inland ports as a dependant variable. After finding the explanatory power of the factors, projections of these factors are going to be used to predict the regional market potential in the future years of interest for the research. Although this method has several limitations, it is one with considerable accuracy of representation of reality and it will give a good approximation of future trends in regional market potential for container transportation on inland waterways. The biggest limitation is that extrapolation of the data into the future is not always accurate and the opening of the Seine Nord canal will change the market situation considerably. However, the method is the best known for the estimation of the future potential.

Another potential pitfall is the accuracy of the data. While the regional GDP, terminal throughputs and number of container terminals have been recorded and can be retrieved reliably, terminal capacities and especially the evolution of number of weekly services to and from the terminals have not been properly tracked through time and have to be determined reliably through interviews with regional specialists and making educated guesses. Table 1 presents the data gathered by informal interviews and from the terminal websites.

Table 1: Data for Regression

TEU throughput	Year	GDP – thousands €	TEU capacity	Number of services	Number of terminals
3,214	1994	327,905	20,000	2	1
5,118	1995	332,238	20,000	3	1
7,337	1996	342,922	20,000	5	1
8,893	1997	354,360	20,000	6	1
12,644	1998	366,583	20,000	6	1
18,902	1999	387,678	50,000	8	1
21,730	2000	411,083	50,000	9	1
25,432	2001	423,811	50,000	10	1
27,951	2002	441,315	50,000	11	1
42,166	2003	455,615	75,000	14	2
56,942	2004	466,588	75,000	15	2
85,648	2005	488,509	125,000	18	2
90,809	2006	506,787	125,000	20	2
105,591	2007	541,536	140,000	24	3
106,663	2008	557,974	140,000	26	3
128,919	2009	552,052	140,000	29	3

It is expected that all the factors will have a positive influence on TEU throughput with different degrees of influence and significance. Due to the nature of TEU capacity and services data, several regressions are going to be run, first including only the factors that can be found in databases (year, GDP and number of terminals), then including the one that are estimated (year, TEU capacity and number of services) and finally a regression including all listed variables. These regressions are done to conclude how important the data which is not retrieved from a fixed database is. Also, in each regression the variable year is excluded after the regression is performed to check its contribution to the model. Finally, a test of multicollinearity is performed between the independent variables. For each test a significance level of 5% is going to be used.

After the regressions equations are derived, the coefficients are going to be analyzed with the aim to spot problems in the results and identify a control variable. The ultimate objective of this analysis is to produce one or several regression equations with logical coefficients, and capable of predicting the future TEU throughput. After these equations are identified, a residual analysis for them is also going to be performed to test whether they conform to the requirements for using them for prediction. Finally, future values of the independent variables are going to be estimated and the identified regression equations will be used to estimate the regional market size for inland shipping in 2015 and 2020.

3.2. Infrastructure Pricing – Scenario Analysis

The demand for imports and exports in Ile-de-France after the opening of Seine Nord Europe canal is going to be supplied by a number of ports in the Hamburg – Le Havre range either by road, barge or rail. The current trends show no rail and barge transport from Port of Rotterdam and only a small traffic flow of trucking to Paris. When the Seine Nord Europe canal is opened, barging is going to become another possible transportation mode between the port and the region, increasing competition between modes and potentially stealing away traffic from the road while also potentially increasing the overall cargo transported over the corridor. The scenario analysis section will identify a number of scenarios, compare the price of road transport with barge transport for each of them and identify the potential of barge transport if the each of the infrastructure pricing policies is applied. The scenarios are explained hereafter and they are shortly labeled Status Quo, ETS (Emissions Trading Schemes), ICR (Infrastructure Cost Recovery) and the combination between Emissions Trading Schemes and Infrastructure Cost Recovery (shortly called ETS+ICR).

The Status Quo scenario refers to a case in which no infrastructure cost is charged and barging is not included into the Emission Trading Schemes of the European Union. This scenario compares the basis of barging costs to road costs and is used as a benchmark for the other scenarios. Although this scenario is highly improbable, its inclusion in the discussion is useful for the purpose of identification of the maximum performance of barging and determining the negative effects which each of the policies will have on their competitiveness.

The ETS scenario refers to the introduction of the Emissions Trading Schemes of the European Union to barge transport. Inclusion of the transport mode would be done either by issuance of emission permits to the whole barge industry and distributing them among the barge operators on a free market basis or by putting a fix tax burden on barge fuel, therefore directly increasing the costs of operating the barges. The bottom line is that the inclusion of barging into ETS would increase the costs of using the mode and make it less competitive to the other modes of transport, as they are already included into the policy.

The ICR scenario will discuss the introduction of a charge for barges for using the canal. There are many ways to charge these costs, but the costs will probably not be equal for every vessel and it will include the distance that the vessel has actually travelled over the canal. The most plausible charge would be per ton-kilometer – that is for each tone transported one kilometer over the canal there is a certain amount being charged. However, examining exactly how many tons each barge is transporting in practice would be fairly difficult and would increase the costs of introducing the policy. Therefore, the introduced charge would most probably be based on the size of the vessel and its carrying capacity, which are highly correlated. For convenience of the discussion, it is thereafter assumed that an Infrastructure Cost Recovery will charge a fixed cost for each kilometer a barge travels over the canal and according to the limits of the vessels reaching the canal from the Port of Rotterdam.

The ETS+ICR scenario will examine the effect of introduction of both policies simultaneously. It is clear that their combination will decrease further the competitiveness of barging in terms of costs compared to road transport, but the scenario is considered to gain an insight about the scale of the change. Essentially, the fourth scenario can be regarded as the most probable one, as the inclusion of barges into ETS is considered on a European-wide level and there are strong indications that it is going to be implemented. On the other hand, pricing the Seine Nord Europe canal is a strictly regional policy, which is only connected to that particular waterway and the status of all the other waterways in Europe is going to be unchanged. The large investment cost and the pressure from various public and private bodies will probably result in pricing that canal to recover the investment.

The cost calculation hereafter is partly subjective, but not all values can be obtained in practice, as every cost data is very sensitive for companies that incur that cost and they are not willing to give it out. To calculate the cost of road transport a trucking company is contacted to obtain freight rates on the route Port of Rotterdam – Port of Gennevilliers and the respective price is 676 Euros for a single trip both with a 20-foot and 40-foot TEU. To calculate the potential future cost of barging on the same leg several manipulations are made. An online interview with Eric van Toor from Kantoor Binnenvaart was conducted obtaining relevant information for the proposed model. First of all, there are two possible routes from the Port of Rotterdam to the Seine Nord Europe canal – through the river Schelde and through the river Leie. The limitations in dimensions of vessels able to go through both routes are 105 meters length, 9.6 meters width and 2.5 meters draft or a maximum cargo weight of roughly 1,700 tons. However, the biggest limitation for vessels is the height of the bridges along the route – at normal water level the river Leie has a height restriction of 4.2 meters which excludes many barges from the operations. Moreover, at 4.2 meters a barge full of containers stacked 1 over 1 is not certain to be able to go through, as the height of the container amounts to around 4.8 meters. The minimum height over the Scheldt is 4.5 meters, which is more acceptable for barges stacked 1 over 1 and for that reason only this route is going to be considered in the consequent analysis. The total sailing distance on the route between the Maasvlakte area in Rotterdam and Gent is 200 kilometers and between Gent and Cambrai, which is the beginning of the Seine Nord Europe canal, is 170 kilometers. The total sailing time through the Scheldt is estimated to 35 hours with an associated fuel consumption for a fully laden vessel of 3,500 to 5,000 liters of diesel, depending on the vessel fuel efficiency. The canal length as already mentioned is 106 kilometers and the distance between Compiegne and the Port of Gennevilliers is 60 kilometers amounting to a total distance of 536 kilometers.

The estimated fuel costs are reported to be 20% of total barge operating costs and Labour costs and Other costs, such as capital costs, insurance and maintenance are reported to be 40% each (Central Commission for Navigation on the Rhine, 2010) and these shares have been considerably consistent in the organization reports since it started to issue them in 2005. Therefore, after estimating the total fuel costs, this share is going to be used to estimated total barge operating costs. One additional cost associated especially with container transport has to be included in the analysis – container handling costs both at the seaport and at the inland port. Mr. Donald Baan from Port of Rotterdam has indicated that a good rule of thumb is handling costs of 80 Euros at the sea-port and approximately 20 Euros per container in the inland ports. The large difference between the two is due to the fact that different cranes are used at the sea-ports and at inland terminals. The sea-port cranes, even at dedicated barge terminals, tend to be a lot larger, because economies of scope are intended to be achieved. Therefore, these cranes are associated with a larger investment, and their operation as well as capital costs are higher than the lower scale cranes in the inland ports. The sum of all the listed costs so far will provide a basis for estimating total barge costs on the route. However, as this data is based on costs and the data on trucking is the price, a margin is going to be added on the cost of barging to obtain a probable price of the service associated with the cost. After all the scenarios are computed, a sensitivity analysis is going to be performed to check the volatility of the assumptions and essentially to make policy recommendations.

3.3. Supply Chain Perspective

In the modern environment of port competition, port competitiveness for a single service is determined by the characteristics of the whole supply chain rather than the efficiency and the cost of the port alone. Therefore, to maximize the impact that Port of Rotterdam is going to have in Ile-de-France after the completion of the Seine Nord Europe project, the port will also have to consider other factors which supplement its overall service level in the region. For this purpose a qualitative analysis is suggested identifying potential competitive advantage areas and policies that will enhance them.

The role of the port in the overall supply chain has to be identified and critically assessed, while also potential partners for successful market penetration have to be identified. Also, calling patterns of liner companies that are operating services among the competitor ports should be analyzed and opportunities for cargo coming from or leaving for potential destinations ought to be identified. The overall objective of this section is to address the potential competitive advantages that the Port of Rotterdam should focus on in order to improve their competitive position in the emerging market.

Chapter 4 Market potential

4.1. Deriving the regression equation

In this section each regression is presented consequently and its results are discussed to conclude the explanatory and predictive power of the independent variables and the significance of the coefficients. The regressions are performed in Excel using the Regression function of the Data Analysis plug-in and the presented results are as displayed in the output of the software. In all regressions the dependant variable is the TEU throughput on the water-side of the terminals and all of them contain the variable year, which is also excluded in each case, therefore in the following discussion they are going to be defined by the other explanatory variables used.

The first regression is with additional explanatory variables GDP and Number of terminals. Although these variables do not provide a full picture of the environment in which the terminals are operating, their explanatory power is very high at Adjusted R^2 of 94.44%. The overall results of the regression are displayed in Table 2. The ANOVA test for regression significance shows that the regression is valid. However, the P-values of the regression coefficients are relatively high and only the coefficient of Number of terminals is significant at the 5% level. However, removing the variable Year from the regression does not affect highly the explanatory power and ANOVA significance of the regression, but considerably improves the significance of the regression coefficients (Table 3). Therefore, while the addition of the Year variable in the regression does not affect highly its explanatory power, it has a negative influence on the coefficients significance and therefore it is better off left out.

Table 2: Regression results (Year, GDP, Number of terminals)

TEU Throughput = ***a*** + ***b****Year + ***c****GDP + ***d****Number of terminals + ***e***				
Multiple R	0.977484548			
R Square	0.955476042			
Adjusted R Square	0.944345052			
ANOVA Regression Significance	2.24061E-08			
	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	-6941561.366	10531985.49	-0.659093328	0.522282762
Year	3455.024893	5335.279441	0.647580868	0.52945081
GDP	0.071546444	0.358732744	0.19944219	0.845256434
Number of terminals	25826.08255	8497.527013	3.03924689	0.010288265

Table 3: Regression results (GDP, Number of terminals)

TEU Throughput = ***a*** + ***b****GDP + ***c****Number of terminals + ***e***				
Multiple R	0.97668832			
R Square	0.953920074			
Adjusted R Square	0.946830855			
ANOVA Regression Significance	2.05507E-09			
	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	-121266.2393	23106.89851	-5.248053489	0.000157393
GDP	0.29812549	0.077391314	3.852182813	0.00199924
number of terminals	23622.02312	7610.270884	3.103966137	0.008382528

The second regression contains the addition variables TEU Capacity and Number of services. These variables provide a good description of the terminals, but do not give a background of the environment that these terminals are operating in. The explanatory power and regression significance is even higher in that case (Table 4), but an increase Adjusted R^2 from 94.68% to 98.6% does not radically change the predictive power. All the regression coefficients are significant at the 5% level and removing the Year variable does not affect the model drastically (Table 5).

Table 4: Regression results (Year, TEU Capacity, Number of services)

TEU Throughput = ***a*** + ***b****Year + ***c**** TEU Capacity + ***d****Number of services + ***e***				
Multiple R	0.994362727			
R Square	0.988757233			
Adjusted R Square	0.985946541			
ANOVA Regression Significance	5.89375E-12			
	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	6442712.616	2577252.468	2.499837597	0.027923718
Year	-3238.979167	1292.247929	-2.50646884	0.027586018
Capacity	0.405109418	0.112016425	3.616517998	0.003537081
Services	4543.22066	919.829371	4.939199381	0.000342547

Table 5: Regression results (TEU Capacity, Number of services)

TEU Throughput = ***a*** + ***b**** TEU Capacity + ***c****Number of services + ***e***				
Multiple R	0.99139865			
R Square	0.982871283			
Adjusted R Square	0.980236096			
ANOVA Regression Significance	3.3053E-12			
	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	-17087.64438	2815.924928	-6.06821731	3.97975E-05
Services	2886.874826	758.7773725	3.804640109	0.002187967
Capacity	0.380950979	0.132346601	2.878434166	0.012932188

The third regression has the additional variables GDP, Number of sevices, TEU capacity and Number of terminals. The combination of all these variables should provide a fairly complete picture of both the terminals and the environment in which they are operating and although some of the data is not obtained from official databases, the previous regressions have shown that it provides a good explanation of the variation in the Terminal throughput. Not surprisingly the Adjusted R^2 is very high at 98.5% and the validity of the regression is confirmed by the ANOVA test (Table 6). However, the problem with the first regression is again apparent as only the regression coefficients of TEU capacity and Number of services are significant. The problem is again solved by removing the variable Year and rerunning the regression (Table 7). The Adjusted R^2 increases to 98.8% and ANOVA test is not affected, but all coefficients have become significant at the 5% level, except for Number of terminals. However, a more serious problem has arisen, as the coefficient of GDP in this case is negative, which means that an increasing demand and supply of products in the region would mean less transport along the inland waterways. While this fact is absurd in itself, it is also contradicting the results of the first regression, which showed a positive relationship between GDP and TEU Throughput.

Table 6: Regression results (Year, GDP, TEU Capacity, Number of services, Number of terminals)

TEU Throughput = ***a*** + ***b****Year + ***c****GDP + ***d****TEU Capacity + ***f****Number of services + ***g****Number of terminals + ***e***

Multiple R	0.995082933			
R Square	0.990190044			
Adjusted R Square	0.985285066			
ANOVA Regression Significance	1.0527E-09			
	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	-1604708.487	6332232.295	-0.253419081	0.805078261
Year	838.9496354	3202.787224	0.261943606	0.798681479
GDP	-0.271661785	0.205556012	-1.321594938	0.215739516
Capacity	0.467650201	0.131645002	3.552358182	0.005247594
Services	4302.35966	1344.420248	3.200159821	0.009489122
number of terminals	1575.348892	6847.055615	0.230076836	0.822670223

Table 7: Regression results (GDP, TEU Capacity, Number of services, Number of terminals)

TEU Throughput = ***a*** + ***b****GDP + ***c****TEU Capacity + ***d****Number of services + ***f****Number of terminals + ***e***

Multiple R	0.995653877			
R Square	0.991326643			
Adjusted R Square	0.988172695			
ANOVA Regression Significance	2.94947E-11			
	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	69499.80343	30791.62	2.257101	0.045322
GDP	-0.275475262	0.094089	-2.92783	0.013744
number of terminals	1091.327175	5004.068	0.218088	0.831354
Services	4772.403255	1073.858	4.444167	0.000988
Capacity	0.482984045	0.110465	4.372263	0.001113

Examining the 4 independent variables more closely reveals two potential problems that might cause the inconsistency of the results. First of all, the small number of observations makes the regression results not very reliable. Especially if a confidence interval has to be derived for future TEU throughputs, the small number of observations will make the interval very wide and decrease the predictive power of the regression equation. However, the first terminal has started operation in 1994 and collection of data at shorter than annual periods is not possible due to its non-availability for such a time horizon. Therefore, this is the maximum number of data points that is available. The other potential problem is that the independent variables seem to be highly positively correlated with each other. To check whether this is the case, a test of multicollinearity is performed (Table 8). This test shows that the correlation between the independent variables is very high and the problem with the GDP coefficient might be partly related to that fact. This correlation is actually not surprising, as the GDP, Number of terminals, Number of services and TEU capacity all grow at the examined time horizon. Moreover, as more terminals appear and they increase their capacity logically there will be more services to these terminals and the terminal throughputs will increase. Therefore, to improve the regression equation, so that it at least partly resembles the background logic behind it, a couple of more regressions are going to be done, to achieve a desired positive effect of the variables on the TEU throughput and derive an equation which will reflect both the economic climate and the terminal conditions.

Table 8: Correlations among explanatory variables

	Year	*GDP*	*Number of terminals*	*Number of services*	*TEU capacity*
Year	1				
GDP	0.993731	1			
Number of terminals	0.885785	0.91005	1		
Number of services	0.976984	0.983074	0.945992	1	
TEU capacity	0.952186	0.967254	0.925718	0.970054	1

First of all, to reflect the economic environment, GDP will be one of the variables included in every regression. The correlation between Year and GDP of 99.37% and the previous problems that this variable has caused has stipulated that the variable Year be left out of the analysis. Including the GDP variable in the regression with TEU capacity and Number of services also causes the GDP coefficient to be negative. Therefore, one of the variables Terminal capacity and Number of services should be left out of the analysis. Leaving the two of them consequently out of the regression shows that if Number of services is included and TEU capacity left out, the GDP coefficient is still negative and if Number of services is excluded, then the GDP coefficient is positive. Two other factors are also contributing to the exclusion of the Number of services variable from the analysis. First, its correlation with GDP and Number of terminals is higher than the TEU capacity and therefore excluding it from the analysis will cause the loss of less information. Second, the collection of the data about number of services was more subjective that TEU capacity and the prediction and evaluation of the future Number of services is going to be even more subjective as it depends on a lot of private economic actors. Therefore, it is likely that leaving the Number of services variable out of the regression will likely improve the overall reliability and validity of the analysis.

The last performed regression analysis, which will also be eventually used to estimate the future TEU throughput is with the independent variables GDP, TEU capacity and Number of terminals. The results of this regression are displayed in Table 9 – the Adjusted R^2 and the ANOVA test providing a reliable proof for the significant effect of the independent variables on TEU throughput. The P-values of the regression coefficients show that the coefficients of the Intercept and GDP are not significant at the 5% level, but the other two coefficients are statistically significant. The derived regression equation is:

*TEU Throughput = -36,710 + 0.0454*GDP + 14,570*Number of terminals + 0.5717*TEU capacity + e*

Table 9: Regression results (GDP, TEU Capacity, Number of terminals)

TEU Throughput = ***a*** + ***b****GDP + ***c****TEU capacity + ***d****Number of terminals + ***e***				
Multiple R	0.987802376			
R Square	0.975753533			
Adjusted R Square	0.969691917			
ANOVA Regresssion Significance	5.89638E-10			
	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	-36710.24064	31080.76731	-1.181124014	0.260433801
GDP	0.045449251	0.096553632	0.470715081	0.646285124
TEU Capacity	0.571713645	0.173920548	3.287211623	0.006492774
Number of terminals	14569.81084	6371.600691	2.286679838	0.041178035

The small number of observation requires a quick interpretation of the coefficients to be performed before that analysis proceeds further to check whether there is some bias associated with the small amount of data points.

The Intercept of -36,710 is at first sight not consistent at all, because there cannot be a negative throughput of containers. However, there are two explanations for this. First, the case where the independent variables have low values is not included in the analysis, and the regression equation is not supposed be used for prediction of these cases. Second, for TEU Throughput to be present, there have to several conditions present: the regional GDP has to exceed some threshold so that trade is needed, an inland waterway terminal should exist and if it has a container berth then its equipment will have some minimum capacity. Therefore the Intercept coefficient is logical.

The GDP coefficient of .0454 is also logical, because looking at the data it can be observed that the GDP starting level is much higher than the TEU throughput. In the first years of barge transport for containers in the region there was already a lot of demand for container transport, but mainly the road and rail modalities were used. As terminals started to emerge and increase their capacities and services to those terminals were started, the container flows started to shift from the more traditional modalities to the river, causing a 3911% increase in TEU throughput from 1994 till 2009, while the GDP has grown by only 68% in the same period. As barge transport matures in the region, GDP will become a driver with more weight in its growth.

However, at the current situation it is likely that GDP is going to have only a small effect on the overall TEU Throughput.

The other two coefficients – Number of terminals and TEU capacity – have to be examined simultaneously, because of their common nature of describing the terminal environment. The Number of terminals coefficient of 14,570 means that an opening of an additional terminal, no matter its capacity would increase the TEU throughput by that many. The TEU capacity coefficient of 0.5717 means that increasing the capacity of any existing terminal or opening a new one terminal with a capacity of 1000 would result in an increase in TEU throughput of approximately 572. Therefore, an opening of a terminal with 30,000 TEU would theoretically result in an increase in throughput of 31,721 TEU, which is simply not possible if all the capacity before the terminal is opened is used. However, looking at the data, terminals have always strived to possess excess capacity, so this case cannot be made an example in the current analysis. Moreover, a 30,000 TEU increase in the capacity of an existing terminal would theoretically cause a throughput increase of 17,151 TEU, which is generally less than observed in the data. Therefore, the regression coefficients give an average estimation and they can be accepted as valid for giving a rough estimation of terminal river-side throughput in future.

There are three reasons for the observed problem with the last two coefficients. First, the nature of the TEU capacity and Number of terminals variables is such that they increase step-wise through time – not every year a terminal starts operations or expands its capacity. Capacity expansions are generally made for a longer period of time, anticipating demand in the coming several years, also because these expansions are generally costly and time-consuming. Second, the variable Number of services which actually develops more gradually has been previously excluded from the analysis, because of its negative effects on the GDP coefficient. Third, the exclusion of the variable Number of terminals would partly solve the present problem. However, the difference between expanding the handling capacity at an existing terminal and starting a terminal at a new location is crucial and adds value to the equation. A new terminal provides access to new markets and has captive hinterlands in its vicinity, which provide new traffic for the regional inland waterways. Expanding the capacity at an existing terminal enhances its economies of scale and has a clustering effect for companies using the cargo flows, therefore further boosting its attractiveness. Although they both result in increased throughput, the two effects are fundamentally different. However, a regression is also going to be performed excluding the Number of terminals variable and the predictions of the two regression equations are going to be compared to gain an understanding of the sensitivity of the results to the exclusion of the variable.

That regression analysis contains TEU throughput as a dependent variable and GDP and TEU capacity as independent variables. The results displayed in Table 10 unsurprisingly show the ever-present high Adjusted R^2 and statistically significant effect of the explanatory variables on TEU throughput. The significance of the regression coefficients does not change from the previous regression, the Intercept and GDP not being statistically significant at the 5% level and TEU capacity being significant. The resulting regression equation used for prediction of TEU Throughput is:

*TEU Throughput = -39,713 + 0.0791*GDP +0.7436*TEU capacity + e*

Table 10: Regression results (GDP, TEU Capacity)

TEU Throughput = ***a*** + ***b****GDP + ***c****TEU capacity + ***e***				
Multiple R	0.982439987			
R Square	0.965188328			
Adjusted R Square	0.959832686			
ANOVA Regression Significance	3.32056E-10			
	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	-39712.69536	35748.76203	-1.110883094	0.286743097
GDP	0.079134176	0.1098529	0.720364925	0.484052579
Capacity	0.743597376	0.18055479	4.118402918	0.001210693

Before it is proceeded to use the regression equations to perform the estimations of future TEU throughput, a last step of regression diagnostics has to be performed in order to ensure that the regression analysis is valid. Essentially, the residuals of the two regression equations are going to be analyzed consequently to conclude whether they fulfill the required validity conditions and if they do, the regression equations are going to be used to predict the future market potential.

Table 11: Residuals 1

Observation	Predicted throughput	Residuals
1	4196.893682	-982.893682
2	4393.82858	724.1714197
3	4879.383665	2457.616335
4	5399.253004	3493.746996
5	5954.77581	6689.22419
6	24064.92715	-5162.92715
7	25128.66687	-3398.66687
8	25707.14493	-275.144933
9	26502.68862	1448.311379
10	56015.26487	-13849.2649
11	56513.9795	428.0204952
12	86095.95479	-447.954793
13	86926.6762	3882.323799
14	111651.5077	-6060.50773
15	112398.6025	-5735.60252
16	112129.4521	16789.54794

The first regression equation has the actual, predicted and residual values as listed in Table 11. The sixteen residuals are plotted into a histogram with 5 categories and displayed in Figure 6. The distribution does not exactly resemble a normal distribution, but there is a clustering of observations in the middle and because of the small number of observations it could be assumed that the residuals are approximately normally distributed. The mean of the residuals is very close to 0 and the different variance of some observations is more likely to be associated with exceptional years and outliers than with a trend of heteroscedasticity (Figure 7). The trends in the distribution of the residuals are associated with the nature of the independent variables or more specifically their step-wise increase through time. Therefore, caution should be taken when predicting future throughput, as the trend is when a terminal opens or expands capacity, the regression equation tends to predict higher throughput that reality and when the terminals have operated for a few years without an expansion, the regression estimate tends to be lower than reality. It is unclear whether this trend is to be observed in future, but it is safe to assume that the regression equation will give a valid estimate of future traffic. Last but not least, a Durbin-Watson test is performed to check for first-order autocorrelation of the residuals. The result of 1.8643 is between d_u and $4\text{-}d_u$ (for k=3, n=16), which are 1.73 and 2.27, and therefore there is no evidence of autocorrelation in the residuals, which means that the value of any error variable associated with a value of y is independent of the value of any other error variable. Therefore, all the required conditions are not violated and the regression equation can be used for the purpose of predicting future container throughput.

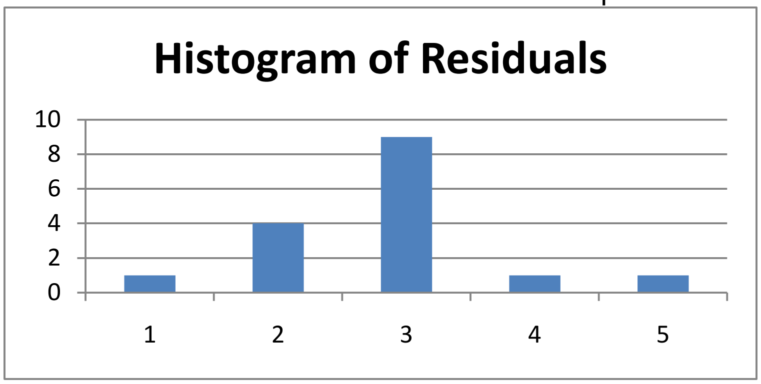

Figure 6: Histogram of Residuals 1

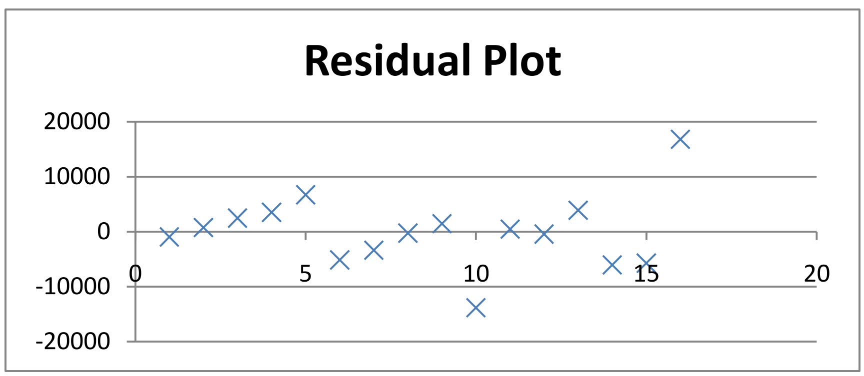

Figure 7: Residual Plot 1

Table 12: Residuals 2

Observation	*Predicted throughput*	*Residuals*
1	1107.768553	2106.231447
2	1450.662674	3667.337326
3	2296.089186	5040.910814
4	3201.262122	5691.737878
5	4168.513261	8475.486739
6	28145.75264	-9243.752642
7	29997.88804	-8267.888038
8	31005.10783	-5573.107835
9	32390.27246	-4439.272457
10	52111.82558	-9945.825578
11	52980.1649	3961.835105
12	91894.73397	-6246.733975
13	93341.14845	-2532.14845
14	107244.9426	-1653.942582
15	108545.7502	-1882.750173
16	108077.1176	20841.88242

The second regression equation values are displayed in Table 12 and the histogram of the sixteen residuals is shown in Figure 8. The histogram shows that residuals are strongly clustered in the left and there is one single positive outlier. Even if that outlier is removed, the tails of the distribution have more observations than the middle part and therefore probability distribution of the residuals cannot be assumed to be normal. The plot of the residuals does not exhibit trends of heteroscedasticity (Figure 9) and the mean of the residuals is exactly 0. The observed trends are similar to the ones in the residuals of the first regression and the same precautions should be taken when analyzing the results. Finally, the Durbin-Watson test statistic is calculated to be 1.2541, which is between d_U=1.54 and d_L=0.98 (k=2, n=16), which essentially means that the test is inconclusive and their might be first-order positive autocorrelation. While the independence of the error variables from each other is not entirely violated, the non-normality of the residuals makes the regression invalid

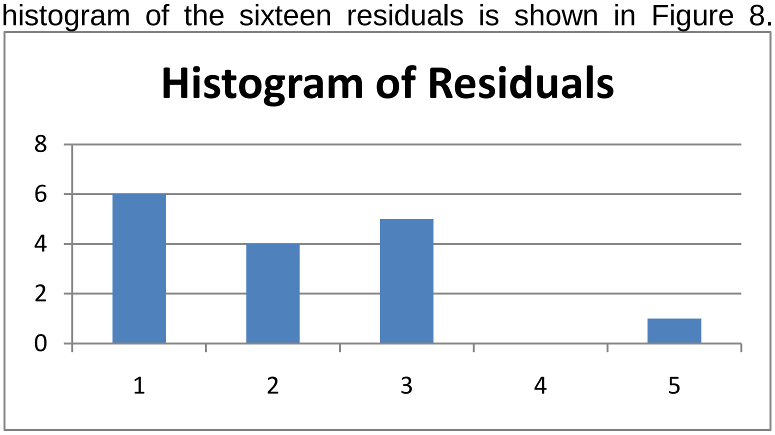

Figure 8: Histogram of Residuals 2

for estimation and prediction of future TEU throughput and therefore, the second regression equation is not going to be used in the further analysis.

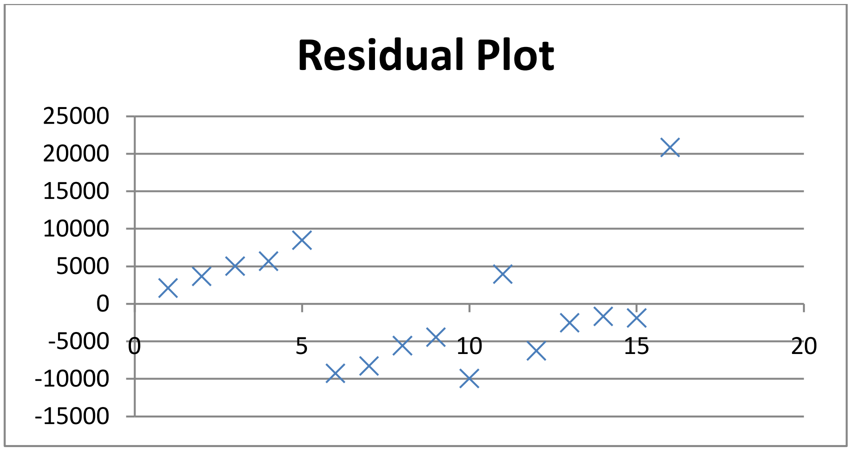

Figure 9: Residual Plot 2

4.2. Variable predictions

The planning and construction of the Seine Nord Europe canal has brought optimism to the Ile-de-France region for an increased demand for river transport of containers and several new greenfield projects and expansions are being planned. Ports de Paris, an organization uniting all the inland ports in the Ile-de-France, has predicted that river traffic along the Seine will grow by 200% in 2020 (Anon 7). To accommodate this projected increase in cargo flows, the organization has set up expansion plans until 2015 and 2020 both for expansion of existing terminals and strengthening the position of Gennevilliers and for the start of a number of new terminals and network formation for them before the canal is opened. As a comparison, from the opening of Gennevilliers in 1994 – the first inland container terminal in the region – until 2009 only 3 container terminals were operating and one of them – Limay – has been opened only recently in 2007 and has a capacity of only 10,000 TEU. From 2009 until the opening of the canal in 2015 there have been plans for another 3 terminals and doubling the capacities of the existing ones. Moreover, 4 intermodal terminals are planned along the canal to be opened in 2015 and the number of container terminals in the region altogether is going to accrue to 10. There are

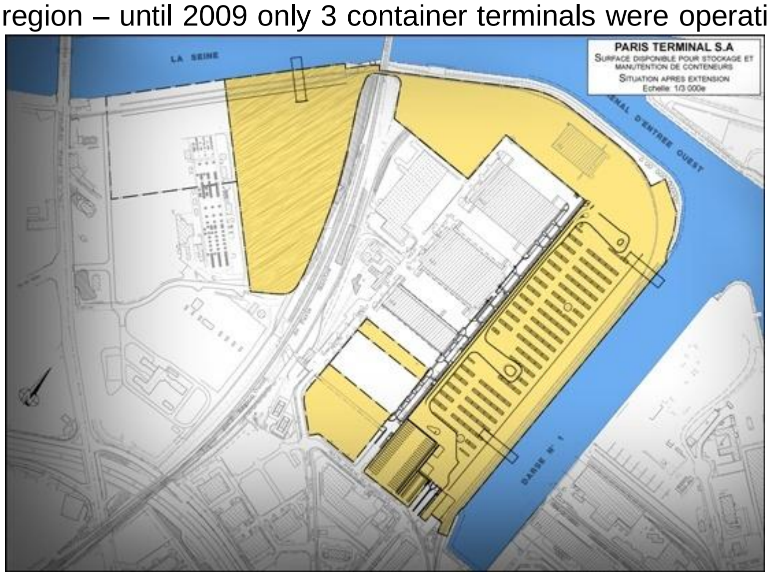

Figure 10: Port of Gennevilliers **Source: www.paris-terminal.com**

no more planned new terminals from 2015 until 2020, but extensions are possible, especially along the canal, where each terminal has saved some space for future expansion.

The existing ports in the region are looking to take advantage of their established positions and accommodate the projected traffic increase. The Port of Gennevilliers plans to double its total throughput until 2015, reaching a total of 600,000 TEU (www.paris-terminal.com). To do that, new land is being planned for development as shown in Figure 10. The new project is likely to double the river handling capacity, increasing it to approximately 200,000 TEU (Ports de Paris, 2011b). The Port of Limay, which was opened in 2007 with a capacity of only 15,000 TEU, has also reserved some space for future expansion and its capacity is likely to double or triple by 2015. The Port of Bonneuil-sur-Marne is concentrated on bulk cargoes, but its size provides great potential for expansion of the container handling facilities if required – it possesses 4 kilometers of quays and a lot of available land for container terminals developments. The current handling capacity of 25,000 TEU is underutilized and expansions are unlikely and no plans have been announced until traffic in the port picks up. The Port of Evry was opened in 2009 with a capacity of 10,000 TEU. As already mentioned, some big companies are considering to direct their container traffic through that port and if it happens, the port capacity should be expanded. However, no such plans have been announced. These ports currently account for a total TEU capacity of 150,000 TEU and by 2015 they would have expanded to 265,000 TEU(www.paris-ports.fr).

There are two additional river-side container platforms that are planned to be opened in the region by 2015 – Montereau-Fault-Yonne and Bruyeres-sur-Oise. The Port of Bruyeres-sur-Oise is situated downstream the Seine from Paris and planned the development of a 3 ha tri-modal container terminal with a river-side capacity of 40,000 TEU. The Port of Montereau-Fault-Yonne is situated upstream the Seine, south of Paris and is also making plans to develop a 3 ha container terminal. Its proposed capacity is still not clear, but it is comparable to the one in Bruyeres-sur-Oise, so it is going to be assumed to also be 40,000 TEU. This port is situated close to the economic zone of Confluent, which houses activities such as manufacturing of machinery and electrical equipment and production of luxury goods, which are likely to use the port for some of their distribution purposes. There are no plans for further expansions of these two ports and they are also not likely to expand their total capacity of 80,000 TEU during the time horizon until 2015 or 2020 (www.paris-ports.fr).

The proposed terminals along the Seine Nord Europe canal are Cambrai Marquion, Peronne Haute Picardie, Nesle and Noyon. These terminals are planned to be opened at the same time when the canal starts operating and all of them are designed to have container operations, aiming to attract logistics, production and distribution activities in the logistics and industrial zones formed near the ports and thus creating clusters of economic activity and strengthening regional potential. It is planned that the terminals are going to be equipped with barge gantry cranes and planned capacities have not been specified, but design characteristics of the berths and yards are mentioned (Biet et al., 2008), so their planned capacities are hereafter going to be estimated.

An average sea container terminal with 30% transshipment, dwell time of containers 5.2 days for full and 8.9 days for empty and a 20% share of empty containers needs a yard area of 42 ha for reach stacker operations, 31 ha for straddle carrier and 27 ha for rubber-tired gantry cranes to handle a yearly throughput of 1 million TEU (Y. Saanen, pers. comm. 04.2011). Completely eliminating the transshipment brings down the terminal capacity to 850,000 TEU. However, the specifications of the dwell time, share of empty containers and mode of operations are immaterial to the current discussion, because what is to be shown is that the river-side terminal capacity of the platforms along the Seine Nord Europe canal are limited by the length of the berths rather than the yard area. Taking Gennevilliers as an example, its current quay wall length of approximately 500 meters provides a terminal throughput capacity of over 100,000 TEU. The biggest of the terminals, Cambrai Marquion, has a designed quay wall length of 300 meters and a traffic forecast of 30,000 TEU by 2020. For the sake of safety of assumptions, the Cambrai Marquion terminal is assumed to be able to handle 100,000 TEU. Although this assumption is unrealistic looking at the figures of port of Gennevilliers, if it could be shown that the yard storage space is more than enough to handle the traffic, then clearly the berth length will be the limiting factor of terminal capacity rather than the yard size. The most space-intensive handling technology of reach stackers would need approximately 5 ha (42 ha / 8.5) to handle 100,000 TEU and the designed yard size of Cambrai Marquion is 15 ha. Even further, the smallest yard of the four terminals is that of Peronne Haute Picardie and is 6 ha, but the terminal berth length is twice shorter than that of Cambrai Marquion – 150 meters. All these facts lead to the desired conclusion that the proposed inland container terminals have the capacity limiting factor in their berth length.

The new terminals along the canal are more similar to the Port of Gennevilliers in terms of handling equipment than to the other ports using reach stackers. Therefore, the Port of Gennevilliers is going to be used as a benchmark when evaluating their respective capacities. Gennevilliers currently has a throughput capacity of around 100,000 TEU and a berth length of approximately 500 meters. This accounts for around 10,000 TEU throughput for each 50 meters of quay wall. Looking at the other existing terminals it is safe to assume that this is the case for terminals with berth length above 200 meters, as they are equipped to handle two barges simultaneously. Only the terminal Perrone Haute Picardie has a berth length less than 200 meters – 150 meters – and it is assumed that its capacity is 25,000 TEU instead of 30,000 TEU to take account of the potential economies of scale provided by the longer quay wall. The terminals of Nesle and Noyon both have a berth length of 200 meters and their capacities are therefore assumed to be 40,000 TEU. The biggest terminal on the canal – Cambrai Marquin – has a berth of 300 meters and therefore an assumed prospective capacity of 60,000 TEU. The total capacity of the four terminals along the canal in their opening in 2015 is therefore 165,000 TEU. The projected throughput of 30,000 TEU in Cambrai Marquin in 2020 means that the projections are that those terminals will not be expanded until 2020 although they have reserved place for further future expansions.

The final projections that have to be estimated before the regression equation is used to predict future throughput are about regional GDP. Such projections are not issued on a regional level, but national projections for France are obtained from Wilson and Purushothaman's (2003) global economics paper written for Goldman Sachs.

These data are in 2003 US$ and therefore they are converted to 2010 US$ and later to Euros using data from the US Bureau of Labor Statistics. Projections for 2015 and 2020 in 2003 US$ are 1,767,000,000,000 and 1,930,000,000,000 $. Using the inflation adjustment the values change to 2,107,324,200,000 and 2,301,718,000,000 $, which is not entirely realistic since the GDP in 2010 was already approximately 2,113,000,000,000 $. To get a more reliable estimate other data from the same study is going to be used – the projected early growth rates between 2010 and 2020 – and GDP will be estimated based on the figure of 2010 GDP, multiplying it by the projected growth rates. The GDP of France in 2010 was 1,692,337,400,000 Euros (Eurostat, 2011) and projected accumulative growth rates from 2010 to 2015 and 2020 are respectively 9% and 19% in real GDP terms (Wilson and Purushothaman, 2003). To convert these rates to nominal values, which are necessary for the regression equation, the average inflation rate for France in the last 11 years, which is 1.6%, is applied on a yearly basis. The final values that are going to be applied to obtain the future GDPs are 17.9% and 39.2%. The respective predictions of French GDP for 2015 and 2020 are 1,995,265,795,000 and 2,355,733,661,000 Euros.

Table 13: French Regional GDPs

Year	Millions of Euros			
	Regional GDP Ile-de-France	Regional GDP Picardie	French national GDP	Share of Regional GDPs from national GDP
1990	293,114	27,343	1,013,563	31.62%
1991	302,806	28,175	1,049,610	31.53%
1992	314,586	29,280	1,091,006	31.52%
1993	318,093	29,385	1,098,790	31.62%
1994	327,905	30,582	1,138,420	31.49%
1995	332,238	31,945	1,176,754	30.95%
1996	342,922	32,603	1,208,936	31.06%
1997	354,360	33,244	1,248,646	31.04%
1998	366,583	34,783	1,303,697	30.79%
1999	387,678	35,359	1,344,467	31.47%
2000	411,083	36,189	1,418,742	31.53%
2001	423,811	37,322	1,472,750	31.31%
2002	441,315	38,227	1,522,766	31.49%
2003	455,615	38,916	1,567,645	31.55%
2004	466,588	40,087	1,631,562	31.05%
2005	488,509	41,302	1,696,144	31.24%
2006	506,787	42,422	1,772,687	30.98%
2007	541,536	44,450	1,860,011	31.50%
2008	557,974	45,492	1,912,248	31.56%
2009	552,052	43,725	1,871,532	31.83%

To estimate the regional GDP, a fixed percentage is going to be taken out of the national account. However, the construction of the canal and the new terminals will also include other regions into the relevant economic area of distribution. The new terminals are situated in the region of Picardie and the canal also passes through Nord-Pas-de-Calais. The latter region, however, is already connected to the European inland waterway network and is almost entirely served by the inland Port of Lille and therefore is going to be excluded from the analysis. The total GDP used for prediction is going to be the sum of the regional GDPs of Ile-de-France and Picardie. The respective regional and national GDPs are displayed in Table 13 for the period 1990 to 2009. The share of the sum of the two GDPs of the national GDP has been reasonably constant and averages 31.33% for the period. This figure is going to be used for estimation of the future sum of regional GDPs as a share of national GDP. The respective regional GDP sums for 2015 and 2020 are therefore 625,116,773,600 and 738,051,356,000 Euros.

All the data for the prediction of the future TEU throughput and the used regression equation are summarized in Table 14. The predicted total TEU throughputs for 2015 and 2020 are 428,937 and 434,065 respectively. As already seen from the analysis of the regression equation, the values tend to be overestimated when new terminals are opened and underestimated when those terminals have been operating for a while, so it can be expected that the throughput is somewhat lower than 428,937 TEU in 2015 and somewhat higher than 434,065 TEU in 2020, because especially the terminals along the canal will need some time for business around them to pick up. To give a more complete picture of the estimation, prediction intervals are also given and although these are very wide, the only way to narrow them down has been ruled out, because it is to increase the number of observations in the regression, which is not possible. The 95% prediction interval for 2015 is between 308996 and 548950 TEU and for 2020 it is between 335560 and 532651 TEU. Although the upper boundaries cannot be reached, because they exceed total terminal capacity, these intervals show the lower boundary of terminal throughput.

Table 14: Regression estimations

	Intercept	GDP	TEU capacity	Number of terminals	**TEU throughput**
Regression equation	-36,710	0.0454	0.5717	14,570	
2015	-	625,117	510,000	10	**428,973**
2020	-	738,051	510,000	10	**434,065**

The analysis so far has identified the potential market size of the newly-developed region and as concluded it is significant enough for Port of Rotterdam to develop services to it and capture a market share. The next chapter is going to analyze the competitiveness of the barge transport as compared to road in the corridor and the effect of the proposed policies for barging on this competitiveness.

Chapter 5 Scenario analysis

5.1. Scenario 1: Status Quo

The objective of this scenario is to compute the approximate costs of a barge for shipping a container from a Maasvlakte 2 terminal in Rotterdam to the Port of Gennevilliers in Paris through the planned Seine Nord Europe canal. To do this, the costs are divided among several components: Fuel costs, Labour and Other costs and Cargo handling costs. As already mentioned, Fuel costs are 20% of the total of Fuel, Labour and Other costs, so after the estimation of fuel costs, the other costs can also be estimated. Handling costs are a total of 100 Euros, both for 20-foot container (1 TEU) and 40-foot container (2 TEU). Therefore, the analysis proceeds with Fuel cost estimation.

The first objective is to estimate the approximate fuel consumption per kilometer of a maximum loaded vessel for the restrictions of the route. As already mentioned, the fuel consumption for a fully laden vessel between Rotterdam and Cambrai, the distance being 370 kilometers, is between 3,500 and 5,000 liters of fuel. However, a fully laden barge with containers will be less than then estimated maximum load of 1,700 tons. An approximation of fuel costs, depending on the load factor of the vessel is that 25% of the fuel burned is not dependent on the load and the additional 75% are influenced by how much the vessel is loaded (Central Commission for Navigation on the Rhine, 2010). A vessel on the route has the restrictions of 105 meters length, 9.6 meters width, 2.5 meters draft and 4.5 meters height. Existing barges with such restrictions can load 3 containers wide, 12 containers long and the height restriction amounts to 2 containers high, because even though the sum of the heights of the containers is 4.8 meters, a small part of the bottom container is going to be below water level, because of the weight of the containers. Therefore, the maximum capacity of a barge on the route is 3 wide*12 long*2 high= 72 TEU, which is pretty low compared to some existing barges on trunk river routes which can load as much as 208 TEU, some even exceeding that capacity. The mean weight of container transport by barge from port of Rotterdam by barge is 12 tons per TEU and therefore the estimated weight of the load for a fully laden barge on the route Rotterdam Maasvlakte to Port of Gennevilliers is 72*12=864 tons. Therefore, the range of fuel burned on per kilometer for a fully loaded barge with size same as the restriction on the waterway is calculated in the following way:

$$Liters\ per\ kilometre = \frac{\left(75\% * \left(\frac{TEU\ capacity * Tons\ per\ TEU * Utilization\ rate}{Ton\ capacity\ of\ the\ barge}\right) + 25\% * 1\right) * Fuel\ consumption\ barge}{Distance\ used\ for\ fuel\ consumption\ measurement}$$

Plugging in the specified parameters, the range of fuel burned per kilometer, depending on the fuel efficiency of the barge is between 5.97 and 8.53 liters, which accrue to a total fuel used for a single trip from Rotterdam Maasvlakte to Port of Gennevilliers of 3,200 to 4,572 liters.

Fuel price for barges is currently 71.55 Euros for 100 liters, which is considerably high on a historical basis and although it has been falling steadily from 79 Euros 6 months ago, exactly before 1 year the price was 60 Euros for 100 liters

(Rhinecontainer, 2011). Although the price of fuel is fluctuating highly, it is mostly affected by the oil price, which is also the main indicator affecting the price of fuel for trucks, so its fluctuations do not cause a considerable differences in the prices of the two modes. The total fuel costs of the specified barge between Rotterdam Maasvlakte and Port of Gennevilliers range between 2,277 and 3,253 Euros. As already established, the fuel costs are approximately 20% of total costs of the barge and therefore the total cost can be estimated to range between 13,337 and 14,312 Euros.

However, the costs of every individual container have to be determined instead of the total cost of the barge. Therefore, these total costs have to be divided among all the containers and additionally 200 Euros per container have to be added for handling of the containers at the two terminals. As the barge has an already established capacity of 72 TEU, the range of costs of transporting 20-foot and 40-foot container by barge are respectively 285 to 299 Euros and 471 to 498 Euros. These costs include fuel, labour, cargo handling, barge maintenance, insurance, interest and all other costs associated with the barge and transportation of the cargo itself. The only item that remains to be added is a profit margin over the cost and this profit margin is for now assumed to be 10%. The determined prices of barging are displayed along with the quoted prices of trucking in Table 15.

Table 15: Prices in Status Quo

Mode	Container Size	Minimum	Maximum
Barge	20-foot	314 Euros	329 Euros
	40-foot	518 Euros	547 Euros
Truck	20-foot	676 Euros	
	40-foot	676 Euros	

It is clear that the price of transporting a container by barge will be somewhere between the two identified limits and that barging has a considerable cost advantage only for 20-foot containers and only in the special case when a single 20-foot container is shipped by truck. However, in most of these cases, the cargo inside of the container is very time sensitive, having a considerably high value and therefore, it is not likely to be shipped by barge. A further bigger disadvantage is that, unless in the few cases when it is destined for the companies which are housed in the business zones in the Port of Gennevilliers, the cargo will generally complete the last leg of the transport by truck, which will further add to the overall cost of transportation by barge. Recommendations about increasing the cost competitiveness of barging along the route will be made in the later subchapters of this section.

5.2. Scenario 2: Emission Trading Schemes (ETS)

The objective of this scenario is to quantitatively examine the actual effect of the inclusion of barge transport into ETS on the price competitiveness of barges on the route Rotterdam Maasvlakte to Port of Gennevilliers. As already discussed the form of the policy, either bunker levies or issuance of emission permits, is not material and the important thing is the ultimate effect of this policy on the cost of barging. So, it is hereafter assumed that the policy will be in the form of a bunker levy and its size is 10% of the price of fuel and later a sensitivity analysis is going to be performed to conclude what is the elasticity of the final price to the size of the bunker levy.

The ultimate calculations for the price of transporting a container on the specified route are identical, the only difference being an increase in the price of the fuel. It is also hereafter assumed that the Labour and Other costs are not affected by the introduction of ETS. Therefore, only the fuel costs change. For the assumed levy size the new price of fuel is 78.265 Euros for 100 liters and the respective prices of barging a container on the route are displayed in Table 16.

Table 16: Prices in ETS

Mode	Container size	Minimum	Maximum
Barge	20-foot	317 Euros	334 Euros
	40-foot	525 Euros	557 Euros
Truck	20-foot	676 Euros	
	40-foot	676 Euros	

A closer look into the data shows that the elasticities of the price to the fuel cost are currently 0.111 and 0.151 for 20-foot containers and 0.134 and 0.182 for 40-foot containers. This means that the price of container transportation from the Maasvlakte in Rotterdam to Port of Gennevilliers is generally inelastic to fuel costs. The difference between the elasticities can be explained by the slightly different share of fuel costs in the price in each case. The effect of introduction of ETS and a consequent increase of fuel price by 10% on the price of the transportation service and the elasticities in each case are displayed in Table 17. Looking at the results it can generally be concluded that the introduction of ETS does not have a significant effect on the price of transportation of containers along the specified route, and the change can even be easily absorbed in the profit margin, leaving the price of transportation unchanged.

Table 17: Price Elasticities

Container size	Price Increase		Elasticity	
	Minimum	Maximum	Minimum	Maximum
20-foot	3.48 Euros	4.97 Euros	0.111	0.151
40-foot	6.96 Euros	9.94 Euros	0.134	0.182

5.3. Scenario 3: Infrastructure Cost Recovery (ICR)

As already discussed, the Seine Nord Europe canal development plans have included an infrastructure charge for the cargo that passes over the canal. The development committee has hinted that the charge will amount to 1.75 Euros for each ton that passes over the canal. However, in the case of containers, each container is not individually weighted neither at the port, nor before it goes onto a barge and therefore a universal charge will have to be applied for containers, probably based on an arbitrary value of their weight. The mean weight of containers that go on a barge from the Port of Rotterdam is 12 tons and therefore this value is going to be used. Generally, there is no significant difference between the weight of 20-foot and 40-foot containers, because heavier goods tend to be transported in 20-foot TEUs and other goods tend to travel into the bigger containers.

Table 18: Prices in ICR

Mode	Container size	Minimum	Maximum
Barge	20-foot	337 Euros	352 Euros
	40-foot	540 Euros	570 Euros
Truck	20-foot	676 Euros	
	40-foot	676 Euros	

Essentially, all the cost calculations are identical to the Status Quo scenario, only the charge for using the infrastructure is added to each container, so the final cost will increase by 12*1.75=21 Euros. Adding the profit margin of 10% over it would increase the price by further 21*10%=2.10 Euros amounting to a total increase of 23.10 Euros. The prices which reflect the introduction of the canal toll are displayed in Table 18. A quick sensitivity analysis shows that the change of the toll by 1 Euro will affect the final price of transportation by 13.20 Euro given that the profit margin barge operators are using is 10%, so they should lobby that the toll is not set too high.

Although the canal toll raises the cost of cargo transportation and has a much greater effect than the introduction of ETS for barging, its charge is relatively small when compared to the overall transportation cost – the increase is only from 4.2% to 7.3%. It can be concluded that for such long distance hauls, the planned infrastructure cost does not affect the overall price significantly and the case when cargo is transported over a shorter distance and the price is lower will be more interesting when looking at the effect of the canal toll.

5.4. Scenario 4: Emission Trading Schemes and Infrastructure Cost Recovery (ETS+ICR)

Table 19: Prices in ETS+ICR

Mode	Container size	Minimum	Maximum
Barge	20-foot	340 Euros	357 Euros
	40-foot	548 Euros	580 Euros
Truck	20-foot	676 Euros	
	40-foot	676 Euros	

The simultaneous introduction of barging into ETS and the set-up of an infrastructure toll for the Seine Nord Europe canal is, as already discussed, the most likely scenario to be present after the canal has been constructed. It is clear that this scenario will also be associated with the highest price of transportation, but by the conclusions of the last two scenarios it is expected that the price increase is not that significant. The calculation methods are identical to the ones used above and the new prices are displayed in Table 19. The next subchapter is going to perform an overall result analysis, a sensitivity analysis about the assumptions made in the status quo scenario and give recommendations for improving the position of barging compared to trucking.

5.5. Analysis of the results

The results so far show that barges have a slight cost advantage on the route from Rotterdam Maasvlakte to the Port of Gennevilliers. If it is assumed that both policies are introduced and that the price of barging will be somewhere in the middle between the highest and the lowest price – that is 348 Euros for 20-foot and 564 Euros for 40-foot containers – the barge will have a cost advantage of 328 Euros for 20-foot containers and 112 Euros for 40-foot containers. However, others factors are present, which decrease the competitiveness of barges and it is not certain whether the price difference, especially in the case of 40-foot containers, would be sufficient to cover for those barge disadvantages. Although these advantages cannot be quantified easily in money terms, especially in a general case, they are going to be discussed hereafter.

Due to the barge low penetration, most of the containers unloaded at the Port of Gennevilliers would have to be further carried to their final destination by truck, which would add to their distribution costs. If a truck is used for the whole leg, it would only have to go a couple of miles more and the additional charge will be marginal if not lower, if the destination is closer than the Port of Gennevilliers. The additional handling in the inland port will also cause greater risk to the cargo, as the more it is handled, the bigger the chance that it will be damaged. Also, the transshipment from barge to truck in the inland terminal will cause an additional delay in time as the container will generally have some dwell time in the inland terminal. This fact might not be always crucial if the cargo is time insensitive, but most of the import cargo travelling in containers will generally possess a certain degree of time sensitivity and Paris is generally more of an import-oriented market than an export-oriented one.

Additionally truck transport itself is faster than barge transport. The road distance between Rotterdam Maasvlakte and Gennevilliers is 478 kilometers, which will be covered in 6 hours driving if the truck has an average speed of 80 km/h. Adding times for breaks and possible delays due to traffic, the driving time will extend to 8-9 hours. The barge travel time on the other hand will have to be estimated using the data provided by Mr. Erik Van Toor. He has proposed that the travel time between Rotterdam and Cambrai will be approximately 35 hours, as the barge would sail at 16 km/h at the deep waters from Rotterdam to Gent and at 8-10 km/h at the shallower waters between Gent and Cambrai and already pass through several locks, which would take an hour a piece. All that remains to be done is to estimate the sailing time between Cambrai and Genevilliers and include the 7 locks over the Seine Nord Europe canal, which would take an estimated 7 hours in total. The speed of the barge in these deep waters will be 16 km/h, which means that it will cover the distance of 166 kilometers for approximately 10 hours. The total travel time for the barge accrues to approximately 52 hours, which is around 6 times more than a truck would take. It is fairly uncertain that the price advantage, especially for 40-foot containers, will be sufficient to offset these disadvantages.

Next, a sensitivity analysis on some of the assumptions is performed to check the effect of each of them on the end variables. To make the effect more visible, the considered output variable will be the mean of the price for 40-foot container in the ETS+ICR scenario, which is 564 Euros before the start of the analysis. The considered assumptions are the break-down of fuel consumption on a fixed and variable share depending on the load factor of the barge and the utilization rate of the barge capacity. A sensitivity analysis for both the policies has already been performed in the respective scenario and the conclusions reached there will not be repeated.

The assumed break-down of fuel consumption fixed:variable is 25:75. However, this consumption is dependent on the barge characteristics and while some barge operators have indicated that their observed split is 50:50, some have even proposed that they have managed to lower their overall consumption by editing their engine so that the share of costs is switched to 75:25, but a trade-off has to be made between the lower overall consumption and the higher consumption on an expected empty leg journey. The results of changing the split in steps of 5% are displayed in Table 20. The Labour and Other costs are kept constant and only fuel costs are affected by the proposed change.

Table 20: Fuel consumption breakdown sensitivity analysis

Ratio Fixed:Variable	0:100	5:95	10:90	15:85	20:80	25:75
Mean Price 40-foot	546 Euros	549 Euros	553 Euros	557 Euros	560 Euros	564 Euros
Ratio Fixed:Variable	30:70	35:65	40:60	45:55	50:50	55:45
Mean Price 40-foot	568 Euros	571 Euros	575 Euros	578 Euros	582 Euros	586 Euros
Ratio Fixed:Variable	60:40	65:35	70:30	75:25	80:20	85:15
Mean Price 40-foot	589 Euros	593 Euros	597 Euros	600 Euros	604 Euros	607 Euros
Ratio Fixed:Variable	90:10	95:5	100:0			
Mean Price 40-foot	611 Euros	615 Euros	618 Euros			

The observed trend is that for each 5% increase in the share of fix costs, the overall trend is a 3 or 4 Euros increase in the price level, or less than 1% change. Therefore, the price is not significantly affected by a slight change in the break-down in fuel costs. Even a shift from 25:75 to 75:25 will only increase the overall price of transportation by 36 Euros or 6.4%.

The assumed utilization level of the barge in the analysis so far has been 100%, which is not entirely realistic, because normally a barge will not always travel completely full. Generally the less utilized the barge is the less fuel it will use, because the tonnage that it will carry will be less and depending on the break-down in fuel costs, the fuel costs will be lower. However, there is a counterbalancing part to the previous argument, that the less containers the barge carries, the more cost will have to be allocated to each container and therefore the price of transportation will increase. In practice the barge operators will fix the price for a route in the short term. The price will be assumed to be the current price of 564 Euros and the effect of decreasing the utilization rate on the profit margin is going to be seen, or what the minimum level of utilization that a barge has to achieve in order to break even is. Table 21 displays the values of utilization and profit margin for the range of utilization 80-100% and Figure 11 displays graphically the break-even point.

Table 21: Barge utilization sensitivity analysis

Barge Utilization	100%	99%	98%	97%	96%	95%
Profit Margin	10%	9.27%	8.54%	7.79%	7.04%	6.29%
Barge Utilization	94%	93%	92%	91%	90%	89%
Profit Margin	5.53%	4.77%	4%	3.22%	2.44%	1.66%
Barge Utilization	88%	87%	86%	85%	84%	83%
Profit Margin	0.87%	0%	-0.73%	-1.54%	-2.35%	-3.17%
Barge Utilization	82%	81%	80%			
Profit Margin	-4%	-4.83%	-5.66%			

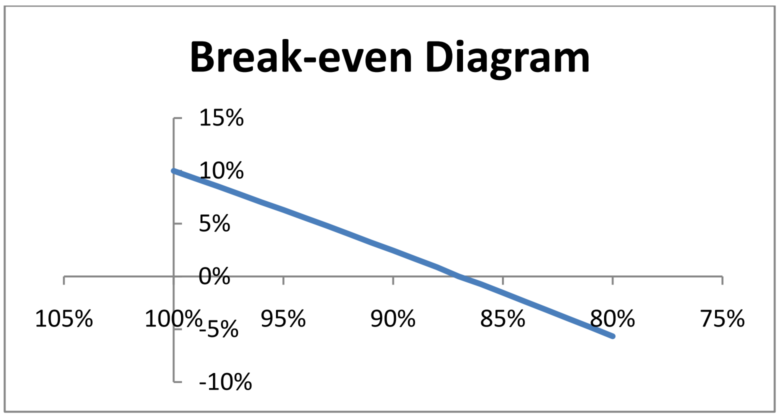

Figure 11: Break-even Diagram

The break-even point for the previously specified and assumed parameters is 87% barge utilization or approximately 63 TEU loaded on the barge. If the barge is carrying fewer containers on board it will mean that it is operating at a loss. Therefore, a service should only be started by an operator if it is certain that this quantity of containers is secure to be carried on board of the barge.

Moreover, in practice the price charged for the transportation of the full containers from the sea-port to the inland destinations tends to set a higher profit margin to be able to absorb the lower utilization of the barge for the reverse journey. The Ile-de-France region is generally an import market rather than an export market and container flows are likely to be imbalanced towards inflowing containers. It is expected that a high share of the containers transported back to the port will be empties and they cannot pay a high cost of transportation. Therefore, the import containers from the ports will generally have to command a higher margin to compensate for the journey leg back from the port. A brief scenario analysis of the ETS+ICR scenario will be performed for a round trip journey to examine the ability of the barge to attract empty containers for the back haulage.

The price of the round trip by truck to the Port of Gennevilliers and back is 1,139 Euros, which is 463 Euros above the price of the single trip. The weight of an empty container, needed for the estimation of the canal toll is 4 tons for a 40-foot container. The total cost of transporting that container (without the 10% profit margin) is 453 Euros, which makes barge transport and truck transport equally attractive for the back-haul carrying an empty. However, to attract more empty containers, the barge will need to operate at lower prices, because of the disadvantages of the mode compared to trucking. Transporting 20-foot containers will be more attractive since their cost averages at 278 Euros. However, to attract more empty containers, barge operators might have to lower their prices, also reducing their profits and making the proposed service infeasible.

The analysis so far has identified the cost characteristics of barging on the route between Rotterdam Maasvlakte and Port of Gennevilliers under some specified restrictions. However, before the opening of the canal in 2017 the canal development committee has made several arrangements with the inland waterways authorities in Belgium to improve the accessibility of the canal, increasing the height of bridges and improving the dimensions of the existing waterways so that bigger barges can reach the canal from the North. The height of the bridges over the Scheldt will be increased to 5.25 meters, which along with the height restrictions between Compiegne and Conflans of 5.25 meters will become the new height restriction. This restriction, however, is also not likely to allow barges stacked with 3 layers of containers to pass along the route as the sinking depth of 2 meters is not likely to be achieved. An opportunity can be spotted here for the ports of Antwerp and Rotterdam, which can form a strategic alliance and lobby for increasing the height of the bridges at least along the Scheldt to allow for barges stacked with 3 layers of containers to pass under. If this is achieved, the capacity of the barges will increase by an additional 36 TEU and the costs of the barges can be split between more containers, making those barges more competitive. A quick calculation of the mean price of transportation in the ETS+ICR scenario with an increased barge capacity of 108 TEU shows that the new price is 439 Euros or a 22% decrease off the original price. This new price will greatly increase the competitiveness of the mode and make it a viable alternative for the cargo corridor.

The political power of Port of Rotterdam alone is not likely to be strong enough to be able to influence the decisions of the inland waterways management authorities in Belgium and France. Therefore, an alliance with the Port of Antwerp on this issue might prove crucial and the formation of a strategic alliance with the biggest and most important Belgian port, which will eventually be a competitor to the Port of Rotterdam on this route, will improve the feasibility of the use of barging. Although the two ports are competitors for almost all of their hinterland markets, the opening of the new market is subject to their joint operation, so they will have to forget their competitive tensions and unite in their efforts for improving the dimensions of the waterways on the way to the Seine Nord Europe canal.

However, even the political power of the proposed alliance might not be strong enough to be able to influence the inland waterway management authorities in France to further increase the height of the bridges between Compiegne and Conflans and it is doubtful whether barges stacked 3 containers high will be able to go under them. Therefore, an adjusted network solution is proposed for the case when barges stacked 3 containers high are able to reach Compiegne from Port of Rotterdam, but not the Port of Gennevilliers. Containers can be offloaded at the closest accessible terminal to Gennevilliers, or the one with the highest frequency of service, which could take the Port of Gennevilliers' role of a hub port for the whole region. From the new designated hub terminal the containers could either continue to their final destination by truck or they could be loaded on a smaller barge and transported further on the river, which would only result in an additional 40 Euros cost and a reasonable time delay, if the network is designed properly.

In conclusion, there is an opportunity for barge transport to be made feasible on the route from Rotterdam Maasvlakte to the Port of Gennevilliers, but some strategies have to be adopted early to facilitate its development and competitiveness and the Port of Rotterdam should play an active role in pursuing the specified plans.

Chapter 6 Supply Chain Perspective

The development of container transport and the consequent emergence of global supply chains have created a new paradigm in port competitiveness – the focus on the efficiency of the entire supply chain specific for certain freight corridors and different types of cargo rather than solely on the port operations when determining port competitiveness. Therefore, the competitiveness of the Port of Rotterdam in the Ile-de-France and Picardie market will not only be determined by the fact who has the lowest transport cost to the region, but also by a number of other factors, some of which not even having a monetary dimension.

First of all, the construction of the Seine Nord Europe canal would never be considered without the strong support of the French national government. There are a few obvious factors behind this decision. The construction of the canal and the establishment of the multi-modal platforms along it is hoped to help spreading the clustering of economic activities in Ile-de-France towards the less development region of Picardie. The two regions north and south of Picardie – Ile-de-France and Nord-Pas-de-Calais are both known for their tradition and strength in logistics and distribution activities and the set up of this inland waterway corridor between them is likely to strengthen their position on a European-wide level and spur the formation of a greater inter-regional cluster. The cheap and abundant land around the canal terminals and the good infrastructure connections to them will set an incentive for various companies to set production and distribution facilities at the designated business locations in and around those terminals.

Second, the Port of Le Havre is the biggest French port and possesses several natural characteristics which could help it improve its competitive position in the Hamburg – Le Havre range. It is the first port next to which the ships incoming from Asia are passing and has depth to accommodate the biggest ships which travel on the route. Therefore, it has the potential to turn into the natural first port of call in the Asia-Europe services. The Seine Nord Europe canal is a necessary infrastructure for Le Havre to access larger hinterlands and compete with Rotterdam and Antwerp at least for the markets in Belgium. It remains unclear whether barging from Le Havre to Germany through the Rhein is economically feasible.

Last but not least, the Ile-de-France region, which is the economically strongest French region, is strongly dependant only on the Port of Le Havre. However, operations at the port have proved to be unreliable and strikes of port workers and slow-downs have been a common occurrence. The French government is therefore looking for ways to diversify the options for supply of their strongest region with import goods and logistical services in order to increase its overall competitiveness. The Seine Nord Europe canal is seen as an opportunity to improve the number of options for imports and exports in the region. This last objective can also be identified as an opportunity for the Port of Rotterdam, as the French authorities are looking for ways to diversify their transportation options and they have identified barge services to Rotterdam as being one of the potential options for this.

However, setting up services from Rotterdam to Ile-de-France and Picardie also requires a threshold of demand from transportation from the French side and if shippers are not convinced that their supply chains will have a clear gain from shifting to Rotterdam, then the link to Rotterdam will remain underexploited and the traditional port for this hinterland will accommodate the projected new traffic. It is clear that the superiority of Rotterdam will not be found in its hinterland connections to the region, because the Port of Le Havre clearly has an advantage in that respect, as the port is closer to the region and provides more and cheaper hinterland transport connections with less travel time. Therefore, the Port of Rotterdam will have to look at the other parts of the supply chain to derive its competitive advantage from there.

One advantage which was already identified is the efficiency in port operations and more importantly their reliability. The Port of Le Havre has been long known for port workers on strike causing delays of services. The high level of unionization of the labor force as well as their not always realistic demands not being met by authorities have resulted in a bad reputation for the port. The Port of Rotterdam on the other hand is known as one of the ports with lowest levels of strikes and has always strived to improve even further the efficiency and reliability of its operations. However, it is not advisable to build a whole network based on such a competitive advantage, because of several reasons. First of all, even though shippers and transport operators value the reliability of port operations, it is by far not the most important characteristic of a supply chain and a trade-off is often made between an acceptable level of port reliability and other superior parts of the supply chain. Moreover, the advantage of superior port operations is copied more easily than a superior network, because the efficiency of port operations is internal to the port and can be influenced by appropriate operational and political actions. The Port of Le Havre might undertake such policies to increase port worker satisfaction and reduce strikes and thus the advantage of Port of Rotterdam would be lost.

If sufficient advantages cannot be derived from port operations and hinterland transport, then they could be sought in foreland connections. As the largest port in Europe, Port of Rotterdam has a considerably higher number of services calling and is connected to more locations through more frequent service. Moreover, not every service to the Hamburg – Le Havre range is calling at Le Havre and there is almost no service to the range which does not call to Rotterdam.

As already explained Ile-de-France and Picardie are import markets – the regions are strong at performing services and adding value to finished goods rather than transforming raw materials to products and exporting them. The evolution of the Ile-de-France into one of the most productive regions in Europe and the concentration of a large population with relatively strong buying power has led to high regional demand for imports from abroad and low potential of exporting low-value and high-volume physical goods rather than high-value services.

The lead time for imports from Asia is fairly long and although the maritime transport leg takes by far the largest share of the overall transportation time, shippers look for various ways to reduce it. Capital is tied up to the cargo in-transit and the longer that cargo is being transported, the longer the period that companies will not be able to use their capital for more productive purposes. Therefore, an importing port will generally derive a competitive advantage if a ship calls at that port first and goes to the other ports consequently.

In theory, looking at the factors that modern large containers ships have in mind when they select their first port of call in a port range, the most important ones can be divided among two categories – physical restrictions and efficiency indicators. Ports in the Hamburg – Le Havre range do not all have sufficient depths for fully laden ships to access them and some containers have to be offloaded first so that the ship can call at all ports. Moreover, container ships will generally first go to the most efficient port, because they have often incurred some delays along the route which they must compensate in ports or they will want to ensure that they leave the first port of call in time so that they do not miss their berthing window in the next port of call. Vessels will also tend to call ports first, where the largest share of their transshipment containers are offloaded, because liner companies generally strive to ensure that all their containers arrive at their last port of destination in the shortest time possible.

Looking at the current calling patterns of vessels, it is often seen that Rotterdam is the first port of call and even more common Le Havre is the last port before the ships leaves to its next cluster of ports along the route. This is not surprising, given the fact that Rotterdam has the greatest depths, as the biggest port in the range it has the highest number of containers offloaded, and the highest number of feedering services originate from there. Moreover, the second and third biggest ports in the port range – Antwerp and Hamburg – are both river ports and a fully laden 14,000 TEU container ship, which is the most common ship used on the Europe-Asia trade, will not be able to access these ports. Therefore, the Port of Rotterdam can derive a competitive advantage due to its superior place in the calling patterns of most of the incoming vessels. Especially when compared to the Port of Le Havre, Rotterdam will have a great advantage for import containers as ships which call at both ports will generally first call at Rotterdam, then go to other ports in the range and finally call at Le Havre before continuing their voyage to another port range. This advantage cannot be copied easily and is strategic for the Port of Rotterdam, so it must work to sustain it and even try to improve it.

Another service pattern which has emerged lately will also benefit the Port of Rotterdam. Maersk has pioneered a service called Maersk Daily, which guarantees that there will be a daily call at 5 exporting ports in Asia and at 3 importing ports in Europe – Rotterdam, Bremerhaven and Felixstowe. This service guarantees fast and reliable cargo transport and other shipping companies will have to follow this trend if they want to stay competitive. Such services will generally hurt the smaller ports in the port range, such as Le Havre, and benefit the bigger ports, such as Rotterdam, as an even larger amount of containers will be concentrated in them.

If Rotterdam is able to sustain its described position until the opening of the canal, this will surely be its strongest competitive advantage over its competitors for the newly-opened market. Along with the port’s superior reliability, these two advantages are likely to offset the problems associated with the higher cost of hinterland transport and higher distance.

The Port of Rotterdam can also take actions in acquiring strategic partners that will facilitate the traffic development from the port to the Ile-de-France region, by guaranteeing a critical mass of containers for the new service or create synergies between the port container terminals and the inland terminals along the Seine Nord canal and in the region. Companies with distribution facilities in the region, such as Toys'R'Us, Carrefour and others have considerate importing demands and if the port can create synergies with these companies, they might prove vital partners for the establishment of barging services. The Port of Rotterdam should also look for partners which operate parts of the supply chain and try to influence them to take actions in the new market. The port should create awareness among shipping companies, such as Maersk, MSC and many others, about the possibility of supplying the Ile-de-France market through Rotterdam and the Port Authority might even try to become a facilitator of joint hinterland services between companies. Probably even more importantly, the Port of Rotterdam should influence terminal operators, such as APM Terminals and ECT, to acquire inland terminals in the region and add them to their network. This way it is most certain that there will be operating services to those inland terminals and there will be potential for further growth in container flows.

Chapter 7 Conclusion

This thesis briefly explores the emerging market situation in the Hamburg-Le Havre range, focusing on the hinterland distribution regions of the ports and exploring the potential of the Ile-de-France region being connected to the main inland waterway network of Europe. After a comprehensive introduction and representation of the market situation, a methodology was developed to facilitate the determination of the solutions of the research objectives. The next steps are the consequent analysis of each of the goals using the identified methodologies and producing answers to the posed questions about the Ile-de-France market potential, the feasibility of the use of barging for the supply of that region from the Port of Rotterdam and the competitive position of the port with respect to the currently leading port in that region – Le Havre.

The regional potential of Ile-de-France has been determined through a regression, using GDP, Terminal capacity and Number of terminals as explanatory variables and extrapolating the results to predict the future TEU Throughputs in the inland terminals. The predictions of the future explanatory variable are later obtained through a method of estimation about regional GDPs from projected national GDP and estimation of terminal capacities through evaluating their characteristics. The overall regional potential for river-side TEU throughput has been given point estimates of 428,973 TEU in 2015 and 434,065 TEU in 2020 and the respective interval estimates of 308,996-548,950 TEU and 335,560-532,651 TEU for 2015 and 2020. The qualitative analysis of the data has allowed predicting that the river throughput will be in the range 308,996-428,973 TEU in 2015 and between 434,065 and 532,651 TEU in 2020. Although these numbers do not convey specific information about the potential traffic that Rotterdam is likely to capture, the mere size of the market should attract the attention of the port as an opportunity for growth through penetration.

The competitiveness of barging as compared to the trucking on the route from Port of Rotterdam to Port of Gennevilliers is determined through a scenario analysis comprising of barge transport in the European Union Emission Trading Schemes and the planned introduction of infrastructure costs for the Seine Nord Europe canal. The estimation of barging costs if the canal was operational today has shown that certain restrictions along the waterways have greatly diminished the cost advantage that barges have against truck transport and that securing a critical mass of containers on that route to start regular barging services is likely to be fairly difficult. However, a proposed strategic lobbying alliance with Port of Antwerp might facilitate an increase in inland waterway capacity on the waterways leading to the Seine Nord Europe canal, so that more containers can be transported on a single barge. The result will be a reduced price per container, improving the feasibility of barging along the route. However, if the waterway capacity restriction is not removed, there is a low probability that there will be barge services to the region and thus that the Port of Rotterdam will be able to secure a market share in the new accessible market. Thus, at present attention should be paid on increasing the bridge height of critical bridges along the route, because if this is not done, all further actions by the port will be in vain.

Having determined the market potential and the necessary conditions for efficient hinterland transport, the only remaining step of the analysis is to evaluate the competitive advantages of Port of Rotterdam when serving the Ile-de-France market.

The main identified advantage that Rotterdam should focus on is its superior position in the port range and more frequent service from shipping companies. If the Port of Rotterdam manages to keep and extend its position it will definitely have a high chance of securing a significant market share in the Ile-de-France and Picardie regions.

In conclusion, Port of Rotterdam will be a potential major player in the Ile-de-France regional market after the opening of the Seine Nord Europe canal if it accomplishes the development and implementation of the identified strategies necessary for the success of the market penetration. The critical condition in that case will be the effective lobby to the Belgian government to increase the height of the bridges over the Scheldt. However, this condition is also likely to be the most difficult to achieve and support should be sought from Belgian ports, which would also benefit from the increased bridge height. The Port of Rotterdam will benefit from the construction of the Seine Nord Europe canal if sufficiently high dedication from the port side is available.

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Appendix: Excel Output for Regressions

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.977485
R Square	0.955476
Adjusted R Square	0.944345
Standard Error	10077.37
Observations	16

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	3	2.62E+10	8.72E+09	85.83927	2.24E-08
Residual	12	1.22E+09	1.02E+08		
Total	15	2.74E+10			

	Coefficients	*St. Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	-6941561	10531985	-0.65909	0.522283	-3E+07	16005664
year	3455.025	5335.279	0.647581	0.529451	-8169.55	15079.6
GDP	0.071546	0.358733	0.199442	0.845256	-0.71007	0.853158
number of terminals	25826.08	8497.527	3.039247	0.010288	7311.562	44340.6

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.976688
R Square	0.95392
Adjusted R Square	0.946831
Standard Error	9849.749
Observations	16

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	2	2.61E+10	1.31E+10	134.5593	2.06E-09
Residual	13	1.26E+09	97017559		
Total	15	2.74E+10			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	-121266	23106.9	-5.24805	0.000157	-171186	-71346.8
GDP	0.298125	0.077391	3.852183	0.001999	0.130932	0.465319
number of terminals	23622.02	7610.271	3.103966	0.008383	7181.032	40063.01

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.994363
R Square	0.988757
Adjusted R Square	0.985947
Standard Error	5063.921
Observations	16

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	3	2.71E+10	9.02E+09	351.7843	5.89E-12
Residual	12	3.08E+08	25643298		
Total	15	2.74E+10			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	6442713	2577252	2.499838	0.027924	827361.9	12058063
year	-3238.98	1292.248	-2.50647	0.027586	-6054.55	-423.413
capacity	0.405109	0.112016	3.616518	0.003537	0.161047	0.649172
services	4543.221	919.8294	4.939199	0.000343	2539.085	6547.357

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.991399
R Square	0.982871
Adjusted R Square	0.980236
Standard Error	6005.258
Observations	16

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	2	2.69E+10	1.35E+10	372.9797	3.31E-12
Residual	13	4.69E+08	36063129		
Total	15	2.74E+10			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	-17087.6	2815.925	-6.06822	3.98E-05	-23171.1	-11004.2
services	2886.875	758.7774	3.80464	0.002188	1247.636	4526.114
capacity	0.380951	0.132347	2.878434	0.012932	0.095034	0.666868

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.995083
R Square	0.99019
Adjusted R Square	0.985285
Standard Error	5181.727
Observations	16

ANOVA

	df	SS	MS	F	Significance F
Regression	5	2.71E+10	5.42E+09	201.8745	1.05E-09
Residual	10	2.69E+08	26850290		
Total	15	2.74E+10			

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%
Intercept	-1604708	6332232	-0.25342	0.805078	-1.6E+07	12504384
year	838.9496	3202.787	0.261944	0.798681	-6297.3	7975.204
GDP	-0.27166	0.205556	-1.32159	0.21574	-0.72967	0.186346
capacity	0.46765	0.131645	3.552358	0.005248	0.174327	0.760974
services	4302.36	1344.42	3.20016	0.009489	1306.805	7297.915
number of terminals	1575.349	6847.056	0.230077	0.82267	-13680.8	16831.54

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.995654
R Square	0.991327
Adjusted R Square	0.988173
Standard Error	4645.562
Observations	16

ANOVA

	df	SS	MS	F	Significance F
Regression	4	2.71E+10	6.78E+09	314.3129	2.95E-11
Residual	11	2.37E+08	21581244		
Total	15	2.74E+10			

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%
Intercept	69499.8	30791.62	2.257101	0.045322	1727.908	137271.7
GDP	-0.27548	0.094089	-2.92783	0.013744	-0.48256	-0.06839
number of terminals	1091.327	5004.068	0.218088	0.831354	-9922.55	12105.21
services	4772.403	1073.858	4.444167	0.000988	2408.858	7135.948
capacity	0.482984	0.110465	4.372263	0.001113	0.239851	0.726117

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.982941
R Square	0.966173
Adjusted R Square	0.957716
Standard Error	8783.781
Observations	16

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	3	2.64E+10	8.81E+09	114.2491	4.33E-09
Residual	12	9.26E+08	77154810		
Total	15	2.74E+10			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	-5279593	8865432	-0.59553	0.562556	-2.5E+07	14036524
year	2655.81	4493.366	0.591051	0.565453	-7134.39	12446.01
GDP	-0.10092	0.324811	-0.31069	0.761363	-0.80862	0.606785
capacity	0.780239	0.195348	3.994093	0.001781	0.354612	1.205866

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.98819
R Square	0.976519
Adjusted R Square	0.970649
Standard Error	7318.276
Observations	16

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	3	2.67E+10	8.91E+09	166.3504	4.87E-10
Residual	12	6.43E+08	53557166		
Total	15	2.74E+10			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	6171811	7013841	0.879947	0.396168	-9110037	21453659
year	-3106.98	3550.186	-0.87516	0.398665	-10842.2	4628.209
GDP	0.022177	0.248225	0.089341	0.930285	-0.51866	0.563012
services	6517.853	1225.885	5.316857	0.000183	3846.88	9188.826

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.995655124
R Square	0.991329125
Adjusted R Square	0.98817608
Standard Error	4644.896838
Observations	16

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	4	27133123381	6.78E+09	314.4037	2.94E-11
Residual	11	237325733	21575067		
Total	15	27370449114			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	-997045.3022	4748971.044	-0.20995	0.837545	-1.1E+07	9455369
Year	541.7519095	2405.397415	0.225223	0.825935	-4752.49	5835.996
GDP	-0.317917102	0.176004032	-1.80631	0.098276	-0.7053	0.069465
services	4884.04999	864.5579619	5.649187	0.000149	2981.171	6786.929
capacity	0.497537508	0.11478399	4.334555	0.001186	0.2449	0.750175

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.995635
R Square	0.991289
Adjusted R Square	0.989111
Standard Error	4457.392
Observations	16

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	3	2.71E+10	9.04E+09	455.1969	1.28E-12
Residual	12	2.38E+08	19868345		
Total	15	2.74E+10			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	72516.41	26395.66	2.747285	0.017691	15005.2	130027.6
GDP	-0.28342	0.083229	-3.40534	0.005218	-0.46476	-0.10208
services	4914.344	819.5555	5.996352	6.25E-05	3128.686	6700.002
capacity	0.48849	0.103185	4.734111	0.000485	0.263669	0.713312

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.987431
R Square	0.97502
Adjusted R Square	0.971177
Standard Error	7252.086
Observations	16

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	2	2.67E+10	1.33E+10	253.7113	3.84E-11
Residual	13	6.84E+08	52592747		
Total	15	2.74E+10			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	33682.04	40818.72	0.825162	0.424163	-54501.4	121865.5
GDP	-0.16284	0.128915	-1.26313	0.228727	-0.44134	0.115667
services	6514.028	1214.789	5.36227	0.000129	3889.635	9138.421

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.990022
R Square	0.980144
Adjusted R Square	0.972923
Standard Error	7029.013
Observations	16

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	4	2.68E+10	6.71E+09	135.7447	2.78E-09
Residual	11	5.43E+08	49407030		
Total	15	2.74E+10			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	-1.2E+07	7456399	-1.56441	0.146016	-2.8E+07	4746575
year	5893.987	3779.417	1.559497	0.147168	-2424.45	14212.43
GDP	-0.36116	0.276244	-1.30741	0.217741	-0.96917	0.246845
capacity	0.617165	0.166952	3.696665	0.003522	0.249706	0.984623
number of terminals	17610.1	6330.069	2.781976	0.017841	3677.714	31542.49

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.98244
R Square	0.965188
Adjusted R Square	0.959833
Standard Error	8561.143
Observations	16

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	2	2.64E+10	1.32E+10	180.219	3.32E-10
Residual	13	9.53E+08	73293162		
Total	15	2.74E+10			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	-39712.7	35748.76	-1.11088	0.286743	-116943	37517.81
GDP	0.079134	0.109853	0.720365	0.484053	-0.15819	0.316457
capacity	0.743597	0.180555	4.118403	0.001211	0.353532	1.133662

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.987802
R Square	0.975754
Adjusted R Square	0.969692
Standard Error	7436.603
Observations	16

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	3	2.67E+10	8.9E+09	160.9725	5.9E-10
Residual	12	6.64E+08	55303057		
Total	15	2.74E+10			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	-36710.2	31080.77	-1.18112	0.260434	-104429	31008.93
GDP	0.045449	0.096554	0.470715	0.646285	-0.16492	0.255822
capacity	0.571714	0.173921	3.287212	0.006493	0.192773	0.950654
number of terminals	14569.81	6371.601	2.28668	0.041178	687.2855	28452.34