

A MODEL FOR MARITIME FREIGHT FLOWS, PORT COMPETITION AND HINTERLAND TRANSPORT

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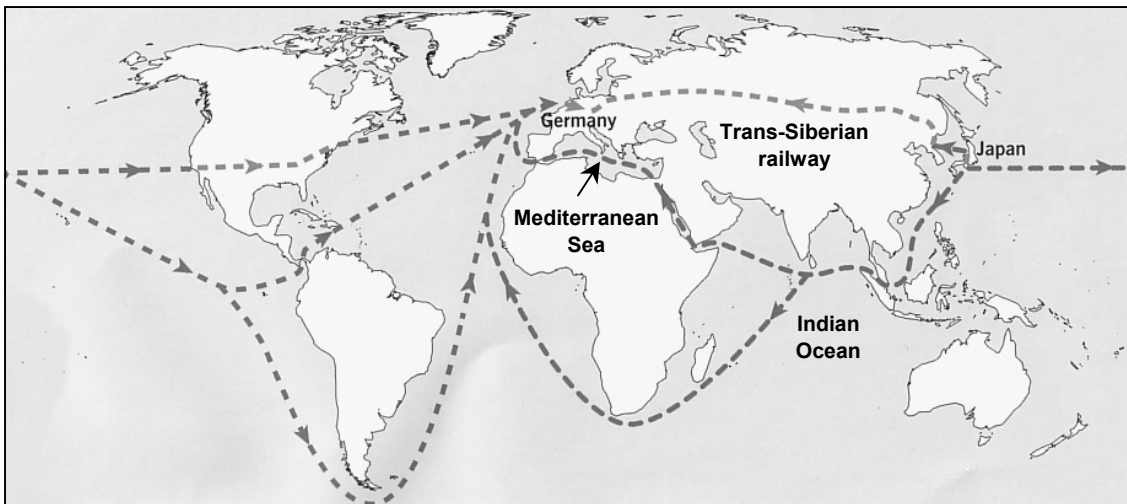
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1. INTRODUCTION

The last three decades freight transport and especially container transport has grown very rapidly worldwide. Globalization, economic growth and the rising Chinese economy have tremendously increased flows of goods between the continents and this has significantly affected the development of container transport. From 1985 to 2005 global container transport grew on average by 10% per year and the growth rate of container flows from now to 2020 is still expected to be 7.5% per year. This growth, which puts high pressure on ports and on their hinterland connections, highlights the need for forecasting tools and decision support systems.



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The purpose of this paper is to enrich existing instruments by presenting an approach that models port competition explicitly. The paper presents a pilot version of a port competition model which is linked to a world wide trade model and the transport costs data base of the EC. The pilot version of the model has been developed for the Le Havre – Hamburg port range but its set up is generic and can be applied to any region in the world facing the issue of port competition.

Section 2 in the paper addresses first the characteristics of port competition and the importance of competition in port planning/investment. The port competition model methodology and structure of the model is discussed in section 3. In section 4 the paper presents results from applying the model to test the sensitivity of port volumes for changes in maritime transport, port efficiency and costs and hinterland transport costs. The conclusions and further research needs are discussed in section 5.

2. PORT PLANNING AND ROLE OF PORT COMPETITION

Seaports are increasingly functioning as the hubs from where the hinterland is supplied with imported goods, and where goods that need to be shipped from the hinterland are grouped together and loaded onto ships. As the capacity of hinterland transportation rarely or never corresponds with the volume of goods to be transported to and from its port, and because the moment of loading and unloading a vessel does not always correspond to the moment of loading of the hinterland mode, the distribution function of the port inevitably involves the storage of goods (Meersman and van de Voorde, 2006). The text here above clearly illustrates the position of a port within a logistic chain, while in more detail a port itself can also be considered as a chain consisting of consecutive links (e.g. ship unloading, storage transport, storage, loading transport, hinterland loading). The ports compete with it each other to be a link within these global logistic chains. In this section we discuss differences in the level of port competition by cargo type and origin and destination, the response of ports/governments to ongoing freight growth and increasing competition and the need for a port competition model.

The level of competition between ports in the North-West European port range differs strongly by cargo type (CRA, 2004). Crude oil is the most captive cargo due to sea-side access requirements, depending on facilities at the ports, and access to inland waterway and pipelines. Other bulk products like mineral oil products or iron & ore and scrap follow in the captivity ranking. The survey puts other general cargo in the middle of the range as this is a very diverse category and captivity varies. Agribulk, containers and roll-on and roll-off cargos are at the lower end of the captivity ranking. Due to its competitive nature and high and still rising importance in freight transport in the remaining of this paper the focus is on container transport.

If we take the Port of Rotterdam as example, which serves a hinterland that includes the industrial heart of Europe, its main competitors for this hinterland are the North Sea ports Hamburg and Bremen in North-Germany, and, particularly, Antwerp in Belgium. However, the competitive position of ports can not be classified by one single status as they do not compete in one single market but in a large set of markets with different features resulting from differences in location of origin and/or destination or cargo type. For example, this means that it is not right to state in general that the port of Hamburg and Rotterdam are in competition. A much more specific market definition is needed like; the port of Rotterdam and Hamburg are highly competitive for container transport to and from the Dortmund region.

In first instance we consider competition among the North-West European ports but it is the ambition to enlarge the scope of the modeling to simulate also competition with other port ranges or alternative routes. Examples of such extension are the fast developing South-European ports such as those in Italy. These ports become stronger competitors for the North West European ports in parts of their hinterland such as Northern Italy, France, Austria and Switzerland. The Trans-Siberian railway option is another potential threat for the North West European ports as this railway connection bypasses the maritime trajectory via, for instance, the Indian Ocean and the Mediterranean Sea and may serve as a faster alternative for container shipments between Asia and Europe (Dekker, 2005).

Elements which are considered to be important criteria for port choice following a survey under the main container carriers (OTB, 2007) are:

- Availability of hinterland connections;
- Attainability of consumers
- Maximum depth of port approaching route
- Port ship time of productivity
- Reliability (absence of labor disputes)
- Reasonable tariffs
- Degree of congestion

The hinterland connections, attainability of consumers, port productivity and reasonable tariffs were most frequently mentioned as important criteria by the container carriers. This survey and previous ones (e.g. NEA 1991) show valuable information on the elements of high importance to be included in the port competition model. Unfortunately it has not been possible, as far as we know, to use these surveys directly for the estimation of a port competition model. This is complicated by the diversity of actors involved in the decision making process, such as senders, forwarders, carriers, etc., and often limited number of respondents.

2.1 port and hinterland infrastructure planning

Ports and governments have responded to the growing market and increased level of competition with large investments. These investments focus on all

components of the transport chain, maritime access, port capacity and efficiency and hinterland transport. To take advantage of scale developments in the maritime industry most ports, often via government support, need to deepen their maritime access to improve their accessibility for ships of over 8000 TEU and recently of 13500 TEU (ship Emma Maersk). This ongoing development in increasing ship sizes will affect the competitive position of ports depending on their natural nautical conditions and level of investment in maritime access. An example of such investment is the deepening and widening of the Schelde access river to the port of Antwerp (CPB/VITO, 2004).

The container handling capacity is growing fast in the le Havre - Hamburg range, large as a result of private investments in terminal capacity. Based on a port survey, as part of this study, covering Rotterdam, Antwerp, Bremen and Hamburg terminal capacity in these ports is planned to double, from 37 million TEU in 2005 towards 70-80 million TEU in 2020. This means that huge investments in terminal capacity are ongoing and being prepared

Hinterland transport and transport costs are an important factor in the costs of the logistic chain and therefore an important competitive factor. Therefore ports, in combination with regional and national governments, are very active in improving hinterland conditions for all modes of transport. For example the hinterland of the port of Rotterdam has recently improved by expansion of its hinterland options with the construction of a rail connection between Maasvlakte 1 and Germany (the so-called Betuwe line; investment cost €4.7 billion). The port of Antwerp has similar ambitions by revitalizing the Iron Rhine railway connection to Germany.

The Hamburg senate will be investing €2.9 billion in all the above aspects to make the port fit for the future. The package includes deepening of the Elbe to enable even future generations of containerships to call at the port. Other investments are in new port facilities and container terminals, renewal of the port railway tracks and expansion of flood protection.

These large investments in maritime access, ports and hinterland transport do call for an application of analytical instruments including a simulation of port competition. As we have seen the port flows, and therefore the utilization of the new infrastructure, do not only depend on trade developments but also on the developments in the market shares of the ports. Such port competition modeling framework should integrate developments in trade by origin, destination and cargo type, in ship sizes, maritime access, port capacity and efficiency, and hinterland transport. With such a tool it will be possible to evaluate the investments under different economic and maritime scenarios while including the effects of developments in competitive ports.

3. PORT COMPETITION MODEL METHODOLOGY

The currently available toolbox to support policy making consists mainly of large scale conventional transport models or more dedicated port forecasting models. The traditional transport models include valuable information on freight flows between regions and hinterland transport infrastructure, which allows chain or door-to-door assignment of freight flows. Big omissions in these conventional transport models are that competition between ports and sector specific trends or developments (e.g. scale expansion in ship size) do not affect the choice of the ports as part of the assignment. Freight transport forecasting models, used as instruments for port forecasting, often produce detailed forecasts by commodity type under assumption that port operations (costs, efficiency) and port capacity constraints do not influence these flows. Furthermore sometimes these models assume a fixed market shares for the ports in the hinterland; so these models cannot simulate changes in the hinterland transport connections.

An early attempt to model port competition was made by NEA for the Ministry of Public Works in the Netherlands (NEA, 1991). Due to data limitations the modeling was basic in its set-up and explicit policy levers were missing. For example geographical distance was used instead of transport time or cost variables and maritime access and port operation variables were not explicitly included in the modeling. Nowadays some port forecasting models do include more components, and associated explanatory variables, of the logistic chain to model the element of port competition (e.g. CPB, 2003 or more academic Dekker 2005, Sanders et al. 2006). However, so far these models lack a detailed integration with trade flows and hinterland infrastructure which is needed to simulate competition between ports at the level of detail it occurs.

The work of Gerrits (2007) following a logit modeling of logistic chain choices including the performance of ports was a next step following his line of research. The work made a contribution by integrating the various components of the logistic chain (maritime access, port and hinterland) in a practical pilot instrument via the inclusion of explanatory variables for each component. Similar to the other efforts the work lacks the necessary detail, e.g. limited number of different OD flows, to capture the detailed nature of port competition. Another omission was the lack of integration with developments in the maritime sector like increases in vessel size, which affects the competitive position of ports.

The methodology in this paper builds on these previous exercises and makes a contribution by integrating the 'logit' modeling of logistic chains with a large scale world wide trade model and the transport costs/time database of the EC. Further progress is realized via a port survey to improve the port specific data in the modeling and the representation of maritime transport (vessel type). These steps enable the new port competition model of Significance and NEA to calculate port freight flows under different macro-economic and maritime sector specific scenarios. The model is capable of calculating the impacts of a wide range of

policy measures (e.g. infrastructure, pricing) in the port itself and its hinterland connections.

Key elements in this approach are:

- Port competition is an explicit component of the modeling. In many regions ports do have overlapping hinterlands and an improvement in port A effects volumes in port B²
- a logistic chain approach (sea transport, maritime access, port, hinterland) is taken in the assignment and developments in each component will affect port volume flows
- Use of utility theory as basis as it provides an integrated value for cost, time and quality factors:
 - responses are consistent with economic theory, e.g. higher costs – lower volumes;
 - the theory accounts for unobserved elements and taste variation – result a spread over the options;
 - is applied to disaggregated market segments (OD, handling type, ship vessel size category);
 - A Multinomial logit model structure has been used covering the logistic chain in the model (see route/logistic chain components for detail)
- Port forecasting tool is integrated with the Worldnet database, which provides world wide freight flows at a NSTR 2 digit level between regions (for Europe the zones are modeled at the NUTS 2 level)
- The model can simulate the effects of developments in the maritime sector like increasing vessel size or developments in the level of containerization.

The structure of the model is schematized in figure 3.1. The figure distinguished the components scenario/policy settings, data, growth model and route/logistic chain choice model.

² An explicit modeling of competition between ports is not only necessary to analyze the impacts of policies in a competitive environment it is also very valuable information to design and evaluate port cooperation strategies

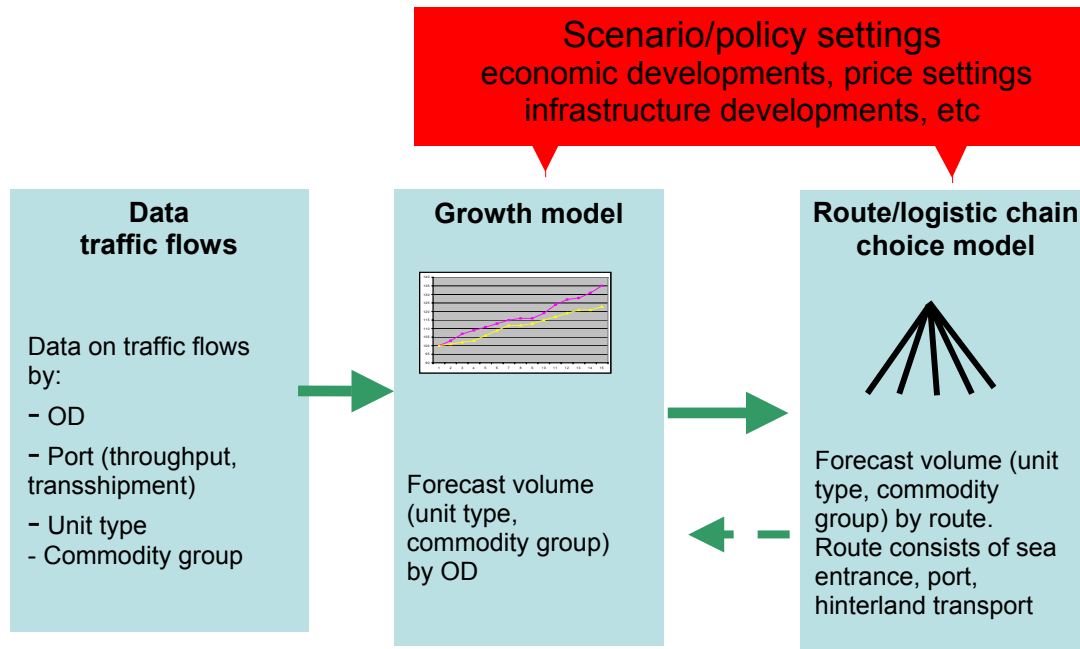


Figure 3.1: structure of the port competition forecasting framework

The future development and growth of European ports depends strongly on the scenario settings. The user is free to set these scenarios but it is the ambition to prepare the model for a baseline scenario based on the iTREN-2030 project of the EC (project expected to finish in May 2009) and to explore two extreme scenarios. The different extreme scenario's that could be shown are the following:

1. Large unconstrained economical growth. Ongoing globalization assuming that technological developments can solve all energy and climate challenges;
2. Changed economy, taking into account that major changes in the economic system, and related trade flows, are needed as a result of energy scarcity and climate change.

In the current prototype port competition model the trade forecast is based on the WORLD NET project. Other scenario/policy settings can be defined by the user of the model and some illustrations are presented in chapter 4. Below the trade growth model and route choice model are described in more detail.

3.1 Trade growth model

The trade flows by origin and destination and commodity type are forecasted by a trade model, the so-called WORLDNET model extending the EU's TRANSTOOLS system (DG-TREN, 2007-2009). In the trade model the country-to-country trade forecasts are based on a combination of an agent-based simulation model that forecasts total trade in dollars between country pairs, and a trend model that determines the flow in tonnes, disaggregated into commodity groups.

The approach of the trade model attempts to be practical and dynamic, requiring only historical trade data and variables such as GDP and population to obtain reasonable forecasts for countries' total imports and exports. An advantage is that country specific data is used and that the usage of the model is not specific or limited to a certain region; for example see the application of the same approach for the Black Sea region (NEA and Haskoning, 2008). Input data (historical value of trade between country pairs) for the trade model is gathered from the EU Comext and the UN Comtrade trade databases. Presently, the last "known" year is 2006, with trade data going back to 1995. The global trade model is an agent-based simulation model. This means that countries are modelled as autonomous individuals, existing as separate entities within the system. They each have their own variables and behaviour. The model simulates one year at a time, starting at the base year (2006) with the capability of continuing indefinitely.

In the trend model the output of the global trade model is used to constrain the disaggregated trade flows in tonnes between country pairs. The commodity grouping used is the three-digit NST/R coding. Trade flows are already grouped accordingly in the EU Comext and UN Comtrade trade databases. Similar to the total trade flows that are used as input for the global trade model, the disaggregated trade flows (in both tonnes and values) are taken from the databases, and the smoothing algorithm is applied to the resulting time series where needed. The forecast results from matching or converging the trade model forecasts and freight transport trends.

As stated the level of competition between ports differs by location and type of appearance. Therefore it is necessary to refine the market analysis to make estimates of the regional decomposition of the freight flows. For the EU countries this decomposition is done at a NUTS 2 zone level following the ETIS-Base (DG-TREN, 2005) technique

3.2 Route/logistic chain components

In the port competition modeling approach a port is considered to be a link in a logistic chain. Therefore, modeling of logistic chain choices is needed to forecast future freight flows by port. The modeling does not need to cover the full logistic chain between origin and destination of the goods; the logistic chain in the modeling focuses on the part for which the competitive position for import and export of the port alternatives in the modeling differs. A full chain can consist of hinterland – port – sea – port – hinterland or more complex chains if for example sea-sea transshipment is also included. The model at this stage only simulates hinterland transport; feeder transport, resulting from sea-sea transshipment, is an exogenous scenario variable.

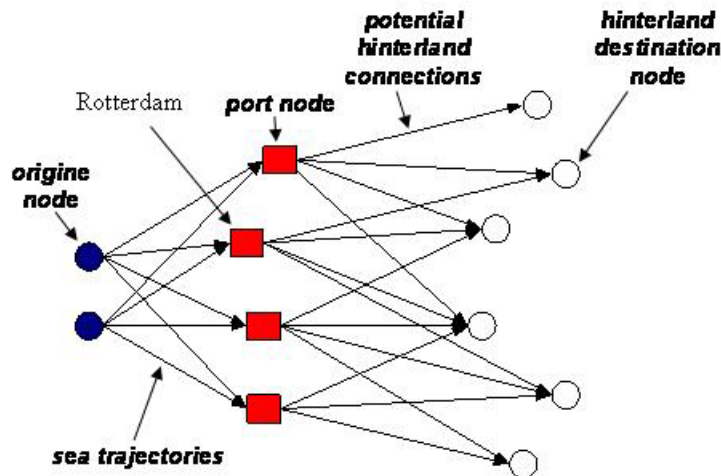


Figure 3.2: schema of logistic chain in the modeling

The complexity of the logistic chain is reduced in the modeling by only including the hinterland transport in the hinterland of the le Havre – Hamburg port range. For example, the logistic chain of a flow from Chicago to Dortmund consists of hinterland transport Chicago – New York, sea transport New-York – Rotterdam (or Antwerp, etc.), port costs and hinterland transport (road, rail or IWW) to Dortmund. The hinterland transport from Chicago to New York is not included in the model as it assumed that this part has no impact on the competitive position of the ports in the Le Havre- Hamburg range. The three core components of the logistic chain in the modeling are therefore sea transport and access, port handling and hinterland transport. Each component can be further disentangled and the paragraphs below discuss the maritime, port and hinterland component of the port competition model.

Maritime component

The maritime component consists of sea transport costs and times between port of origin and destination, additional sailing costs to ports (e.g. sailing Scheldt river to Antwerp) and sailing windows depending on the tidal cycles and draft of the incoming ship. A generalized cost approach is used, for all three elements of the maritime component, which uses time (Euro/TEU hr) and cost values (Euro/TEU km) by TEU for six ship size categories (<2000 TEU, 2000 – 3500 TEU, 3500 – 5000 TEU, 5000 – 8000 TEU, 8000 – 12000 TEU, > 12000 TEU). The time and costs values by TEU for the various ship size categories have been derived from various sources. Due to scale advantages the sea transport costs by TEU decreases if ship sizes increase³. Further the average speed by ship size category⁴ differentiates the sea transport cost per TEU by ship type.

³ Ship transport costs data by TEU km and TEU hr from Sweden and Norway by ship type, CPB/VITO 2004, diverse websites

⁴ <http://www.globalsecurity.org/military/systems/ship/images/teu-trend-1.gif>

For a specific OD container flow the sea transport costs differ by port due to differences in sea distance and time, the market share of the ship type categories and the sailing windows by ship type. A skim of the worldnet network (part of EU TRANSTOOLS) has been made to collect the data on sea distances. The port survey has been used to collect port specific data on the number of calls by ship type and the tidal window by ship type (draft).

Port component

The port related costs are collected via the survey by port and terminal operators in addition to figures from the CRA report (CRA, 2004). The port related part of the total unit cost (generalized cost) is subdivided into port investment costs and port residence costs. The port investment costs consist of port dues and terminal charges. The terminal charges consist of all other call costs (except port dues) and container handling costs. For containers, the share of other call costs in terminal charges is relatively low. The main part of these charges is container handling costs.

The port residence cost consists of time costs, e.g. costs for the duration of transportation, storage or container handling. A monetary value has been assigned to a time unit the so-called Value-of-Time. The VOT expresses the willingness to pay of a port user for a unit reduction of transportation time. The VOT can consist of both the daily loss on capital for the receiver of the container in transit or time cost for transport (e.g. labor costs on a ship). Therefore the VOT per TEU differs for storage time or ship waiting time. The storage costs do largely consist of losses on capital, where the time cost for containers on a ship depends on losses on capital as well as costs for the usage of the ship. The VoT figures in the model were derived from a study by Rand Europe (RAND Europe, 2004). The storage time and handling times in the ports were derived from CRA (2004) and the port survey carried out as part of this study.

Hinterland component

The hinterland component of the generalized cost function consists of transport costs and times between the ports and origin/destination region for road, rail and inland waterway transport. The mode share in the port competition model for each of the OD relations, port to/from hinterland NUTS 2 zone, and generalized costs by mode are derived from the EC ETIS database (ETIS consortium, 2004).

The database consists of a large set of cost components covering both the fixed and variable costs for the hinterland modes. For example the generalized road costs consist of toll costs, cost for operating vehicle (investment, maintenance, fuel, labor, etc) terminal and service costs. The generalized costs for rail and inland waterway are built up in a similar way.

Logistic chains – choice set

The choice set in the modeling is specific for each origin and destination trade relationship in the modeling; in the model there are more than 500 regions included. The alternatives between an OD consist of the features of the logistic chains including one of the four ports. In the current set-up a multinomial logit model is used in which the chance of an alternative depends on its overall generalized cost. The generalized cost function is decomposed in the components maritime access cost a time, port performance and costs and generalized hinterland costs. The coefficients in the model are calibrated on base year (2005) hinterland transport volumes by port.

In the pilot model the market shares by ship type category, in the maritime component, and hinterland transport mode are fixed and based on respectively port statistics and the ETIS data base. In further versions it is the ambition to enlarge the choice set with an endogenous modeling of ship types and model split for hinterland transport. In the current version these component can change due to scenario assumptions on maritime transport by ship type or exogenous model runs to change the model split with NEAC (or TRANSTOOLS).

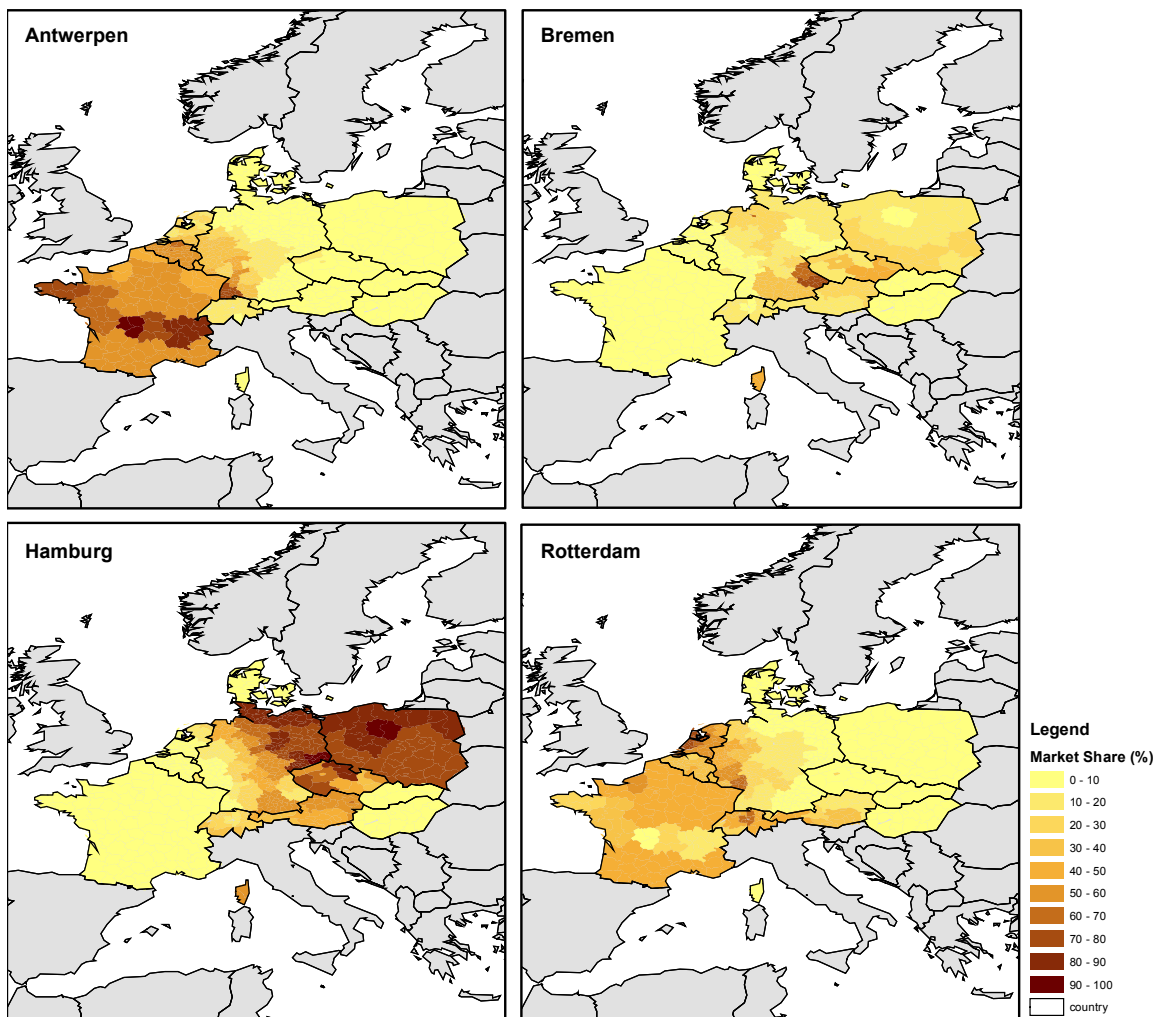
4 IMPACTS OF POLICIES IN A COMPETITIVE ENVIRONMENT

In this section the pilot port competition model is used to derive the markets share by region for the ports, paragraph 4.1, and to calculate the changes in market share resulting from a set of test policy measures, paragraph 4.2. A clear market definition is the starting point for an analysis of the market shares. In this version of the model the market is defined as the total container flows, via the Ports of Hamburg, Bremen, Rotterdam and Antwerp, to and from The Netherlands, Belgium, Luxembourg, Germany, France, Austria, Switzerland, Czech, Slovakia and Poland. A basic assumption in the pilot model is that the four ports only compete among themselves and not for example with the port of Gdansk for Poland or le Havre/Marseilles for France. So this means that for Poland or France only a part of their total market is included in the model. Competition with other ports or land transport is part of the total market definition, can be scenario sensitive, or alternatively there can be an extension of the number of ports in the future (at least le Havre and Amsterdam will be added in near future)

4.1 Market share by port

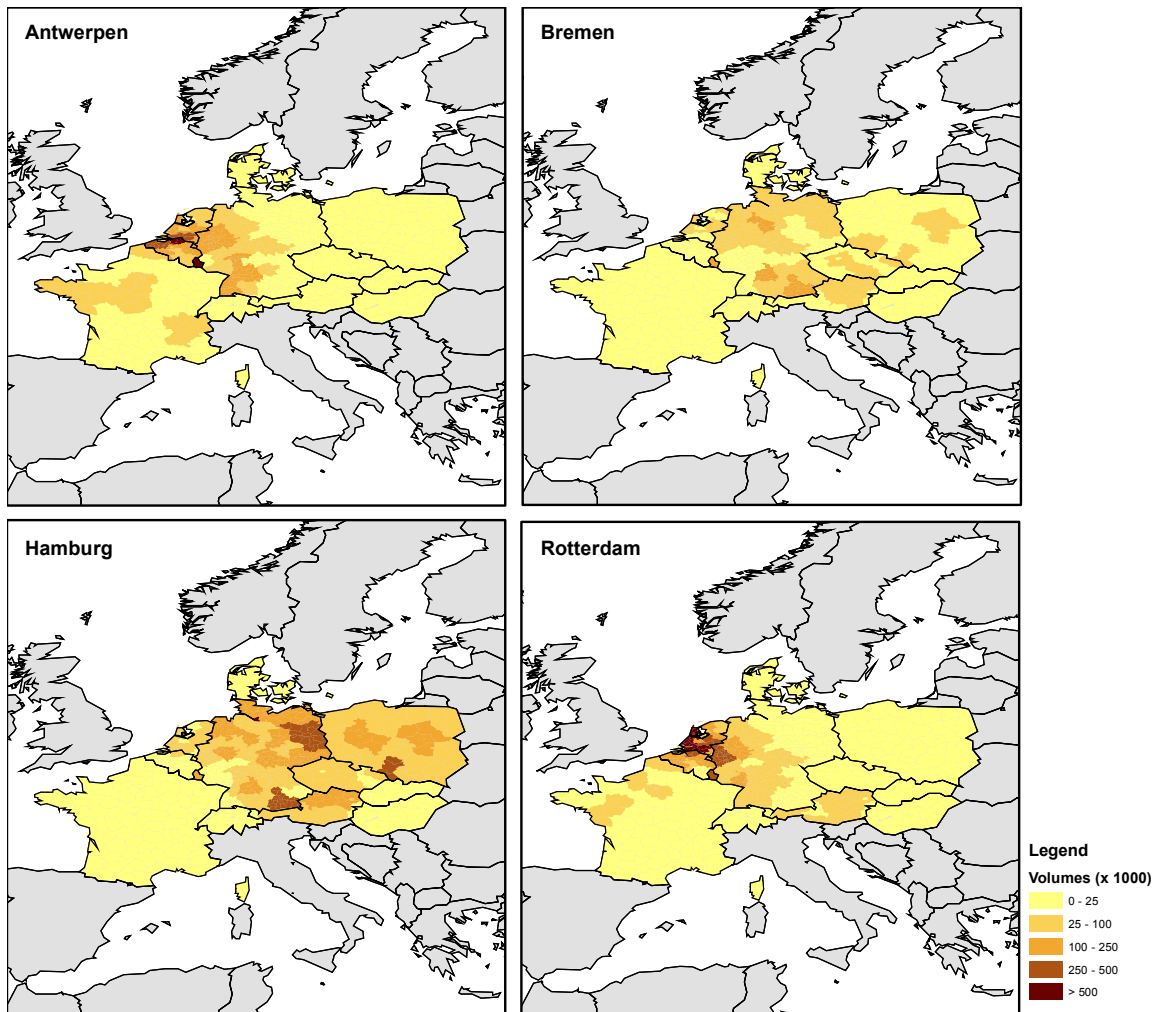
The maps below present the market share by port (of the total market for the four ports – 100%) and the volumes transported to and from the NUTS 2 regions by port. The market shares/volume are calculated for the total container flows, both import and export, but if needed much more detailed visualizations are possible by import/export and/or place of origin.

Map 4.1 illustrates how the competitive position of a port within its port range differs geographically. For example, Rotterdam has a dominant position for the Netherlands, Western part of Germany and Switzerland while Hamburg is the most competitive port of the four for Eastern Germany and Poland.



Map 4.1: Market share of ports by NUTS 2 region within their port range

Map 4.2 shows the volumes of transport to/from region via one of the four ports to illustrate which regions are of key importance for the ports. For example, both the port of Antwerp and Rotterdam have substantial markets shares for France (within their port range) but the transported volumes are modest as for most of France its maritime transport is transported via other ports (e.g. Le Havre, Marseilles). It should be noted that large size differences exist between the NUTS 2 regions and therefore the volumes in the map do strongly depend on the size of the region.



Map 4.2: Volume to and from NUTS 2 region by port

The maps above show the results for the Worldnet reference scenario 2020. Of course the market share will change due to differences in the socio-economic development of the hinterland. For example it can be seen that a high economic development in Poland will increase the volumes in the port of Hamburg more than in the other three ports. In practice different socio-economic scenarios are simulated within the trade growth model and the port competition model can be used to analyze the impacts for specific ports. Besides socio-economic scenarios the port competition model can also calculate the impacts of changes in the level of containerization, for example, due to technological developments.

4.2 Changes in market share by port

As mentioned above the transport volumes in the ports, and their total market shares, can change due to differences in the socio-economic development of the hinterland. Furthermore the container volume in a port depends on how changes in the maritime access, port operation and hinterland transport affect the competitive position of the port. To analyze the sensitivity of the port volumes for various elements in the logistic chain several test runs were performed, namely:

- a) increase all hinterland road transport costs from Rotterdam with 10% - this applies to wide definition for road costs (see 3.2 – including labor costs etc.);
- b) increase all hinterland road transport costs from Rotterdam with 100 Euro by TEU;
- c) increase IWW transport costs from Rotterdam with 20%;
- d) improve port efficiency Antwerp – reduction generalized port costs (unloading, storage, loading) with 10%;⁵
- e) scenario for no change in market share by ship type category – the reference scenario assumes a substantial shift to larger vessels and associated lower maritime costs, case e assumes as a test that this shift is not happening (same vessel type distribution in 2020 as in 2005).

The results, changes in market shares and volumes, can be analyzed at various levels of detail, namely the aggregated level of market share for the port, markets shares by hinterland country and maps with changes in market share by NUTS 2 region. The overall results in market share by port for the five cases are presented below in Table 4.1. The results show a substantial response to the various test cases, especially for road transport costs changes and port efficiency changes.

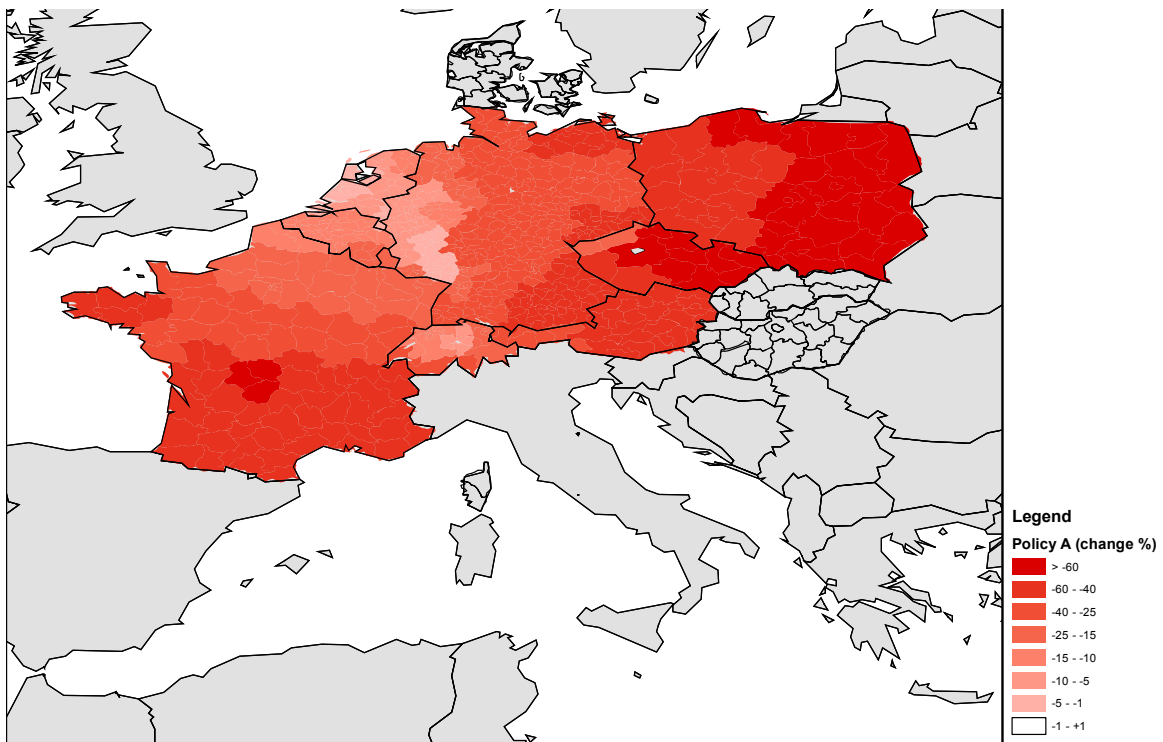
	Hamburg	Bremen	Rotterdam	Antwerp
Reference 2020 ⁶	28%	10%	33%	29%
Case a	30%	10%	29%	32%
Case b	30%	10%	25%	34%
Case c	29%	10%	32%	29%
Case d	27%	9%	30%	34%
Case e	29%	10%	31%	30%

Table 4.1: market share by port

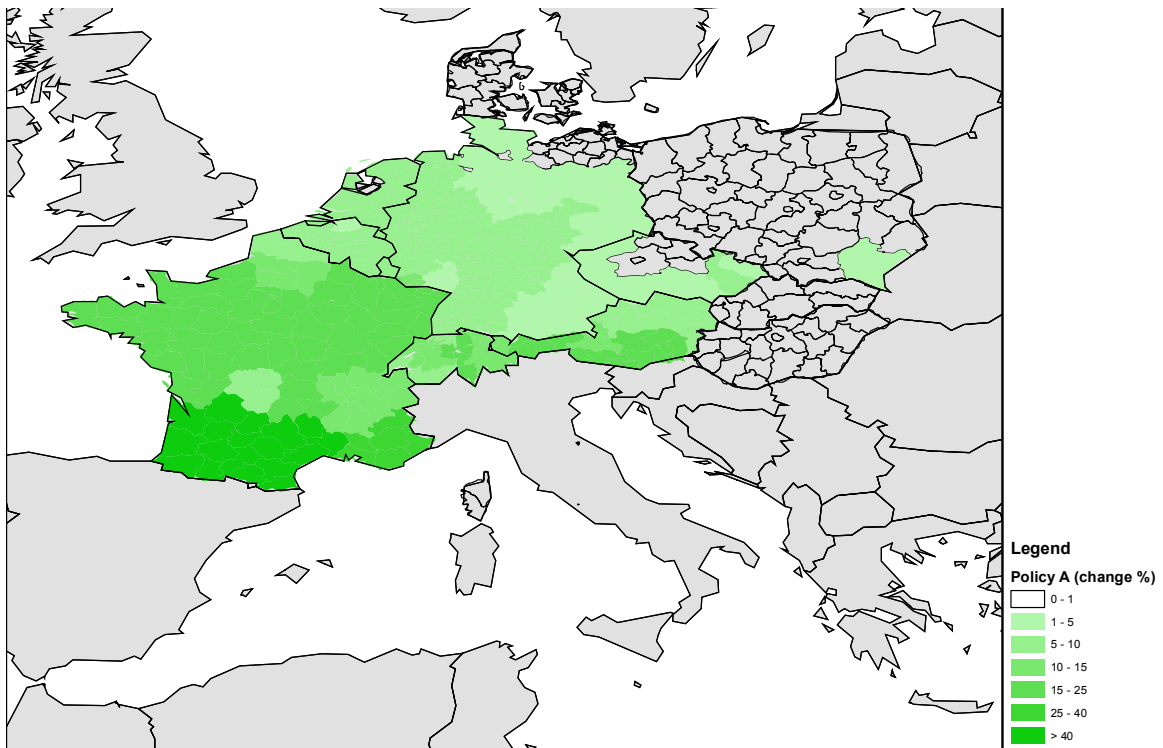
The changes in market share for case a, all road costs + 10%, and case b, road costs + 100 Euro, show the strong competition between Rotterdam and Antwerp. The results show that the market share of Rotterdam is reduced more by case b than a. This can be explained by the higher transport volumes at relatively short distance relations such as the Netherlands, Belgium and Western Germany which are affected more by a 100 Euro increase than by 10% increase (for example road transport costs of 500 – 700 Euro per TEU). Map 4.3 and map 4.4 show the impact of case a on the market shares of Rotterdam and Antwerp. Rotterdam is especially losing its market share for long distance road locations such as Southern Germany, Austria, the Czech republic and Poland. The impact of case a is more modest for short distance flows and locations with a high share of Inland water way transport.

⁵ Improvements in efficiency might require investments and tariff increases to pay for these investments. In case d these potential increases in port tariffs are not included but if defined the impacts of these changes in tariffs can be analyzed with the modeling as well.

⁶ The market share are calculated for the hinterland freight flows, without feeder transport. This means that a strong feeder port, like Bremen has a smaller market share than usual in statistics including all flows.



Map 4.3: decrease in market share for port of Rotterdam by NUTS 2 region due to 10% increase in road transport costs (Case a)



Map 4.4: increase in market share for port of Antwerp by NUTS 2 region due increase in road transport costs from Rotterdam (Case a)

Please note that all results are illustrative as they are calculated with the pilot port competition model. Further calibration/fine tuning and extension of the model (at least port of Le Havre, Amsterdam) is needed before the model can be applied to support policy decision.

5. CONCLUSIONS AND FURTHER RESEARCH

The set-up of the modeling and preliminary results for the test simulations give confidence that combining a port competition model, following a discrete choice modeling of logistic chain choices, with a detailed world wide trade model and transport database for hinterland transport results in a planning framework with more functionality than present “fixed market share” models or port specific models without geographical detail in their OD flows. In practice this modeling framework can play an important role in analyzing the effects of different port development strategies and developments in the hinterland transport under various socio-economic and sector specific (scale developments in ship size) scenarios.

The modeling of port forecasting following a logistic chain approach is especially of importance as port volumes appear particularly sensitive in the test applications to port efficiency as well as the effectiveness of hinterland connections. The test results also illustrate the importance of geographical detail as the market shares of the ports and size of the changes in market shares, due to policy measures, differ strongly by zone of origin and destination.

A further upgrade/expansion of the model structure and data base will be necessary in order to prepare an established planning model for practical use. The following upgrades/expansions can be mentioned:

- 1) *Port operations and efficiency*: In the existing pilot version of the model information on the consecutive links within a port as container discharge time and costs, storage time and hinterland loading has been gathered via a port survey in addition to existing literature. An increased insight in port congestion and relationship to capacity, considering the maritime/nautical as well as the land side of the port transfer processes is needed to improve the support of strategic planning for the port. This could be established via further interaction with port authorities and terminal operators;
- 2) *Scope of the model*: the model now incorporates four ports in the Le Havre -Hamburg range and as a next step it is planned to include the port, and its features, of Amsterdam and Le Havre in the modeling. Further extensions to improve the results for the current hinterland are inclusion of the ports in France, Poland and Italy;
- 3) *Feeder transport*: To include feeder transport in the modeling a wider geographical area (including Britain, Scandinavia, etc) and the main ports in this wider area needs to be included in the modeling. This is

needed to make future trade-offs between the use of feeder transport or direct calls;

- 4) *Choice process*: factors other than generalized cost play a role in the choice for a particular logistical chain; such are reliability of services, port communication system, labor flexibility and strike changes and the potential outlook for further development of the port and business opportunities. The discrete choice model can be further elaborated to include such factors. This may be linked to an extended modeling of port features.
- 5) *Dedicated terminals*: The pilot model does not distinguish between dedicated terminals and general terminals as all terminal capacity is considered as normal capacity. This has an impact on the findings as in general the existence of dedicated terminals is likely to diminish the level of competition. Following which dedicated terminals also result in lower demand elasticities for travel cost or time changes. The idea is to implement this in the modeling by using scenarios about the ongoing vertical integration between shipping companies and terminal operators.

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