PORT COMPETITION MODELING INCLUDING MARITIME, PORT AND HINTERLAND CHARACTERISTICS

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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 (UNCTAD). Also for the coming decades a substantial, above average, growth is foreseen in this type of freight transport, although this outlook is in the short term negatively affected by the economic crisis, in mid- to long term projections it is expected that global trade and in association container transport will return to its path of growth. Another characteristic of container transport is that it is one of the least captive cargo types. Ports and governments have responded these high growth figures and competitive nature (and are planning to respond) with large investments to accommodate this high growth in container transport and to improve the market share of their port in this competitive market. These developments highlight the need for forecasting and policy analysis tools supporting governments and port authorities with developing their strategy and decision making.

The purpose of this paper is to present an operational port forecasting 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.

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Section 2_in the paper addresses 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 above discusses 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). Therefore, ports compete with each other to be included within these global logistic chains, meaning that, from an analytical perspective, chain systems compete with chain systems. Amongst others, Robinson (2002) calls for a paradigm change to consider ports as elements embedded in value driven chains. The port competition model, as presented in this paper, followed the logistic chain approach as far as possible considering the data availability.

The level of competition between ports in the North-Western 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 waterways 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. In the remaining part of the paper the focus is on container transport, as widely reckoned to be highly competitive and to have a still increasing importance in the freight 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 cannot 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 it is not correct to generally state that the port of Hamburg and Rotterdam are in competition. A more specific market definition is required, as that 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-Western European ports but it is our 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-Western 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-Western 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).

Ports and governments have responded to the overall market growth in container transport and more competitive conditions with large investments to attract these container flows. 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 Scheldt access river to the port of Antwerp (CPB/VITO, 2004). The trend has been that shipping lines try to outperform their rivals by deploying larger vessels driven by a unilateral focus on operational costs at sea. The future developments in ship size are however rather uncertain as scale increases proves to have its limitations and there is a shift from pure shipping operations to integrated logistic solutions including port handling and hinterland transport (Notteboom, 2004).

Free terminal capacity is crucial to attract new or expanding services and the container handling capacity has been (and is planned to) growing fast in the Le Havre - Hamburg range, largely 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 reactivating the Iron Rhine railway connection to Germany.

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 distribution 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. Port forecasting models often produce detailed forecasts by commodity type under assumption that developments or capacity constraints in the ports do not influence these flows. Furthermore sometimes these models assume a fixed hinterland; so these models cannot simulate changes in transport connections in hinterland transport.

Some port forecast models do include the element of 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 needed to simulate port competition as part of logistic chain choices. A first step in this direction has been made in the work of Gerrits (2007), which distinguishes a limited number of different OD flows. However, this work lacks the necessary detail to capture the detailed nature of port competition and integration with developments in the maritime sector.

The methodology in this paper builds on these previous exercises and makes a contribution by its integration with a large scale world wide trade model and the transport costs/time database of the EC. Further a port survey has been executed to improve the port specific data in the modeling and the representation of maritime transport (vessel type).

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 B;
- 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, a Multinomial logit model structure has been used, as basis because :

  - 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. This results in a spread over the options;
  - it can be applied to disaggregated market segments addressing the variation between these segments (OD, handling type, ship vessel size category);
- 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.

The characteristics of the new port competition model of Significance and NEA makes it possible to calculate port freight flows under different macro-economic and maritime sector specific scenarios. The model is further capable of calculating the impacts of a wide range of policy measures (e.g. infrastructure, pricing) in the port itself and its hinterland connections. The use of the modeling focuses on how port authorities and governments can improve the competitive position of a port. It should be noted that the realization of changes in market shares depends on a complex interaction between various stakeholders (among others carriers, forwarders, terminal operators, etc.).

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.

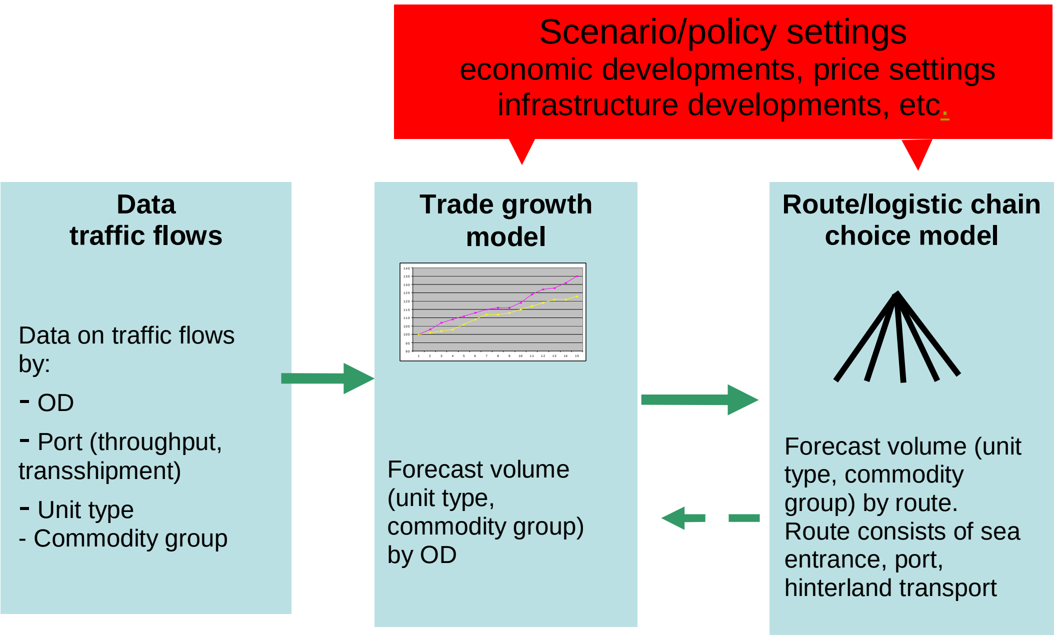

Figure 3.1: structure of the port competition forecasting framework

The scenario/policy settings can be defined by the user of the model and some scenario/policy 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 Worldnet 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 tons, disaggregated into commodity groups. Below the most relevant aspect of the Worlnet model for its usage within the port competition framework model are discussed, for more detail reference is made to NEA et al., 2009.

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 the same approach as for the EU has been applied for the Black Sea region (NEA and Haskoning, 2008). Trade input data (between country pairs) for Worldnet was gathered from the EU Comext trade database (classified in European Harmonized System) and the UN Comtrade trade database (classified in Standard International Trade Classification -SITC). The SITC classification and European Harmonized System classification were converted into the NST/R coding as used in the modeling. This conversion was performed at a detailed level, which ensures a rather good match between the various classification systems (e.g. form 4 digit SITC into 3 digit NST/R). At the time of developing the port competition model the last "known" year was 2006,and time series data for 1995 – 2006 was available.

The global trade model is an agent-based simulation model. This means that countries are modeled as autonomous individuals, existing as separate entities within the system. They each have their own variables and behavior. 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 tons 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 tons 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 was done at a NUTS 2 zone level following the methodology as applied in the ETIS project which prepared a pan-European transport database (ETIS consortium, 2004). In this approach regional data on the economic composition and consumption is collected and related to freight flows by product type. In the Worldnet project the regional data has been updated in comparison with the ETIS project taking advantage of the latest data improvements at Eurostat as well. In Worldnet the containerized share of the regional origin-destination flows is labeled at the level of the NST\R 3-digit product groups. In the port competition model average figures for the net weight by TEU have been used to transfer tons into TEU.

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. Due to data limitations the modeling can not cover the full logistic chain between origin and destination of the goods. The logistic chain in the modeling focuses on the part for which data is available and fortunately this is also the part for which the competitive position for import and export of the port alternatives differs most strongly. The current model only simulates sea-land hinterland transport and feeder transport, resulting from sea-sea transshipment, is an exogenous scenario variable.

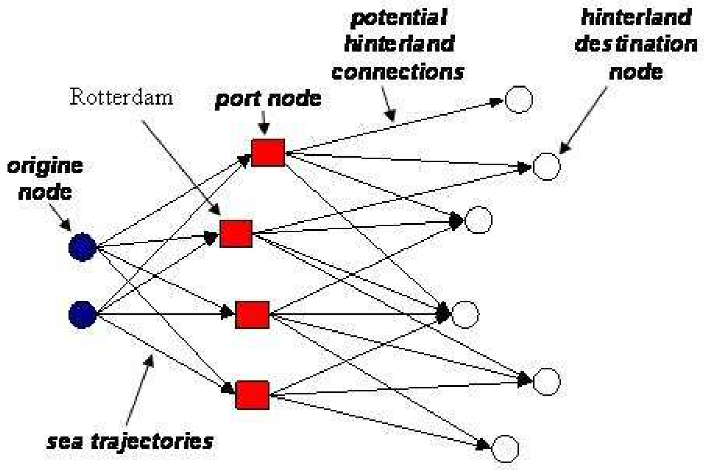

Figure 3.2: scheme of logistic chain in the modeling

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 because data on hinterland transport outside Europe is not collected. The three core components of the logistic chain in the modeling are therefore sea transport and access, port handling and hinterland transport.

Logistic chains – choice set

The choice set in the modeling, consisting of logistic chains as described above, is specific for each origin and destination trade relationship and more than 500 regions are 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.

A logit-type assignment modeling (multinomial logit model) incorporates uncertainties about the factors that determine route choice by shipping companies. The probability of choosing a specific chain (port, *i*), can then be expressed as:

$$P_{odi} = \frac{\exp(U_{odi})}{\sum_{j=1,\dots,n} \exp(U_{odj})} \qquad (1)$$

in which *n* is total number of ports included in the model.
The shipping companies choose the logistic chain and the associated port based on the utility for each chain. The generalized transport cost for the different logistical chains is a main variable in the utility function. In the present model, we differentiate for ship size. Following this approach, the utility for the shipping companies to choose port *i* as part of the logistical chain, can be written as:

$$U_{odi} = -\mu \cdot GC_{odi} + \varepsilon_{odi} \qquad (2)$$

where,

GC_{odi} : generalized transport cost between region *o* and hinterland region *d* via port *i*
μ : cost coefficient
ε_i : error term representing measurement errors and choice attributes not modeled .

The generalized cost function is decomposed in the following components: a) maritime transport by ship size and by maritime access (cost and time); b) port performance and port costs; and c) generalized hinterland costs. The coefficients in the model are calibrated on the base year (2005) hinterland transport volumes by port.

The generalized transport cost GC_{odi} can be specified as follow:

$$GC_{odi} = GC_{oi} + GC_i + GC_{id} \qquad (3)$$

where GC_{odi} can be defined as $GC_{odi} = GC_{oi}^m + GC_i + GC_{id}^h$ or $GC_{odi} = GC_{oi}^h + GC_i + GC_{id}^m$.

In the functions above *m* defines the maritime link (which can be from the port of origin *o* to the port of unloading *i,* or from the port of loading *i* and the destination *d*) and *h* defines the hinterland link (which can be from the port of unloading *i* to the hinterland destination *d* or from hinterland origin *o* via the port of loading *i*). For simplicity, the generalized cost formula for the chain segment will be used as one direction in the remaining of the paper, but similarly generalized cost could be used in the opposite direction.

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 draught 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 cost 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 increase[2]. Further the average speed by ship size category[3] differentiates the sea transport cost per TEU by ship type.

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 (draught).

The maritime component GC_{oi}^{m} can be formalized as follow:

$$GC_{oi}^{m} = \sum_{S=1,\ldots,s} MS_{si} * \left[(\varphi_s * D_{oi}) + (\gamma_s * (D_{oi} / sp_s * 1.85)) + (\gamma_s * A_{psi}) \right] \qquad (4)$$

where,

MS is the market share for ship size category (s) for each port of loading/unloading (i);

φ is the distance coefficient per ship size category;

D is the distance between port of origin and port of loading/unloading (i);

γ is the time coefficient, which is the sum of the ship time coefficient and the goods time coefficient;

sp is the speed (in knots, therefore converted into km/hr dividing by factor of 1.85) of the different ship size categories;

A is the penalty (p) for each port and ship size category (s), which is composed of sailing time (from the sea opening to the port), time window (depending on ship size and tidal cycle) and access restriction (depth is not sufficient enough for certain ship size to enter the port) to the port.

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 terminal handling charges, discharge times,

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

[3] .http://www.globalsecurity.org/military/systems/ship/images/teu-trend-1.gif

storage costs and times and port dues. .For container transport the terminal handling charges and time related costs are usually the major port related costs,.

Formally, the port cost function is defined as follow:

$$GC_i = PC_i + CC_i \tag{5}$$

where PC_i is the generalized port and terminal cost, and CC_i is a penalty for congestion cost. More precisely the port and terminal cost can be described by the following formula:

$$PC_i = v_i + r_i + d_i * vot_{di} + z_i * vot_{zi} \tag{6}$$

where,
v is the port dues;
r is the terminal dues;
d is the discharge time (day);
$vot(d)$ is the value of time for discharge (day);
z is the storage time (day);
$vot(z)$ is the value of time for storage (day);

The port residence cost consists of time costs, e.g. costs for the duration of transportation, and 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, operating vehicle costs (investment, maintenance, fuel, labor, etc.) terminal and service costs. The generalized costs for rail and inland waterway are built up in a similar way.

The hinterland cost GC_{id}^{h} from the port of loading/unloading (*i*) to the final destination (hinterland), is defined as:

$$GC_{id}^{h} = \sum_{m}(MS_{dmi} * C_{dmi}) \qquad (7)$$

where, *MS* is the market share of each mode (*m*) (i.e. road, rail and barge) to a specific region (*d*) and *C* is the cost of each mode (*m*) (data that come from EC ETIS, see above) to a specific region (*d*), both associated to a certain OD link.

Market Share

The market share of a port is mainly determined by the generalized unit cost of the logistical chain, where it makes part of *and* the generalized unit cost of logistical chains with other port nodes, serving the same hinterland.

The total demand is assigned to the different ports (logistical chains) by using the discrete choice model:

$$Q_{odi} = \frac{Q_{od} \cdot \exp(-\mu \cdot GC_{odi})}{\sum_{j=1,\dots,n} \exp(-\mu \cdot GC_{odj})} \qquad (8)$$

where Q_{odi}: number of containers that moves from o to *d* and uses port (loading/unloading) *i*;

GC_{odi}: total generalized cost for transporting containers from o to d through the port *i*;

μ: cost coefficient.

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).

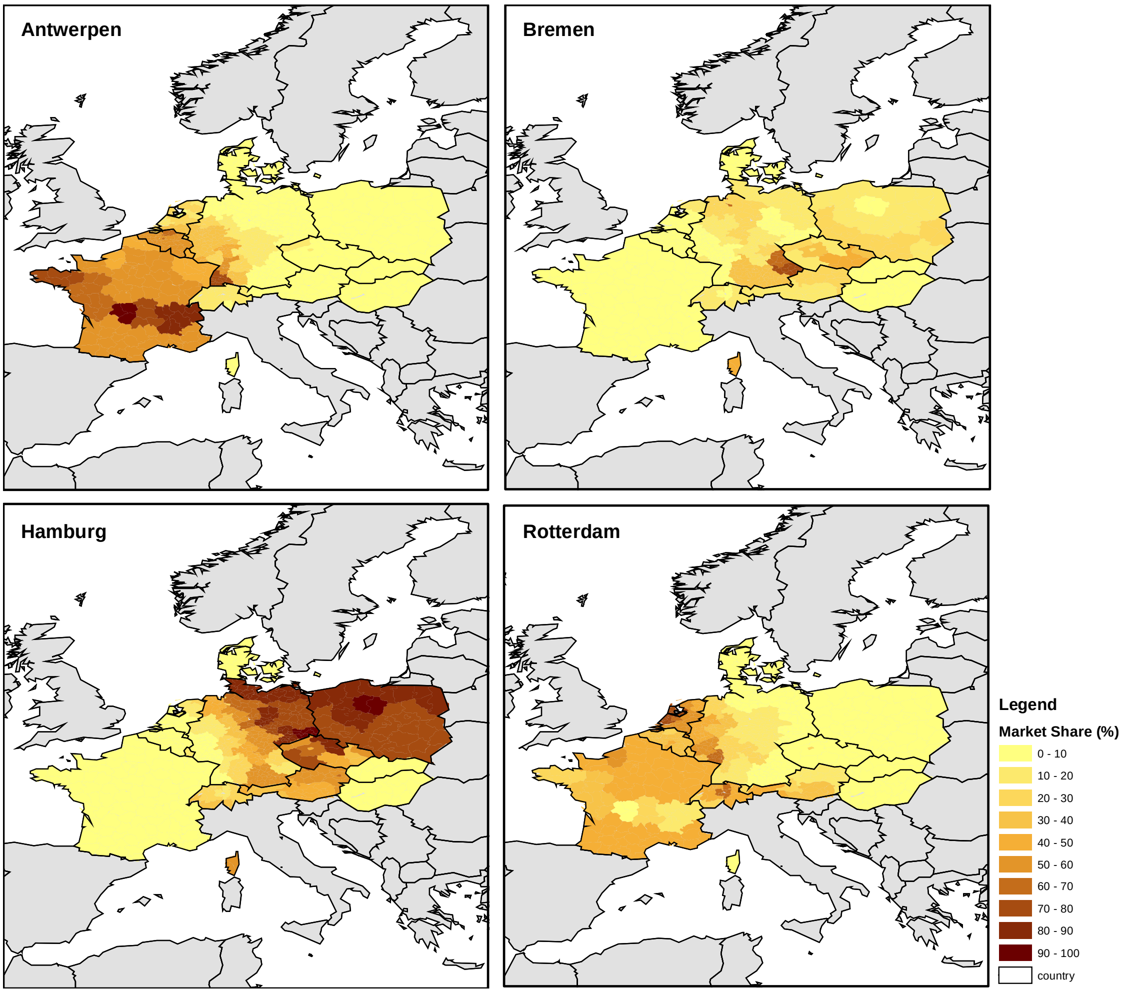
4 IMPACTS OF POLICIES IN A COMPETITIVE ENVIRONMENT

In this section, the pilot port competition model is used to derive the market 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 Gdanks 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

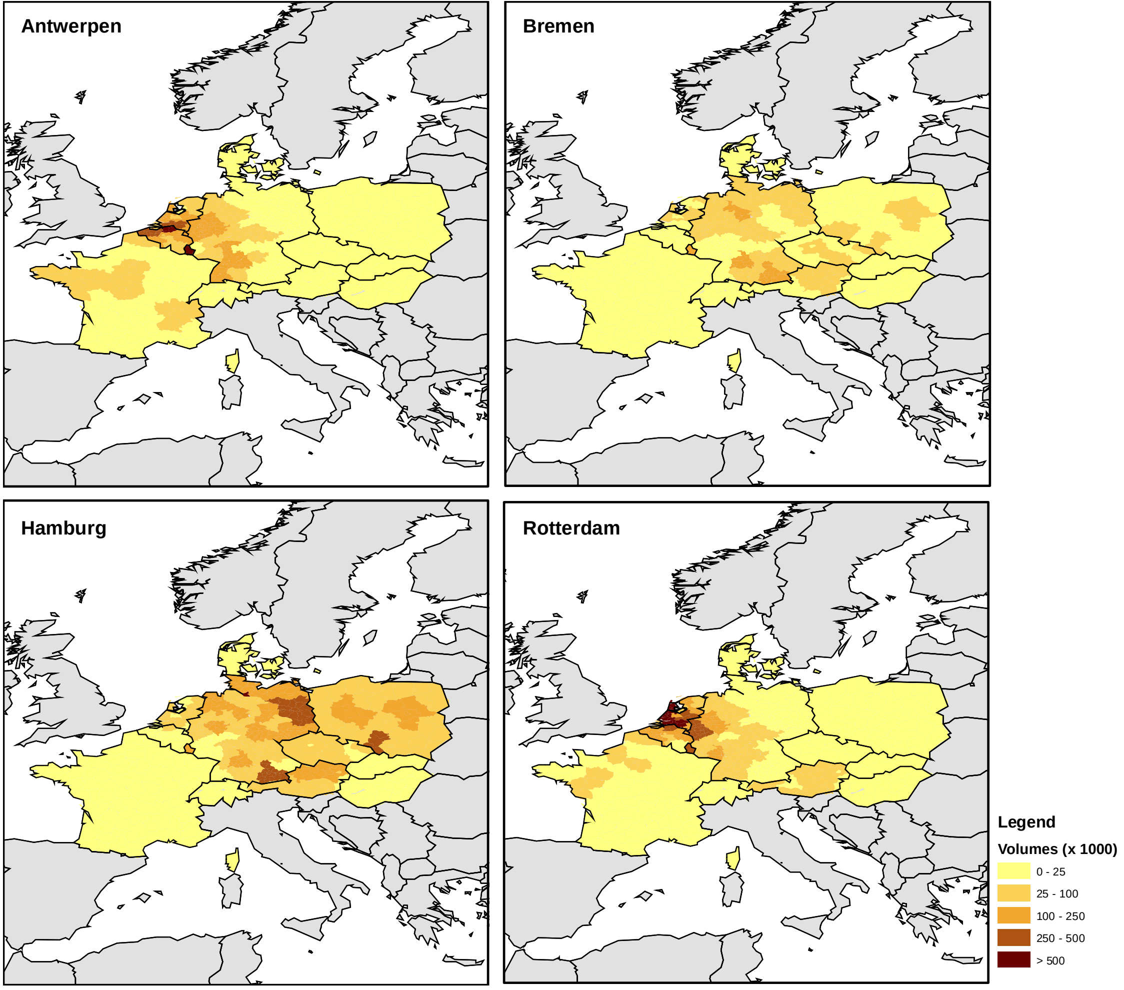
The maps below present the market share by port (of the total market for the four ports – 100%) and the volumes transported to and from the NUTS 2 regions by port. The market shares/volumes are calculated for the total container flows, both import and export, but if needed much more detailed visualizations 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 a 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 market 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 exists between the NUTS 2 regions and therefore the volumes in the map do strongly depend on the size of the region.



Map 4.2: Volumes 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%;
e) apply scenario for change in market share by ship type category – the reference scenario assumes a substantial shift to larger vessels, 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, market share 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[4]	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 loosing its market share for long distance road locations such as Southern Germany, Austria, the Czech Republic and Poland. The

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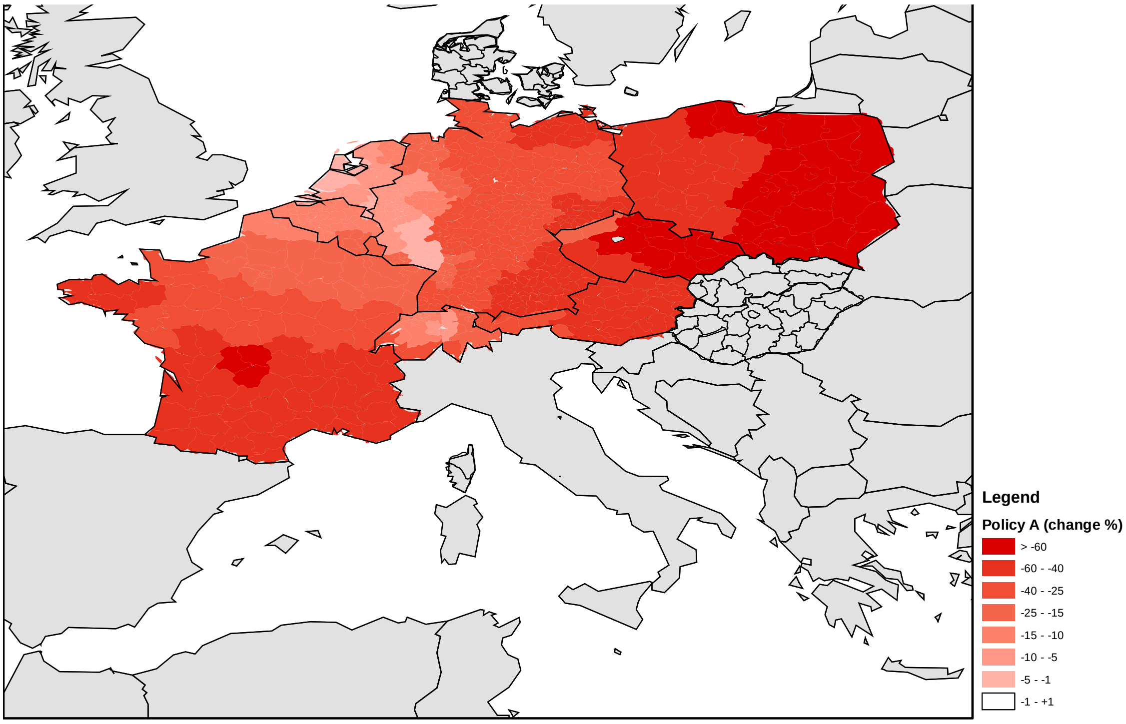
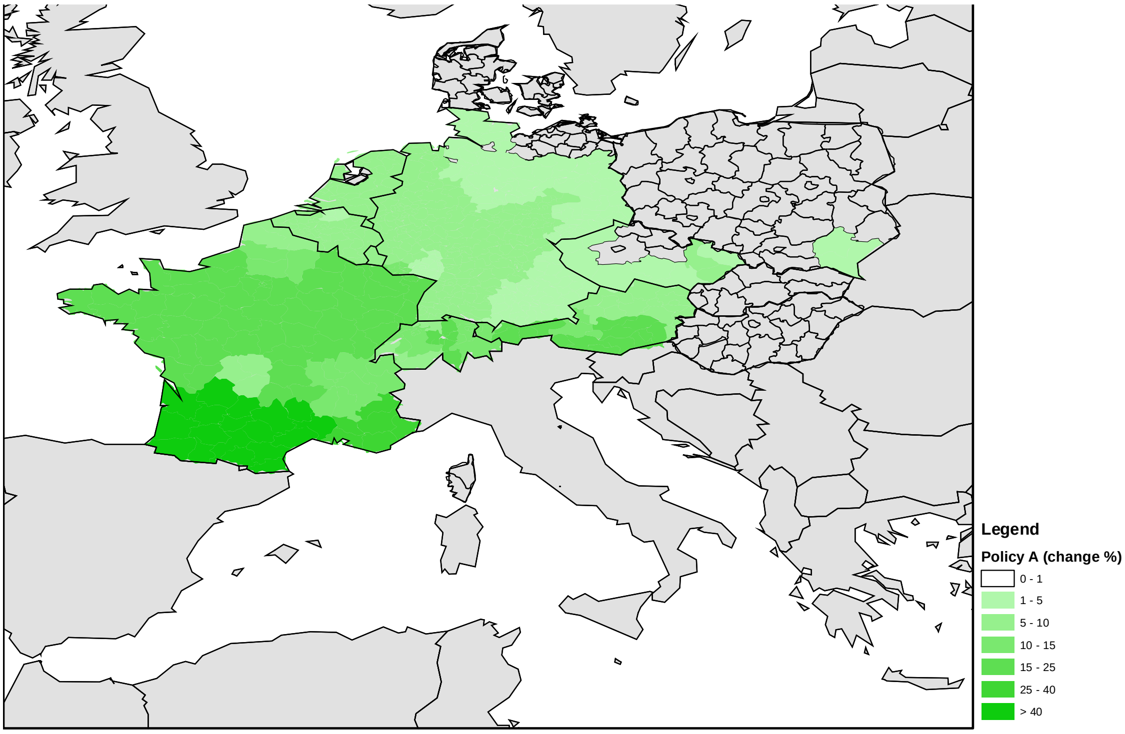
[4] The market shares are calculated for the hinterland freight flows, without feeder transport. This means that a strong feeder port, like Bremen has a smaller market share than usual in statistics including all flows.

impact of case *a* is more modest for short distance flows and locations with a high share of Inland waterway transport.



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/finetuning 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 present modeling and test simulations give confidence that using a port competition model in combination with a detailed trade model and transport network a planning framework can be constructed with more functionality than present “fixed market share” models or port specific models without detail in the OD of flows. This modeling framework can play an important role in clarifying 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.

Such framework including competition is especially of importance as port volumes appear in the test applications particularly sensitive 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 database will be necessary in order to prepare an established planning model for practical use. Ongoing activities are:

1) *Feeder transport*: To include feeder transport a wider geographical area (including Britain, Scandinavia, etc.) covering the main feeder destinations of the North Range ports needs to be included in the modeling. The ports in Britain and Scandinavia need to be included not only as potential feeder destination but also to analyze future trade-offs between the use of feeder transport or direct calls;
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 ports, and their features, of Amsterdam and Le Havre in the modeling. Further planned extensions are inclusion of the ports in the Southern range of France, Spain and Italy;

Other upgrades/expansions that can be mentioned are:

3) *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;
4) *Choice process*: factors other than generalized cost play a role in the choice for a particular logistical chain; such are reliability 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) *Co-operation, mergers and acquisitions among carriers and terminal operators*: The pilot model does for example 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 too diminish the level of competition, with lower demand elasticities for travel cost or time changes. The idea is to implement these aspects in the modeling by using scenarios about the ongoing vertical or horizontal integration between shipping companies and terminal operators.

REFERENCES

Charles River Associates (2004), *Study of the Port of Rotterdam- Market definition and market power-final report*, report prepared for NMa

CPB/VITO (2004), Verruiming van de vaarweg van de Schelde – een maatschappelijke kosten-batenanalyse, The Hague, The Netherlands

Dekker S. (2005), *Port investment – Towards an integrated planning of Port Capacity,* PhD thesis Delft University of Technology, Trail thesis series number T2005/5

ETIS consortium (2004), *D5 main report: ETIS-Database methodology development and database user manual – synthesis report*, Project funded by the European Community under the 'Competitive and Sustainable Growth' Programme (1998-2002)

Gerrits W.A. (2007), *Dynamic port planning under competition,* MsC thesis Delft University of Technology and Significance, Delft, The Netherlands

Meersman H. and E. van de Voorde (2006), *Dynamic ports within a globalised world,* 17th International Symposium on theory and practice in transport economics and policy, ECMT/OECD, Berlin

NEA transport and training and Royal Haskoning (2008*), Improvement of Maritime Links between TRACECA and TENs Corridors – A market analysis,* TACIS project 117107, prepared for EuropeAid Cooperation Office of the European Commission

NEA, DEMIS, IWW, MKMETRIC, OSC, TINA Vienna (2009), *WORLDNET final report (D11*), project *funded by the* European Commission under its sixth Framework Programme

Notteboom T.E. (2004), Container Shipping and Ports: An overview, *Review of network Economics, vol. 3, Issue 2, pp 86-106*

RAND Europe (2004), *Hoofdonderzoek naar de reistijdwaardering in het goederenvervoer*, RAND TR-154 AVV

Robinson R. (2002), Ports as elements in value-driven chain systems: the new paradigm, *Maritime Policy & Management, vol. 29, no. 3, pp 241-255*

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Sanders F.M., R.J. Verhaeghe and S. Dekker (2005), *Investment dynamics for a congested transport network with competition: application to port planning,* Faculty of Civil Engineering, Delft University of Technology, the Netherlands

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