SOME EFFECTS OF HINTERLAND INFRASTRUCTURE PRICING ON PORT COMPETITIVENESS: CASE OF ANTWERP

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ABSTRACT

Now, more than ever, issues of port competitiveness are important, also in a context of containerized cargo. In a survey conducted amongst major shipping lines, the quality of hinterland connections is the second most important criterion for competitiveness of a port after the cost factor. However, most seaports, major as well as smaller, are often affected by congestion on those hinterland links. This paper tries to assess some of the effects that infrastructure pricing can have on the competitiveness of the seaports.

It is essential to identify the determinants of port competitiveness. In order to do that, a total of 30 literature sources were reviewed. Some older sources were reviewed, but the main attention is on the most recent literature. We focused on the criteria that other authors identify as important and also on the methodology that they use.

In order to test the information obtained in the literature review and evaluate the criteria identified in the literature, interviews with shipping lines were held. Top management people were interviewed covering 11 shipping lines that operate 45.7% of the world fleet of container vessels. The input provided by respondents from shipping companies enabled us to identify

decision makers in port selection, evaluate the importance of each port selection criterion for shipping companies, by applying those to a set of selected ports in Europe and compare their attractiveness. An evaluation by shipping companies of the importance and properties of different hinterland transport modes was obtained. According to the input provided by the respondents from shipping lines, the most important port competitiveness criteria for shipping companies are the cost of transport operations and the quality of hinterland connections. Previous research has shown that infrastructure pricing measures can be an efficient instrument for influencing the characteristics of the use of hinterland connections.

With the help of the Freight Model Flanders, a number of purpose-made scenarios were run. The scenarios were based on possible developments in the economy and in other parts of worldwide logistics networks, as well as on possible policy that could be introduced by the government. For interpreting the results, an important hinterland link for the Port of Antwerp was chosen: motorway E313, which serves as a freight connection between the Port of Antwerp and Germany. It is in a geographical position where it features competition from both rail and inland waterways, especially in dealing with port-bound traffic.

The results of this study show that not only in a Flemish context, but also in case of similar port hinterlands featuring strong road use and availability of rail and/or inland waterway infrastructure, pricing can be a factor that increases the competitiveness of the port. However, adverse effects are also possible in certain situations. The results are of high relevance to port authorities and policymakers in charge of alleviating port hinterland congestion problems.

Keywords: seaports, port competitiveness, hinterland transport, congestion, infrastructure pricing, mode choice

1. RATIONALE, SETTING AND METHODOLOGY

Ports these days get affected by competition more than ever before. In the past, typically, such competition was noted between individual ports in a range. More recently however, competition has evolved towards a different geographical and functional extent. First of all, the competitive field is no longer limited to some neighbouring ports. This is all the more true as the land transport means are further developing and compose alternatives for the maritime transport mode. Furthermore, competition nearly always also covers entire logistics chains, where ports and the maritime section are only elements, although elements that can make the difference between adoption and rejection of a particular chain. In those chains, different actors are present. For ports, there are not only port authorities, but also handling companies, shipping companies, and many other service providers. Each of these services has witnessed particular developments, either in the sense of a multiplication of the number of providers, a concentration on the other hand, or vertical integration through the chain.

All these developments have turned upside down the traditional view of port competition. Ports are confronted to a multitude of actors, that themselves are in permanent evolution. In this context, decision-making happens at a different rhythm and frame than in the past. To this evolution, it adds that the type of definitions to be taken is no longer comparable to the past. For instance, where, till now, ports counted on governments for infrastructure investment, or at least the biggest share of it, this is no longer so. Generally speaking, public budgets are shrinking, and there is strong competition with other consuming budget items, which, very often, feature less resistance among the public than port investments. The latter are often told these days to be very space-consuming, and bad in terms of environmental effects. In this frame, for ports that want to grow, there is an immediate need to go and get financial means elsewhere, for instance in co-operation with the private sector. This is a new task for ports. Next to that, other responsibilities have imposed themselves the latest years to port authorities.

This paper aims at clarifying the role of good hinterland connections in port competition. To this purpose, first, it is essential to identify the determinants of port competitiveness. In order to do that, a literature review based on 30 sources was done. In order to test the information obtained in the literature review and evaluate the criteria identified in the literature, interviews with shipping lines were held. This enabled us to obtain an evaluation by shipping companies of the importance and properties of different hinterland transport modes. In reality, most seaports, major as well as smaller, are often affected by congestion on those hinterland links. This paper tries to assess some of the effects that infrastructure pricing can have on the competitiveness of the seaports by modelling the effects to a case in Flanders. With the help of the Freight Model Flanders, a number of purpose-made scenarios were run. The scenarios are based on possible developments in the economy and in parts of worldwide logistics networks, as well as on possible policy that could be introduced by the government. For interpreting the results, an important hinterland link for the Port of Antwerp was chosen: motorway E313, which serves as a freight connection between the Port of Antwerp and Germany. It is in a geographical position where it features competition from both rail and inland waterways, especially in dealing with port-bound traffic.

In the analysis, the focus will be on the ports in the Hamburg – Le Havre range, and in particular the larger ports in that range. Equally, mainly the case of containers will be analysed, as this sector features the strongest worldwide changes.

This paper is composed of four more sections. Section 2 deals with the analysis from the literature on the importance of different criteria in port call selection and port competitiveness. Section 3 verifies this literature analysis with the survey and in-depth interviews among sector actors. Section 4 applies the results to the E313 case in Flanders.

2. LITERATURE REVIEW OF TRANSPORT CHOICE AND COMPETITIVENESS FACTORS

In the situation of fierce competition between ports, it is essential to identify the determinants of port competitiveness. This analysis splits up into two different parts. First, one needs to get hold on who actually takes decisions. Second, identification of their criteria for choice is required. In order to do that, a total of 30 references were used as the basis for the analytical review. Some older sources like Slack (1985), Branch (1986), Bird and Bland (1988), Frankel (1992), Murphy *et al.* (1992), Gibson *et al.* (1993), Murphy and Daley (1994) and Tongzon (1995) are reviewed, but the main focus is on the most recent literature. The choice of sources was not constrained by geographical considerations. The focus was on the criteria that the authors identify as important and also on the methodology that they use.

2.1 Decision makers identified

The decision makers that are identified by the authors of the papers are: shippers, forwarders, shipping companies and terminal operators. Some authors identify port authorities and government agencies influence on port choice.

A major part – 15 of the studies – identifies shippers as main or one of the decision makers in the port selection. Studies done by Branch (1986), Murphy and Daley (1994), Kumar and Vijay (2002), Nir *et al.* (2003), Tiwari *et al.* (2003), Malchow and Kanafani (2001), (2004), Guy and Urli (2006), Ugboma *et al.* (2006) and Leachman (2008) focus only on shippers as decision makers in port selection. Other sources, like Slack (1985), Murphy *et al.* (1992), Song and Yeo (2004), Cullinane *et al.* (2005), De Langen (2007) and De Martino and Morvillo (2008) consider shippers, but also take into account other actors as decision makers for port selection.

The studies that evaluate forwarders' decisions in port selection are by Slack (1985), Murphy *et al.* (1992), De Langen (2007) and De Martino and Morvillo (2008); in these sources, other actors are also considered. However, in studies of Bird and Bland (1988), Tongzon and Sawant (2007), Tongzon (1995),(2009), Grosso and Monteiro (2008) forwarders are the only decision makers considered, and a survey is chosen as the method of research.

Seven of the sources (Murphy *et al.* (1992), Lirn *et al.* (2004), Ha (2003), Song and Yeo (2004), Shintani *et al.* (2007), De Martino and Morvillo (2008), Meersman *et al.* (2008)) also evaluate shipping companies as port choice makers. Terminal operators are mentioned only in three sources (Song and Yeo (2004), Acosta *et al.* (2007), Meersman *et al.* (2008)). Only a few (Frankel (1992), Cullinane *et al.* (2005), De Martino and Morvillo (2008), Meersman *et al.* (2008)) focused on port choice criteria influence by government/port authority decisions.

2.2 Shifts of attention over time

Shippers and shipping companies have been in focus of the researchers during the whole period covered by the literature reviewed (from mid 80s till 2009). For a brief period of time around 1990 (Bird and Bland (1988); Frankel (1992); Murphy *et al.* (1992)) and in recent years (De Langen (2007); De Martino and Morvillo (2008); Grosso and Monteiro (2008); Tongzon (2009)) literature focuses on forwarders. Terminal operators are evaluated as port choice decision makers in the literature reviewed (Song and Yeo (2004); Acosta *et al.* (2007); Meersman *et al.* (2008)).

2.3 Methodologies applied

The most popular methodology for approaching the problem of determining port choice criteria is surveying the decision makers. This approach was taken in half of all the sources reviewed. Other approaches like analytic hierarchy process, literature analysis, multivariate and discrete choice analysis were also used by the authors in the literature reviewed.

2.4 Port choice criteria assessment

The literature reviewed reveals a considerable range of factors that have an influence on the decision of port choice. The most mentioned factors in order of citation times are: cost, location, port operations quality / reputation, speed / time, infrastructure / facilities availability, efficiency, frequency of sailings, port information systems, hinterland / intermodal links and congestion in port.

The authors have identified different criteria as important for port selection for different actors.

The criteria that are most mentioned as important to shippers (in order of citation times) are cost, port operations quality/reputation and port location. Less cited are frequency of shipping services, speed/time, efficiency of service, efficiency, port facilities/infrastructure, port information system, intermodal/hinterland connections, congestion in port, port services and flexibility (for special cargo).

According to the literature, the most mentioned criteria for forwarders are efficiency and port operation quality/reputation. Fewer times mentioned are cost, frequency, location, speed/time, port information systems and intermodal/hinterland connections.

For shipping companies, criteria that are most mentioned (in order of citation times) are cost, location, port facilities/infrastructure and port operations quality/reputation. Criteria of a lesser importance are speed/time, efficiency, congestion in port, frequency of shipping service, intermodal/hinterland links, port information systems, information availability, port administration, port services and flexibility for special cargo.

For terminal operators, criteria that are mentioned as important (in order of citation times) are: port facilities/infrastructure, port operations quality/reputation, cost, location, intermodal/hinterland links, port information systems, congestion in port and efficiency.

3. INTERVIEW RESULTS OF TRANSPORT DECISION-MAKING AND SELECTION CRITERIA

In order to test the information obtained in the literature review of section 2, and so as to objectively evaluate the criteria discussed previously, interviews were held. For the interviews, the following actors (a total of 35) were selected:

- Shipping companies;
- Terminal operators;
- Shippers;
- Logistics groups;
- European Logistics Centres.

Top management people were interviewed, covering among others 11 shipping lines that operate 45.7% of the world fleet of container vessels. Interviews were held during a period of almost 2 months from 7 April till 15 June 2009.

The input provided by respondents from shipping companies enables us to identify decision makers in port selection, evaluate the importance of each port selection criterion for shipping companies, applying those to a selected set of ports in Europe and to verify their attractiveness. Equally, the company's current flows are mapped, and insight is gained in the evolution of their future flow structure. Finally, an evaluation by shipping companies of the importance of and the score on different characteristics of hinterland transport modes will be made.

The input provided by terminal operators enables identifying decision makers in port selection, evaluating the importance of each selection criterion for investment purposes, and obtaining similar information on port selection by their customers. Evaluation of perceived current and future qualities of a selected set of seaports in respondents' opinion, split among terminal operators themselves, as well as by their customers, is also achieved. The same is done for the wider chain sections. Estimation is also made of the future development of carriers' networks, which in turn has an important impact on port competitiveness.

From the interviews with shippers, data on the latter's importance of transport service selection criteria are obtained, and performance of transportation services or transportation modes is evaluated. Perceived current and future qualities of selected ports can also be identified from the results.

The questionnaire among logistics groups allows for evaluation of transport solution and port selection decision making and criteria that the decisions are based on. Also, from the point of

view of logistic groups, perceived current and future qualities of transport modes can be identified. The same is true for seaports in case the logistics operator is involved.

Finally, the purpose of the questionnaire among logistics centres is to evaluate the importance of different location criteria, with main categories seaport accessibility, customer accessibility, land price, building/rental price and fiscal policy. Different regions in Western Europe are compared in their scores on the different variables. The EDC market is also mapped by gathering information on traffic flows through EDCs' logistics chains.

The main results from the interviews that have taken place are analyzed below.

3.1 Decision-makers in transportation

The answers on decision makers obtained from shipping lines seem to be greatly influenced by the business strategies that each company is using. However, some general conclusions still can be drawn.

Seaport selection is always done by the shipping company, but, as comments obtained during the interviews show, this choice is influenced by geographical considerations: the range of clients that can be served through that port, links to particular destinations, etc. Recently, there is a trend that the big shippers become more powerful in the decision on seaport selection because of their increased importance in the market. At the individual shipment level, the sender, forwarder and receiver also take part in the seaport selection.

In the selection of the transportation solution or mode, the most important role is played by the forwarder and sender of the cargo. However, in some cases, the shipping company takes part in making this decision.

Logistics/transport providers in most cases are selected by the forwarder or sender, and only in some business environments, it is made by the shipping company or receiver of the goods.

3.2 Criteria in selecting transport solutions

In order to evaluate the importance of port selection criteria for shipping companies during the interviews, the interviewees were presented a list of port selection criteria and asked to rank them and give comments on them. The most important criteria in order of importance for shipping companies are cost, quality of hinterland connections, capacity, reliability, port location (at sea or inland) and cargo base. Criteria of a lower importance are flexibility, customer service quality, location in port (if locks need to be used), total door-to-door transport time and feeder frequency. Risk of loss/damage is of low importance.

Shipping companies comment that a decision to call at a port can not be made without available cargo from/to that port, which is closely linked to ports' geographical location and

area that can be served through it. Also, inland port location is perceived as an advantage by shipping companies, because it allows for chain cost savings.

In evaluating hinterland transportation services or hinterland transport modes, by far the most important criterion is cost. After that come reliability, frequency of service, flexibility, and total door-to-door transport time and customer service quality. Environmental impact and risk of loss/damage are of low importance.

The transport mode or a set of transport modes that is used, is chosen mainly by taking into account the destination that has to be served, the value of goods, time constraints and the cost. The environmental impact of a transport mode is slowly gaining importance, mainly because of government policy with for instance internalization of external costs.

3.3 Scores for selected ports on port selection criteria

During the interviews, respondents were asked to evaluate the different port selection criteria identified in a defined set of ports with a scale from 1 (very bad) to 5 (very good). The set of ports was constructed looking for ports that are diversified in size, as well as in the origins of traffic. Due to the geographical distribution of the companies surveyed, not all companies could comment on all ports that were included in the questionnaire.

Table 1: Evaluation of port selection criteria for selected seaports (AVG (MIN - MAX))

	Felixstowe	**Zeebruges**	**Antwerp**	**Hamburg**	**Le Havre**
COST	3.2 (2 - 4)	4.0 (3 - 5)	4.4 (3 - 5)	3.4 (3 - 4)	3.1 (1 - 4)
HINTERLAND CONNECTIONS	3.4 (3 - 4)	3.3 (2 - 4)	4.5 (4 - 5)	4.4 (4 - 5)	3.6 (2 - 4)
PORT CAPACITY	2.7 (1 - 4)	4.3 (3 - 5)	4.6 (4 - 5)	3.7 (2 - 5)	4.4 (4 - 5)
RELIABILITY	3.0 (2 - 4)	4.3 (4 - 5)	4.5 (4 - 5)	4.1 (3 - 5)	2.4 (2 - 4)
PORT LOCATION	3.2 (2 - 4)	3.4 (2 - 4)	4.2 (3 - 5)	4.4 (3 - 5)	3.8 (2 - 5)
CARGO BASE	3.4 (1 - 4)	3.1 (2 - 5)	4.4 (3 - 5)	4.2 (3 - 5)	3.3 (2 - 4)
FLEXIBILITY	3.0 (2 - 5)	4.0 (3 - 5)	4.5 (4 - 5)	3.8 (2 - 5)	2.4 (1 - 3)
CUSTOMER SERVICE	3.5 (3 - 5)	3.8 (3 - 5)	4.2 (3 - 5)	3.9 (3 - 5)	3.1 (2 - 5)
FREQUENCY	2.7 (1 - 4)	2.9 (2 - 4.5)	3.4 (2 - 5)	4.8 (4 - 5)	2.6 (1 - 4)
RISK OF LOSS/DAMAGE	4.0 (2 - 5)	4.4 (4 - 5)	4.8 (4 - 5)	4.6 (4 - 5)	4.3 (2 - 5)
CUSTOMS SERVICE	3.6 (2 - 5)	3.4 (3 - 4)	3.0 (2 - 4)	3.9 (3 - 5)	2.9 (2 - 4)

The best scores for most criteria considered are found in Antwerp. On the most important criterion, the cost, a wide divergence among ports is observed. Respondents furthermore commented that the port of Le Havre is scoring low in reliability and flexibility because of the social instability created by trade unions and frequent strikes. Some shipping lines mentioned that this is one of the main reasons why they decide to stop calling Le Havre. Also, lack of hinterland connections is mentioned as a disadvantage in Le Havre and particularly also in Felixstowe and Zeebruges. For Felixstowe, port capacity is one of the main problems.

3.4 Evaluation of port investment plans, including hinterland

Shipping lines were presented a summary of improvements and investments (see Table 2) that are planned or being effectuated in some of the ports, in order to give their evaluation of the importance of these actions.

Table 2: Summary of port investment actions

Port	Improvements
Felixstowe	improved rail connections
Zeebruges	Extend quay length at various terminals + new terminal (3 million TEU extra); new lock; logistics zone development; new shunting yard
Antwerp	complete Deurganckdok + build Saeftinghedok (3+6 million TEU extra); new intermodal terminal; Scheldt deepening
Hamburg	terminal extensions: 10 million TEU more by 2010
Le Havre	logistics zone and multimodal platform for rail and barge development Complete Port 2000 (capacity of 4.2 M TEU)

In general, all the investments are perceived positively, but also some valuable comments and suggestions were received. In Felixstowe, the developments of rail connections were valued positively since rail hinterland connections is the problematic issue that this port is facing.

Zeebruges receives very positive valuation of developments: extending of quay length, logistics zone development and railway developments. Some shipping lines mention that Zeebruges might become a hub port for their operations in the future.

For Antwerp, one of the developments that is mentioned: the Scheldt dredging is of vital importance. However, the Saeftinghe dock development is perceived as an unnecessary action at the moment and it should be slowed down or postponed until the end of economic crisis.

In Hamburg, the planned developments are valued positively because lack of capacity is an important issue; some rationalization initiatives should also be developed. It is mentioned that dredging works should be planned in order to be able to accommodate new larger ships.

For Le Havre it was mentioned that further investments should focus on the development of hinterland connections. Barge and rail connections should be improved in the direction of Paris. Further promotion of barge connections in the direction of Strasbourg was also mentioned as a suggestion. The improvements that were mentioned were evaluated as valuable. It was also noted that Le Havre has no capacity problems.

3.5 Expected future quality of hinterland transport modes

The respondents from shipping lines were asked to give an evaluation of the expected future quality of hinterland transport modes. Table 3 shows a summary of the responses. It can be seen that, rather surprisingly, intermodal transport is expected to leave better scores than individual road and rail solutions, in particular on cost and reliability.

Table 3: Expected future quality of hinterland transport modes (averages) by shipping lines

	ROAD	RAIL	INTERMODAL (including Short Sea and Barge)
RELIABILITY	3.90	3.56	4.40
FLEXIBILITY	4.64	2.44	3.50
RISK OF LOSS/DAMAGE	3.50	3.67	3.80
FREQUENCY	4.70	3.44	3.75
COST	3.40	3.33	4.30
D2D TOTAL TRANSPORT TIME	4.09	3.28	3.50
CUSTOMER SERVICE	4.10	2.67	3.70
ENVIRONMENTAL IMPACT	1.90	4.00	3.90

4. APPLICATION OF ROAD PRICING TO THE E313 CASE

As far as congestion is concerned, sea ports are often shown to be worst hit on the land side, as is also shown in the port scores and improvement needs identified in the previous section. This observation is also true for Flanders. At the same time, smooth hinterland connections turn out to be crucial in port selection. In this paper, we analyse the situation for the E313 motorway, which is approximately 120 kilometres long. It connects Antwerp to Liège and is a link to the Ruhr area in Germany, as can be seen in Figure 1. For most of its length, it has two lanes in each direction.

The Port of Antwerp, the second largest port in Europe for international freight shipping, is one of the main generators of heavy goods vehicle traffic for the E313 route. Data for recent years shows that around 40% of all goods flows of the Port of Antwerp are transported to/from the port by road.

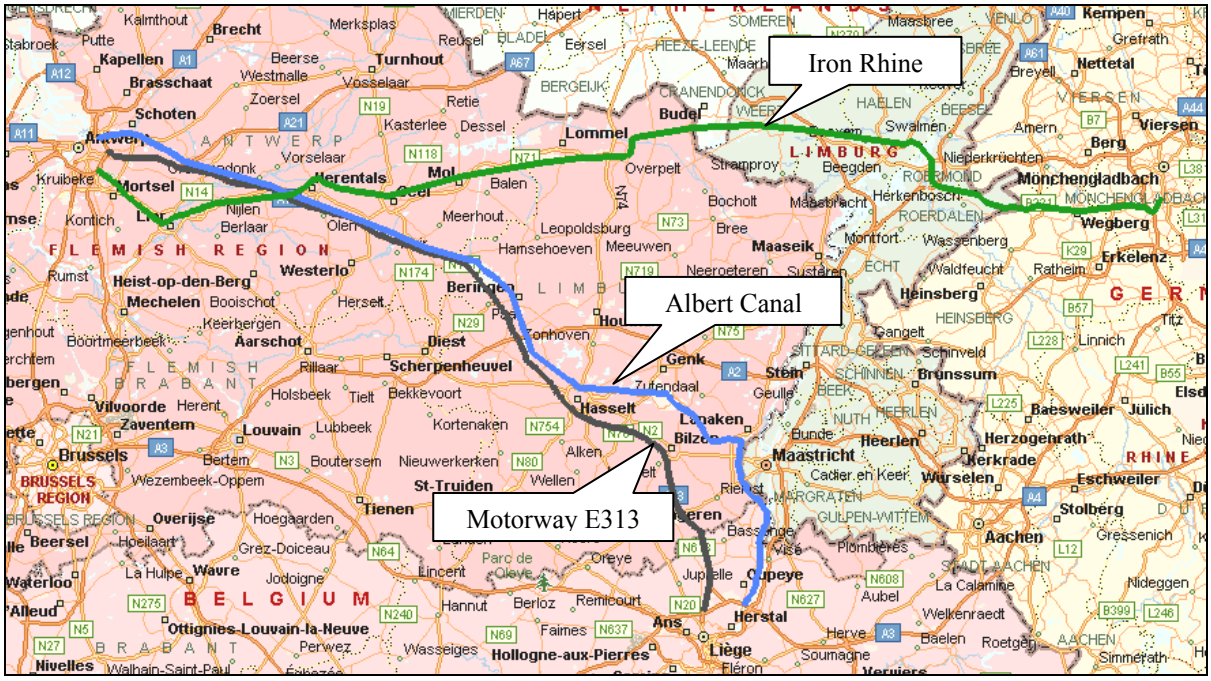


Figure 1: Motorway E313 (grey), Iron Rhine (green) and Albert Canal (blue)

The motorway features particular competition from both rail and inland waterways, especially in dealing with port-bound traffic. As to waterways, the Albert Canal, which runs mainly in parallel with the motorway, is currently being subject to capacity expansion through the extension and elevation of a number of bridges that cross the canal. From the rail side, the Iron Rhine is a potential competitor of the E313 motorway. It is the historic railway line, started up in 1879, that runs from Antwerp to the German Ruhr area. Since 1991, this track is no longer used for international transport. Nowadays, the so-called Montzen route is used, which makes a detour over Liège. The Belgian Government has stated its intention to resume and intensify the use of the Iron Rhine railway line. Restoration, alteration and modernisation (referred to as “reactivation”) of the Iron Rhine route will therefore be required. Both Iron Rhine and Albert canal are part of the TEN-T network. The Iron Rhine falls within rail axis nr.24 (Lyon/Genova-Basel-Duisburg-Rotterdam/Antwerpen), whereas the Albert Canal is part of axis nr.18 (Rhine/Meuse-Main-Danube).

Capacity optimization seems to impose itself, in view of the frequent occurrence of congestion and the many accidents featuring the motorway. The severity of the problem shows up also in a survey held among Flemish road transport companies (Gevaers *et al.* (2009)). On the other hand, a number of more general capacity optimization measures are being put in place by the European Commission but more importantly also by the Flemish government. The latter also deploys a mode shift strategy, with the aim of increasing the chances of both inland navigation and rail transport.

The study focuses on measuring the effectiveness of policy instruments and their combinations on E313 traffic. Various kinds of instruments are taken into account in the model scenarios. As a key instrument, the impact of road pricing is considered. Road pricing could either be deployed on motorways only or on all roads.

4.1 The E313 context and future developments

In order to outline possible future developments, first, a qualitative impact analysis was performed of port traffic evolutions, Albert canal expansion, short sea shipping evolutions, European policy developments, instruments developed within Flanders Logistics, Flanders Port Area and Flanders Inland Shipping Network, the possible re-introduction of the Iron Rhine, road infrastructure bottlenecks, and other important influencing factors on the E313. Expanding road infrastructure over part or all of the motorway length was not considered to be a feasible solution at reasonable notice.

1. The Port of Antwerp, the second largest port in Europe for international freight shipping, is one of the main sources of lorry traffic for the E313 route. Mode split data (in TEU) for recent years show that ~60% of the container turnover that is generated by the Port of Antwerp is transported to/from the port by road overall.

   Based on the capacity and demand forecast by Ocean Shipping Consultants (2006), and the two possible scenarios of the port market increase (case1 – the market share of the Port of Antwerp increases according to the current trend, case2 – the market share of the Port of Antwerp stays at the current level), a forecast of container turnover for the Port of Antwerp can be done using linear extrapolation (see Figure 2). Estimates containing the longer-run effects of the economic crisis starting in 2008 were not available at the moment of writing this paper.

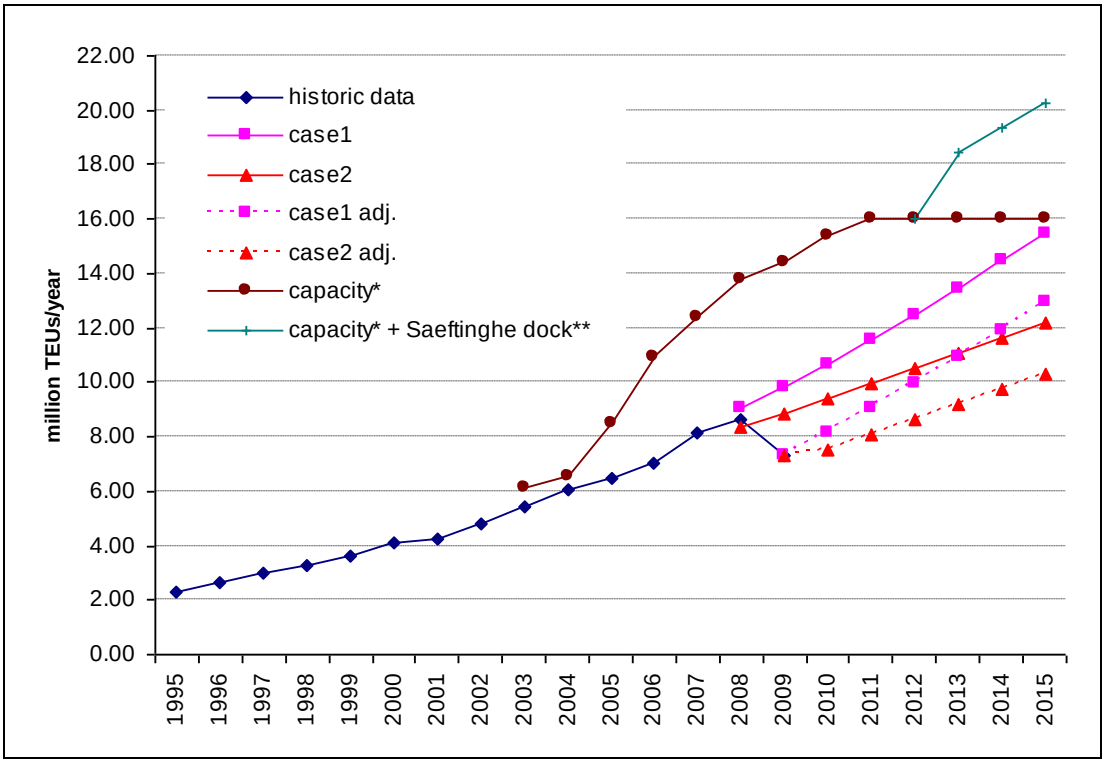
   Making abstraction of the current economic crisis and assuming recovery after it[1], container turnover in future years is expected to continue its growth. In the optimistic scenario, case1, it is expected to reach 15.5 million TEUs. In a pessimistic situation, case2, it will rise to 12.7 million TEUs in 2015.

   For the year 2008, which marks the beginning of the current economic crisis, the initial forecast was accurate. In 2009 a 15.6% reduction is observed (shown in Figure 2). New adjusted case 1 and case 2 scenarios could be put in place then.

   It is important to look at port container handling capacity, because it is a limiting factor in port development. There is also a risk of decreased service level in the port in case it is working near its full capacity. The information on container handling capacity as forecast by Ocean Shipping Consultants is also displayed in Figure 2. A forecast of the capacity development with the Saeftinghe dock in the Port of Antwerp from 2013 onwards is given.

[1] The crisis might have structural impacts on the port of Antwerp. This might have as a consequence that it will take a considerable number of years before the port traffic is again at the pre-crisis level. However, at this stage, it is unclear how strong this effect will be.

Figure 2: Container turnover forecast, Port of Antwerp



*Capacity forecast for Port of Antwerp by Ocean Shipping Consultants (2006)

** Forecast of Saeftinghe dock capacity

Based on an analysis for the period 2001-2009 of the historic data on port turnover for the Port of Antwerp, traffic count data obtained from the Flemish Traffic Centre on heavy goods vehicle traffic, and results from simulations with the Freight Model Flanders, there seems to be a relation between the traffic volumes of those vehicles on the E313 motorway and the port turnover. The forecast long term increase in port traffic (see Figure 2) may therefore have an effect on the heavy goods vehicle traffic on the E313 motorway.

2. Short Sea Shipping (SSS) holds an important share of the transport market within the European Union. According to European Commission (2009), it represents 40% of the intra-EU exchanges in terms of tonne-kilometres. The relevance of this transport mode in maintaining an efficient transport system in Europe today and in the future was emphasized by the European Commission (2001) in its White Paper on European Transport Policy 2010. SSS has maintained its position as the only mode of transport able to challenge the fast growth of road transport. Between 1995 and 2004, the tonne-kilometre performance of SSS in the EU-25 grew by 32 %, while road performance grew by 35 % (European Commission (2006b)).

   The average annual tonnage growth rate of SSS over the period 2000-2006 for Belgium was 3.2% (on average 3% for the EU-15 countries). The SSS container

turnover in Belgium for the same years has gone up on average by 19.3%, compared to the average of the EU-15 countries, which was at 8.0% (Amerini (2008)).

Although SSS overall may reduce the share of road traffic, it induces local concentrations of traffic, from and to ports. This for sure also affects the E313 motorway, in both ways. Therefore, trends of increase in SSS should be taken into account, although the exact magnitude of both effects is not fully sure

3. The Albert canal is a direct competitor to the E313 motorway. A project to increase the capacity of the Albert Canal has just started and requires the replacement of a number of bridges. Modernization of the Albert Canal waterway for navigation of vessels of up to 9,000 t carrying capacity will allow barges to sail with containers stacked up to four high. The work that still has to be done includes the elimination of a bottleneck between Wijnegem and Antwerp, where the Canal is barely navigable for vessels of class Va, whereas the rest of the Canal is suited for class VIb vessels and push convoys. Moreover, on this section, the bridges have the lowest clearance, some less than 7 m, which is the standard for three-layer container navigation only. Eliminating these barriers will open up the Albert Canal for bigger and wider vessels and will allow full use of the Canal on its total length. The project includes the widening of the Canal up to a minimum width of 63 m. (United United Nations Economic and Social Council (2006); European Commission (2008a); nv De Scheepvaart (2008))

4. Just like the Albert Canal, the Iron Rhine is also a potential competitor to the E313 motorway. It is the historic railway line, built in 1879, that runs from Antwerp to Duisburg. Since 1991 this track has not been used anymore for international trains. From Antwerp the track runs through, among others, Lier, Budel, Weert and Roermond and ends in Mönchengladbach. The complete track has a length of 162 km of which 96 km is located in Belgium, 48 km in the Netherlands and 18 km in Germany.

   Currently, Antwerp port-related traffic uses the Montzen route, south of the Iron Rhine, from Antwerp to Aachen via Aarschot, Hasselt, Tongeren and Montzen, for transportation of goods to Germany. High passenger traffic on parts of this route causes a lack of capacity for goods. Moreover, a number of steep slopes over the route make it problematic for long and heavy trains to pass. In 2004, Belgium requested a reopening of the Iron Rhine.

   In 2006, it was concluded that by the year 2020, in a situation where the Iron Rhine is reactivated, the line is expected to attract between 9.4 and 12.3 million tonnes on the section crossing the Dutch-Belgian border. Most of the traffic, approximately 80%, is estimated to be diverted away from the Montzen route. Freight transport from other competing rail lines would also be attracted, e.g. from the route from Belgium via Luxemburg to Germany and the Brabant route. A slight mode shift of 0.3 to 0.4 million tonnes towards rail will also occur, mainly diverted away from inland shipping. By the

year 2030, the volume of freight transported over the Iron Rhine will have increased to between 10.8 and 17.2 million tonnes. Recent analyses also show that economic viability at short notice of this project, under current market and operating conditions, is not evident. (NEA Transport research and training and Universiteit Antwerpen (2007); Transport & Mobility Leuven (2007))

5. Europe is currently in a situation where the pressure from increasing goods flows rises. The road network is congested during peak hours and on crucial stretches, the rail sector is struggling to increase freight transport capacity, and the existing land based infrastructure cannot readily cope with the increase in traffic volume at the pace at which it is now growing, mainly due to bottlenecks. Additionally, in Flanders, a supplementary problem occurs with inland navigation, which is hampered in some locations by too shallow waters. As European freight volumes might increase with as much as 50% by the year 2020 (Institute of Shipping Analysis, Göteborg *et al.* (2006)), the situation will continue to worsen unless action is taken.

   The EU legislation and developments that may have the biggest influence on the further development of the E313 motorway are the following:

   a. Taxation of heavy goods vehicles: “Eurovignette” Directive
   Directive 1999/62/EC of the European Parliament and of the Council of 17 June 1999
   Amending acts: directive 2006/38/EC and directive 2006/103/EC.
   The Directive covers vehicle taxes, tolls and user charges imposed on vehicles intended for the carriage of goods by road and having a maximum permissible gross laden weight of not less than 12 tonnes. From 2012 onwards, Directive 2006/38/EC will apply to vehicles weighing between 3.5 and 12 tonnes.
   Proposal for a Directive on road tolls for lorries (amending 1999/62/EC)
   This proposal would enable Member States to reduce environmental damage and congestion through more efficient and greener road tolls for lorries. Revenue from the tolls would be used to reduce environmental impacts and cut congestion. This proposal is part of Greening Transport Package (adopted 8 July 2008). (European Commission (2008b))

   b. TEN-T plans
   The TEN-T network axis with most impact to the E313 motorway are rail axis nr. 24 Lyon/Genova – Basel – Duisburg - Rotterdam/Antwerpen, which includes the Iron Rhine Rheidt-Antwerp railway and inland waterway axis nr.18 Rhine/Meuse-Main-Danube with sub-section Albert canal. Other TEN-T network links have little or no impact on the E313 motorway.

   c. Road safety: Road Safety Action Programme (2003-2010)
   Main measures: to propose a Directive on road infrastructure safety, draw up technical guidelines concerning audit methods, urban safety management and speed-moderation techniques, draw up good practice guidelines for level-crossings, carry out research and demonstration projects on 'intelligent roads', carry out safety impact

assessments of new projects, improve safety levels in tunnels, etc. (European Commission (2003))

d. Road vehicles: maximum weights and dimensions
Council Directive 96/53/EC of 25 July 1996 laying down for certain vehicles circulating within the Community the maximum authorised dimensions in national and international traffic and the maximum authorised weights in international traffic. Amending act: Directive 2002/7/EC

4.2 Modeling setup, scenarios and assumptions

In the previous sub-section, some elements have been selected which have effect on the use of the E313 motorway. A number of these elements have been inserted a freight model, in order to quantify the effects.

Commissioned by the Flemish Traffic Centre, a new freight model for Flanders has been developed by K+P Transport Consultants, Tritel and Mint. Based on the freight model, it is possible to simulate future freight flows, split up by mode (road, rail and inland waterways) and NST freight category. A classical 4-step model has been used:

- Generation of flows: determines the flows leaving from (or arriving in) zone i (j) in a period. For freight transport, this means that for freight category k it is calculated how many tons are leaving from (arriving in) zone i (j);
- Distribution of flows: the generation of flows serves as input for this stage. The freight flows are determined between zones i and j;
- Mode choice: analyses which mode is used to move tons from zone i to j;
- Assignment: comprises route choice, after translating the tonnages into number of vehicles in a traffic conversion section.

Transport Logistic Nodes (TLN) are also included in the model. A TLN zone is a transfer point where loads change the means of transport, which is not necessarily the mode, simultaneously with a re-consolidation of the shipment. The Freight Model Flanders takes into account the so-called decided infrastructure changes of the Flemish government.

A number of purpose-made scenarios have been constructed (see Table 4). The scenarios are based on possible developments in the economy, as well as on possible policy that could be introduced by the government. Each scenario is a combination of several assumptions: economic, policy-related, linked to population and household consumption, dealing with import and export, and with inland navigation and ports. Underlying assumptions are explained in the next section.

Table 4: Modeling scenarios

	Economic assumptions; assumptions import and export	**Policy assumptions**	**Assumptions inland navigation**	**Port assumptions**
Scenario 1	Low growth	Continuation of current policy	Continuation of current policy	Following economic assumptions
Scenario 2	Low growth	Continuation of current policy	Extra measure inland navigation	Following economic assumptions
Reference scenario	**Normal growth**	**Continuation of current policy**	**Continuation of current policy**	**Following economic assumptions**
Scenario 3	Normal growth	Continuation of current policy	Extra measure inland navigation	Following economic assumptions
Scenario 4	Normal growth	Moderate transport policy	Continuation of current policy	Following economic assumptions
Scenario 5	Normal growth	Moderate transport policy	Extra measure inland navigation	Following economic assumptions
Scenario 6	High growth	Moderate transport policy	Continuation of current policy	Following economic assumptions
Scenario 7	High growth	Moderate transport policy	Extra measure inland navigation	Following economic assumptions
Scenario 8	Normal growth	Internalizing external costs of all modes	Continuation of current policy	Following economic assumptions
Scenario 9	Normal growth	Continuation of current policy	Continuation of current policy	0.5 x results economic assumptions
Scenario 10	Normal growth	Continuation of current policy	Continuation of current policy	1.5 x results economic assumptions
Scenario 11	Normal growth	Internalizing external costs of all modes	Continuation of current policy	0.5 x results economic assumptions
Scenario 12	Normal growth	Internalizing external costs of all modes	Continuation of current policy	1.5 x results economic assumptions

Following assumptions are taken into account in the modeling exercise.

1. Economic, import and export assumptions

   In *European Energy and Transport Trends to 2030 – update 2005* (European Commission (2006a)), a yearly economic growth of 2% until 2020 in Belgium is reported. This economic growth represents the yearly evolution of the Gross Domestic Product (GDP) in real terms, adjusted for inflation. This leads to 3 economic assumptions in this research project:
   Economic assumption 1: low growth (growth GDP – 0.5% = 1.5%)
   Economic assumption 2: normal growth (growth GDP = 2%)
   Economic assumption 3: high growth (growth GDP + 0.5% = 2.5%)

   For foreign zones, the evolution of GDP is used as a proxy for the magnitude of freight flows between Flanders and those zones. We also refer to the forecasting report of the European Commission (2006a).

The growth of the import and export flows in value also serves as an explaining variable in the freight model. Both import and export flows follow the economic assumptions described above. Based on Federaal Planbureau (2008), it is assumed that the import and export flows will grow by 4.3% yearly when we have a normal growth in the economic assumptions, 3.8% if economic assumptions indicate a low growth, and 4.8% in case of high growth.

2. Policy assumptions

A distinction is made between a continuation of the current policy, a moderate transport policy, and a policy where the external costs of all transport modes are internalized.

a. Continuation of the current policy

In the assumption of continuation of the current policy, a growth of 0.1% per year of the costs of road and rail transport is assumed to exist. A growth of the costs of road transport is considered as probable given the far advanced deregulation of the road freight transport sector, where the largest cost advantages from deregulation have already been gained. For rail freight transport, the persistent dominance of national railway companies is assumed. A deregulation leads to a reduction of national subsidies and will cause an upward pressure on the prices (NEA Transport research and training and Universiteit Antwerpen (2007)). These growth percentages should be seen as relative percentages. In other words, road transport and rail transport will have a slightly bigger cost increase compared with inland navigation. In this analysis, it is not necessary to look up the actual growth percentages. Growth percentages respecting the relative position between the modes, which are much easier to obtain, are sufficient.

b. Moderate transport policy

The moderate transport policy differs from the continuation of the current policy in the assumptions made for the evolution of the costs for road and rail[2]. It is assumed that road pricing is introduced on the highways in the Benelux. The amount is set to be €0.15 per kilometre and it will replace the traffic tax and the Euro-vignette. On the non-highways, this value is set to be €0 per kilometre. In theory, a difference should be made between Belgian, Dutch and Luxemburg trucks on the one hand and other trucks. Given the fact that the traffic tax and Euro-vignette will disappear for the Belgian, Dutch and Luxemburg trucks, the other trucks have still a cost per kilometre different from zero. However, in the freight model, it was not possible to make this distinction. For rail, it is assumed that a higher user fee will be introduced: in total €3.30 per train-km).

c. Internalizing external costs of all modes (road, rail and inland waterways)

[2] The values mentioned in this text refer to NEA Transport research and training and Universiteit Antwerpen (2007).

Internalizing external costs of all modes starts with the assumptions from the scenarios on continuation of current policy and of moderate transport policy. It is now assumed that the internalization of external costs will apply to all modes of ground transport. According to NEA Transport research and training and Universiteit Antwerpen (2007), the following values were used in the model and applied to all types of infrastructure:

- Road: €0.075 per tonkm
- Rail: €0.005 per tonkm
- Inland waterways: €0.005 per tonkm

3. Specific assumptions for inland navigation

   In order to simulate cost advantages for inland waterway transport, specific assumptions have been introduced.
   - Continuation of current policy;
   - Extra measure for inland navigation: a yearly cost reduction of 2% of the cost of inland navigation, e.g. as a result of more efficient use of inland waterways.

4. Port assumptions

   In scenarios 9-12 (see Table 4) explicit assumptions about the port of Antwerp are taken into account. Scenarios 1-8 and the reference scenario comprise a basic growth path for the port of Antwerp which is based on the different economic assumptions.

   Additionally, in scenarios 9-12 some specific growth patterns are considered to simulate a weakening or strengthening of the competitive position of the port of Antwerp:
   - In case of a stronger competitive position it is assumed that the incoming and outgoing flows in tonnage for the port of Antwerp are 1.5 the initially estimated values;
   - In case of a weaker competitive position, it is assumed that the incoming and outgoing flows in tonnage for the port of Antwerp are half the initially estimated values.

   Scenarios 9-12 therefore allow for changes in port competition within the freight model.

4.3 Modeling results

A three-level approach has been adopted to interpret the simulations results. The full simulation results themselves are available in the report by Aronietis *et al.* (2009). Three types of output were produced:

1. Calculation of total tonnages and growth figures for every scenario. For some specific points on the E313 motorway the tonnages (and hence vehicles) passing by are analyzed.
2. Evaluation of route changes based on difference plots.

3. Mode shift analysis.

Based on the three-level approach that has been adopted to interpret the simulation results, a list of observations was made. On a general level we found that:

1. The results of the simulations show that combinations of measures with similar consequences have a bigger effect. Therefore, for practical implementation, a combination of measures is more advisable.
2. A specific scenario may have different, even adverse effects on the traffic volumes in different points and directions of the road network.

Pricing policies have the following consequences

1. The introduction of a moderate transport policy leads to a decrease of the traffic on the E313, but leads to an increase at the lower network. In practice, it means that route diversion occurs when a moderate policy in terms of kilometre cost charging on the highways is being enforced.
2. In the case of charging the entire network with a kilometre cost variable equal to €0.15 together, the results differ substantially, showing that the decrease in tonnage becomes more widespread in the network.
3. The introduction of the internalization of external costs policy for all modes creates the same network pattern but with the effects being more pronounced than the scenarios of moderate policy.
4. The introduction of the internalization of external costs leads to a significant change in the mode split between road, rail and inland navigation. The shift of road transport mainly moves towards inland navigation. For instance, concerning incoming flows to the port of Antwerp, the mode share for inland waterways goes from 40% to 48%.

With regard to evolutions of port traffic, the major conclusion is that scenarios with port growth variations clearly show the impacts of port turnover dynamics on the traffic on the locations at the E313 motorway. The increased/decreased port throughput has an influence both on incoming and outgoing flows, but the level of effect is different. The incoming flows are influenced less than the outgoing flows.

Changes in economic and transport growth have the following major impacts:

1. The result of low-growth assumptions on the goods flows on the E313 motorway is that, as expected, the volumes of the goods flows and also the annual growth decreases in all the locations on the motorway.
2. The model captures the increase (decrease) in economic growth and international trade and links it to the higher (lower) growth of goods flows on the E313 motorway.

5. CONCLUSIONS

It is clear from the analysis in this paper that hinterland connections and accessibility are an important factor in port selection and transport decision-making, in general by all actors that

make decisions. This is learned from the literature review performed, as well as from the in-depth interviews that were held with shipping companies, shippers, forwarders and logistics groups in or linked to ports. Equally, it turns out that the valuation of different ports with respect to hinterland connectivity strongly differs. Moreover, a number of factors are related to connectivity: reliability, frequency of services, etc. For these factors too, strong divergencies between ports are observed.

When applying road pricing as a solution to road hinterland capacity problems, it turns out that this is an effective means of reducing traffic overall. However, when introducing road pricing only on motorways, negative, traffic-increasing effects exist on the underlying, secondary road network. Equally, it can be seen that road pricing mainly leads to a shift towards inland navigation. The effect is all the stronger as a full internalization of external costs replaces a moderate transport policy. It can also be observed that a well-equilibrated package of measures leads to better results than when pricing is introduced in isolation.

Road pricing therefore turns out to be an effective measure for improving the smoothness of hinterland operations. A first effect to be observed is a shift towards other modes. When the price exceeds a certain level, or when insufficient alternatives are available, a shift towards other ports may be made. It therefore requires further research, so as to test what price level is optimal in internalizing external costs made, and at the same time not pushing away valuable port traffic.

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