Original Article

The container transport system: Selection criteria and business attractiveness for North-European ports

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Abstract In the modern global business environment, port policymakers must continuously make an effort to understand what factors influence port users' choice of port. This article identifies which factors affect port selection most strongly. It does so for three ports: Antwerp, Rotterdam and Hamburg – and three types of decision makers: shippers, carriers and freight forwarders. The Analytical Hierarchy Process method is applied to gauge port players' prioritization of decision factors in port selection. Data are collected by means of two sets of questionnaire surveys. The prioritized criteria differ between the three mentioned respondent groups, which is attributed to their respective positions and responsibilities within the supply chain, and the contract of carriage concerned (carrier haulage or merchant haulage). The overall results yield the following ranking of port selection criteria in decreasing order of importance: port costs, geographical location, quality of hinterland connections, productivity and capacity. In respect of general port attractiveness, Antwerp is found to be the most attractive, followed by Rotterdam in second place, and Hamburg in third.

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Introduction and Problem Setting

With the ongoing globalization of production and expansion of consumption and trade, and in view of their strategic role in domestic economic growth, ports are playing an increasingly crucial role as transport nodes in supply

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chains and as logistics centres. At the same time, port competition is becoming stronger especially among those ports vying for the same container flows (Meersman *et al*, 2013; Van Hassel *et al,* 2014) and serving overlapping secondary markets and hinterlands.

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

The significance of this issue is raised further by the debate that arose for instance in Antwerp after General Motors' decision in late 2010 to close the Opel production facilities in the port of Antwerp. Relocation of such manufacturers as main port clients has significant consequences for ports, in terms of demand.

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

Additional insight is required also for the generally well-studied North-European ports. Container throughput in the nine main ports of Northern Europe – Hamburg, Bremen, Amsterdam, Rotterdam, Antwerp, Ghent, Zeebrugge, Dunkirk and Le Havre – is four times greater than that of the principal 11 ports located along Europe's southern coastline. The northern seaports offer the most efficient routes for container transport into a large part of the central European hinterland (CargonewsAsia, 2012; Meersman *et al*, 2013).

Among these Northern European ports, Antwerp, Hamburg, and Rotterdam are the leading players in the fields of conventional general cargo and containers, and they compete among each other for as large a share as possible in these trades (Ng, 2010, 2006; Port Technology International, 2014a; van Hassel *et al*, 2014)

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

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

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

The article takes off in the next section with a review of similar past analyses and a methodology selection. The subsequent section continues by applying the different steps of the methodology: choice criteria determination, criteria ranking, and port scoring on the criteria. The results of the analysis are presented, analysed and discussed in the one but last section. The final section draws conclusions and lessons for further research.

Literature Review and Methodology

An approach that has often been applied in various contexts for similar research is The Analytical Hierarchy Process (AHP), developed and introduced by Saaty (1977, 1986). Applications outside ports include travel demand (Banai-Kashani, 1989), land evaluation techniques (Elaalem *et al*, 2010), environmental issues (Colombo *et al*, 2006), project management (Al-Subhi Al-Harbi, 2001; Torfi and Rashidi, 2011), consumer preferences (Meiβner and Decker, 2009; Kallas *et al*, 2011) and shipping finance (Psaraftis, 2006). For port choice selection, applications do exist too: Pires da Cruz *et al*, 2013; Onut *et al*, 2011; Chou, 2010; Xiaoqing, 2009; Meiβner and Decker, 2009; Ugboma *et al*, 2007; Lirn *et al*, 2004; Song and Yeo, 2004;

Meiβner and Decker (2009), by comparing AHP and CBA for market share predictions, find that AHP significantly outperforms CBA. Chou's (2010) study of north, central, and south ports in Taiwan reveals that the draught of containership berths, port costs, and efficiency are the most relevant factors for ocean carriers. Ugbom *et al* (2007) identify seven port seclection factors and four Nigerian ports that shippers consider in their decision-making process; their findings suggest that the highest emphasis should be on efficiency, frequency of ship calls, and adequate infrastructure. Pires da Cruz *et al* (2013) distinguish among port users' and service providers' key port selection factors. Service providers rank the technical factors – for example, port facilities, channel depth, and so on – highest while for port users, commercial factors – for example, vessel turnaround time, intermodal links and so on – are more important. Lirn *et al*'s (2004) findings reveal that both carriers and service providers have similar perceptions of the most important attributes for transhipment port selection. Onut *et al* (2011) applied AHP to evaluate alternative ports in the Marmara region based on conflicting qualitative and quantitative criteria. Song and Yeo (2004) identified five important factors for Asian ports which are cargo volume, port facilities and location, service level, and port costs. Despite this wide scope of application, the procedure followed has remained basically the same. What follows is an overview of the advantages of the method in relation to the research of this article, and argumentation of how disadvantages are taken into account.

Advantages of AHP

The advantages of AHP relate to its capability of capturing a wide range of quantitative and qualitative variables. Many users favour this methodology because of its combinability with other approaches like for example, fuzzy analysis (Carter, 1991; Mendoza *et al*, 1999; Kurttila *et al*, 2000; Kangas *et al*, 2001; Leviakangas and Lahesmaa, 2002; Chou *et al*, 2003; Mahmoodzadeh and Shahrabi, 2007; Xiaoqing, 2009), as well as its ease of application (Department for Communities and Local Government, 2009). Moreover, pairwise comparisons of data input is found straightforward and convenient by most users (Kasperczyk and Knickel, 2014). The possibility to check for consistency of judgments across all pairwise comparisons makes AHP a useful and flexible instrument (Saaty, 1986; Ramanathan, 2001). In this research the observations with inconsistency indicator less than 0.1 are included. By calculating the geometric mean of the individual pairwise comparisons, AHP methods allow extrapolation to group decision making (Zahir, 1999). The geometric mean is used in the current study to explore the group decision out of individuals' judgements. Another important benefit is that AHP yields more realistic results

for policy makers which are one of the target groups for implementing the results of this article. Moreover, no specific time scale is associated with AHP and there are no limitations regarding geographical coverage (Kasperczyk and Knickel, 2014).

Disadvantages of AHP

With regard to input data collection, interviewees may often find the questions vague and confusing and therefore individual responses may not always be scientifically trustworthy. The scale of measures representing the preferences of respondents is not always clear to them. Much has been written on what is the most appropriate scale (see for example Kasperczyk and Knickel (2014), Belton (1986), Belton and Gear (1983), Triantaphyllou (2001), Communities and Local Government (2009)). In the literature, two important criticisms come to the fore. First, it is argued that respondents may find it hard to distinguish on a 9-point scale. For the sake of simplification in this research, the 9-point scale is converted to a five-point one. Second, concern has been raised in relation to rank reversal. Taking care of inconsistency indicators overcomes this drawback of the methodology.

Moreover, when applying AHP to a group, divergent or contrary answers may cancel each other out (Kasperczyk and Knickel (2014)). This article takes care of this by sample-checking answers in person.

On the whole, the disadvantages of AHP do not outweigh its advantages, since AHP promotes the understanding of the nature of decision making by creating a framework that is used to define the decision, summarize the information available, prioritize information needs, and elicit preferences and values. Potential drawbacks are taken care of as illustrated above.

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

Application of the AHP Methodology to the selected ports

The basic procedure for applying the AHP methodology in the present research encompasses three phases, the latter of which is composed of seven steps, as represented in the process flow chart of Figure 1.

In phase one, the decision-making problem is decomposed into its components, the goal is defined and alternatives are identified.

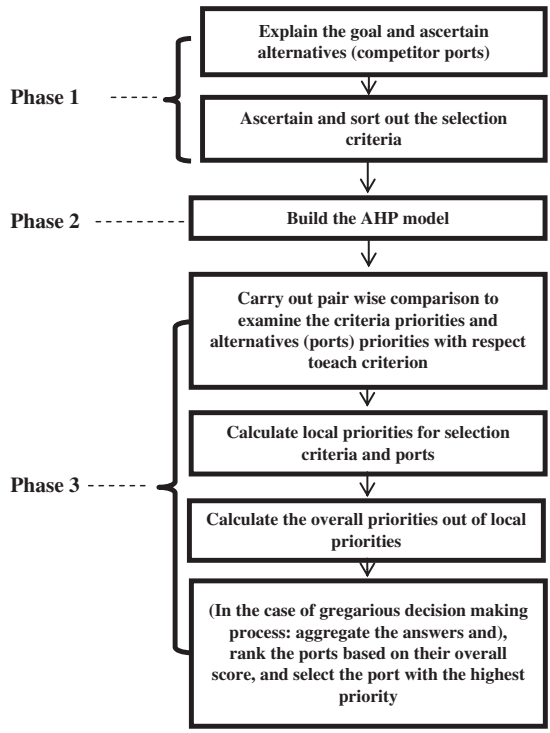

Figure 1: Process flow chart for port selection by AHP methodology.
Source: Authors

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

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

The most commonly cited criteria for port selection in the literature are costs – consisting of port charges (port dues, pilot costs, towage and so on), terminal charges, and storage costs –, operational quality, location, facilities, productivity and efficiency, and reputation. However, different groups of port users may consider different factors in selecting a port. Table 1 provides an overview of the most important and the most frequently cited criteria in the literature for each group separately.

Next, the selected criteria and sub criteria for this research are represented in a tree structure, as is customary in the literature. (see Appendix A).

Phase two hierarchizes all components, providing insight into the complicated decision-making process and allowing accurate comparison of the components (Saaty, 1990). To construct the hierarchy, it is essential to bear in mind the problem environment, as this affects the identification of participants associated with the problem, as well as attributes that contribute to its solution (Kasperczyk and Knickel, 2014).

Phase three provides a ranking of criteria and of the three ports.

Figure 2 represents the hierarchy in three levels. The highest level consists of the question of the decision maker (port selection); the middle level is made up of the criteria; and the bottom level consists of the three alternative ports, Antwerp, Hamburg and Rotterdam.

The data for phases 2 and 3 are collected by means of an interview survey with three groups of principal port selection decision makers. The survey was held among carriers (nine responses), freight forwarders (six responses), and shippers (seven responses). In all, 22 responses were collected. Second, privileged expert assessment of the attractiveness of criteria was recorded by face-to-face interviews

Table 1: Port selection influencing factors for each group

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

Source: Adopted from Aronietis *et al*, 2010

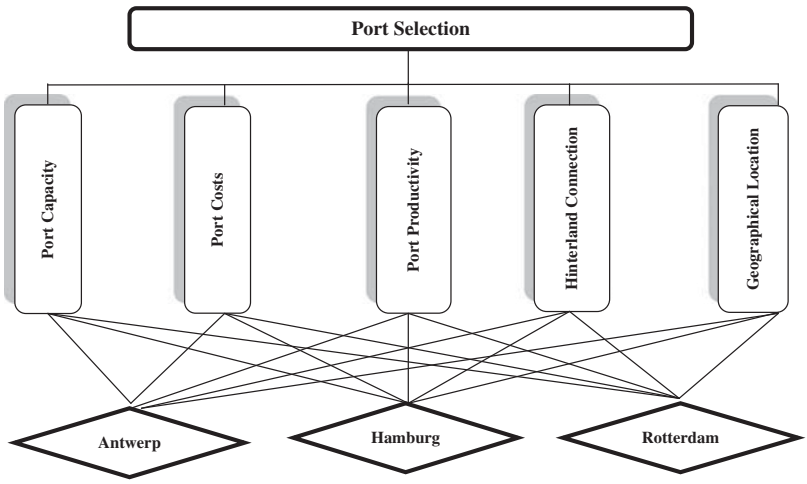

Figure 2: Constructing AHP for port selection goal.
Source: Authors

and an online survey. The interviewees participating in this research are categorized into three groups: shippers, carriers and freight forwarders located in the ports of Antwerp (14 responses), Rotterdam (six responses) and Hamburg (two responses). They were selected randomly from the largest companies in terms of market share. Most of these concerns are global operators with a presence in all three ports, but they identify one port as their main location. The respondents were not asked directly about sub-criteria, but it may be assumed that they have taken them into consideration in their judgment regarding the main criteria, as the sub-criteria were mentioned in general when introducing the structured interview.

Subsequently, the survey data is used as input data to run the AHP model. The outcome of the AHP model specifies individual interviewees' priorities regarding selected criteria and sub-criteria, as well as a ranking of the three ports in respect of each criterion. Appendices 1 and 2 provide the template questionnaires distributed among the respondents for respectively criteria ranking and port ranking.

To determine the weight of the factors through pairwise comparison, decision makers must answer the question: 'How preferable is one criterion over the other'? Assigning a relative weight to criteria, ranging from 1 for equal importance to 9 for extreme importance, gives the reciprocal values to the other criterion. When all criteria have been compared, the weights need to be normalized and averaged in order to achieve an average weight for each criterion.

A next step consists of the scoring of alternatives with respect to criteria by pairwise comparison. Using the same scale, respondents are asked to answer the

Table 2: Scale of relative importance

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

Source: Saaty, 1986

question: 'How much do you prefer one alternative over the other in relation to a specific criterion'? The scales used for pairwise comparisons are illustrated in Table 2. Reciprocal values are given to the other alternative. The scores obtained for each of the alternatives need to be normalized and averaged in order to attain the average score.

The final computing step is to determine the overall scores of each alternative combining to criteria weights. Table 2 illustrates how judgments are turned into numerical scales.

AHP method is applied for each group of respondents separately. When AHP is utilized for a group, their judgments should be combined on the basis of the geometric mean to the judgments (Aczel and Saaty, 1983).

The methodology description and the structured model applied in a super decision software environment are provided in Appendix C.

Empirical Results

This section presents the findings from the 22 port user responses. The empirical results differentiate between individual port user priorities and preferred port, as

well as between aggregate answers for each group. On the one hand, respondents were asked about their ports of call, while on the other, our methodology revealed their preferences. This provided a comparison of port users insofar as their 'preferred port' and 'port choice criteria' are concerned.

Shippers' Priorities

With seven valid responses from shippers, the following outcome was obtained. All outcomes were obtained in inconsistency indices less than 0.10. As Table 4 shows, Shipper 1 weighed the ports of Rotterdam, Antwerp, and Hamburg with 0.49, 0.33, and 0.17 respectively. As regards port choice factors, Shipper 1 assigned weights of 0.55, 0.25, 0.11, 0.05 and 0.02 to respectively cost, geographical location, hinterland connection, productivity and capacity. Hence, Shipper 1 considers port costs as the most important factor in choosing a port, while he regards port capacity as the least important factor in making that choice.

The stated preferences of the other shippers may be interpreted along the same lines. Table 3 provides a summary of shippers' port choice and port choice factor preferences.

Table 3 indicates that, on average, shippers assign the greatest relative importance to port costs (0.43), followed by geographical location (0.27), quality of hinterland connections (0.16) and productivity (0.06), port capacity (0.04). Rotterdam (0.45) is the shippers' preferred port followed by Antwerp (0.32) and Hamburg (0.21).

Since the business nature of port users is different, the concept of geographical location for each of them is also different. For shippers, the port location concept refers to how well the port is located in their distribution networks of

Table 3: Shippers' port and port choice factor preferences

Company	*Port preferences*			*Port choice factor preferences*				
	Antwerp	*Hamburg*	*Rotterdam*	*Location*	*Capacity*	*Cost*	*Productivity*	*Connection*
1	0.33	0.17	0.49	0.25	0.02	0.55	0.05	0.11
2	0.18	0.23	0.57	0.26	0.03	0.48	0.14	0.06
3	0.3	0.2	0.5	0.53	0.04	0.16	0.05	0.2
4	0.35	0.17	0.47	0.25	0.11	0.55	0.02	0.05
5	0.3	0.3	0.4	0.27	0.03	0.5	0.08	0.11
6	0.52	0.25	0.22	0.19	0.06	0.24	0.03	0.47
7	0.3	0.16	0.53	0.18	0.05	0.57	0.06	0.13
Average	0.32	0.21	0.45	0.27	0.048	0.43	0.06	0.16

Source: Authors

suppliers and consumers. For freight forwarders, it refers to how well the port location contributes to both carriers' and shippers' strategic plans and business, as well as to cost aspects. For carriers, port location relates mainly to where demand (cargo) is located, and how well the port is located in their global shipping network configuration. In this case, for shippers, all three selected ports are located relatively closely to the core European market. However, any questionnaire-based research carries the risk of bias because of prejudice by interviewees. Since the ports under investigation are located within a close proximity and they are competing over the same hinterland, the risk of bias towards the port that users have already chosen for their operations might exist in this research as well. To minimize this risk we interviewed company branches in all three ports as much as possible.

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

Carriers' Priorities

Nine valid carrier responses were used. Table 4 depicts carriers' judgments regarding port choice factors and port selection. The table illustrates that carrier 1 assigns weights 0.49, 0.38, and 0.13 to respectively Rotterdam, Antwerp, and Hamburg. The choice factors cost, productivity, geographical location, hinterland connection and capacity are assigned weights of 0.49, 0.21, 0.11, 0.09 and 0.07 respectively. Hence, the results indicate that carrier 1 considers port cost the most important decision factor in selecting a port of call, and port capacity as the least important. The stated preferences by the other shipping companies can be interpreted in the same way.

On average, carriers assign the greatest weight to port costs (0.35), followed by quality of hinterland connections (0.25), geographical location (0.23), productivity (0.10) and port capacity (0.04). Rotterdam (0.41) emerges as the carriers' preferred port followed by Antwerp (0.40) and Hamburg (0.18).

Table 4: Carriers' port and port choice factor preferences

Company	*Port preferences*			*Port choice factor preferences*				
	Antwerp	*Hamburg*	*Rotterdam*	*Location*	*Capacity*	*Cost*	*Productivity*	*Connection*
1	0.49	0.13	0.37	0.11	0.07	0.5	0.21	0.09
2	0.1	0.2	0.7	0.19	0.02	0.34	0.06	0.36
3	0.52	0.11	0.36	0.13	0.03	0.47	0.05	0.3
4	0.75	0.07	0.17	0.13	0.02	0.58	0.04	0.2
5	0.25	0.18	0.57	0.24	0.03	0.05	0.1	0.56
6	0.51	0.12	0.36	0.11	0.04	0.37	0.3	0.17
7	0.38	0.11	0.5	0.28	0.02	0.31	0.04	0.34
8	0.37	0.31	0.3	0.35	0.04	0.27	0.13	0.2
9	0.25	0.4	0.33	0.55	0.11	0.25	0.02	0.05
Average	0.40	0.18	0.41	0.23	0.04	0.35	0.10	0.25

Source: Authors

Overall, the findings are in line with those of shippers, be it that port cost is slightly less dominant here, and hinterland connections gain importance. The latter finding most likely has to do with the fact that bottlenecks over time have shifted from the 'wet' port side to the 'dry' port side: terminal gates, intra-port connections and connections with long-distance modes of transport have become the real issue. At the same time, carrier haulage is gaining ground, with carriers assuming responsibility for larger parts of supply chains. For the newly developed infrastructure in the three ports, the situation is particularly problematic. In Rotterdam, the Maasvlakte II is built westwards, towards the sea, while the market is located to the east. This means that the entire existing port, with already congested infrastructure, needs to be transversed. In Antwerp, the newest Deurganck dock is located on the Left Bank, where multimodal transport infrastructure is still underdeveloped. Hamburg, finally, features congestion in its conventional network, through increased volumes, sparking the need for expansion, or optimization in the short run (Port Technology International, 2014b).

The difference in overall valuation of Rotterdam and Antwerp gets very small in the case of carriers; this implies that both ports are more or less interchangeable. This may explain the nearly immediate traffic shifts between them in case of capacity problems, as illustrated above.

Freight Forwarders' Priorities

Six valid responses from freight forwarders were used. Table 5 depicts forwarder judgments regarding port choice factors and port selection. The table shows that

Table 5: Freight forwarders' port and port choice factor preferences

Company	*Port preferences*			*Port choice factor preferences*				
	Antwerp	*Hamburg*	*Rotterdam*	*Location*	*Capacity*	*Cost*	*Productivity*	*Connection*
1	0.45	0.11	0.43	0.18	0.18	0.21	0.15	0.26
2	0.52	0.23	0.23	0.15	0.05	0.6	0.06	0.12
3	0.53	0.14	0.32	0.1	0.03	0.59	0.05	0.2
4	0.64	0.07	0.28	0.04	0.12	0.22	0.2	0.4
5	0.75	0.06	0.18	0.19	0.02	0.63	0.03	0.1
6	0.64	0.18	0.17	0.07	0.03	0.48	0.28	0.12
Average	0.58	0.13	0.27	0.12	0.07	0.45	0.13	0.2

Source: Authors

Forwarder 1 assigns weights of 0.45, 0.43, and 0.11 to Antwerp, Rotterdam, and Hamburg respectively. The weights for the port choice factors hinterland connection, cost, geographical location, capacity and productivity are respectively 0.26, 0.20, 0.18, 0.18 and 0.15. The results indicate that Forwarder 1 considers geographical location to be the most important consideration in choosing a port, while port productivity emerges as the least important decision factor. The stated preferences of the other freight forwarders may be interpreted along the same lines.

On average, forwarders attach the greatest relative importance to costs (0.45), followed by quality of hinterland connections (0.20), geographical location (0.12), productivity (0.10) and port capacity (0.07). Antwerp (0.58) emerges as the forwarders' preferred port, followed by Rotterdam (0.27) and Hamburg (0.13).

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

Summarizing View

The ranking of criteria and ports for each group of decision makers is summarized in Table 6. There is a difference in port selection criteria and their rankings in different regions of the world because of the differences in regional supply chain characteristics, marketing processes and local economic conditions. The results of this article are therefore a useful addition to existing

Table 6: Ranked criteria priorities and ports in the point of view of each decision-maker group

Decision maker groups	*Factor priorities*					*Port ranking*
	1	*2*	*3*	*4*	*5*	
Shippers	Port cost	Geographical location	Quality of hinterland connection	Port productivity	Port capacity	Rotterdam (1) Antwerp (2) Hamburg (3)
Ship operators	Port cost	Quality of hinterland connection	Geographical location	Port productivity	Port capacity	Rotterdam (i) Antwerp (ii) Hamburg (iii)
Freight forwarders	Port cost	Quality of hinterland connection	Port productivity	Geographical location	Port capacity	Antwerp (i) Rotterdam (ii) Hamburg (iii)

Source: Authors

literature as a specific regional study in North-European ports in general and Antwerp, Rotterdam and Hamburg as important gateways in particular.

The results support and quantify claims in the literature about the considered region, but also qualify certain past perceptions. In this sense, it is confirmed that cost is a prime selection criterion for all actors, albeit to a lesser extent for carriers. This is somewhat contradictory to prevailing thinking, as carriers are the ones paying directly for out-of-pocket port expenses. Apparently, they are able to pass on those expenses to their own customers.

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

Finally, the relative preference for Rotterdam to Antwerp to Hamburg does not conform to observed container volumes – where Hamburg in 2013 surpassed Antwerp in actual container volumes – and this is not equal for all actors, illustrated by the behaviour of freight forwarders.

Table 7 shows the aggregated outcome for three port choice decision makers. The often-stated importance of 'capacity' is clearly qualified: although perhaps an important issue in other regions around the world with capacity constraints-*capacity* is not an issue in the ports considered here.

Conclusions

The AHP method has been applied to examine the importance and attractiveness of individual port selection criteria for the ports of Antwerp, Rotterdam and

Table 7: Port choice decision-makers' preferences

Shippers, shipping companies, and forwarders							
Port preferences			*Port choice factor preferences*				
Antwerp	*Hamburg*	*Rotterdam*	*Location*	*Capacity*	*Cost*	*Productivity*	*Connection*
0.43	0.18	0.38	0.22	0.05	0.41	0.1	0.21

Source: Authors

Hamburg. To this end, a set of five influential port choice factors was selected on the basis of the literature and expert opinions. The AHP methodology was applied to determine criteria weights by means of pairwise comparison. The hierarchical model also highlights, for each of the three ports, the importance of each criterion to the selection decision of three different groups of port users.

The research finds that port costs play the most significant role in the port selection process according to all three groups of respondents, followed by location, connectivity, productivity and, least importantly, port capacity.

However, there are some discrepancies between respondent groups, with respect to their ranking of criteria, which may be attributed to their respective positions and responsibilities within the supply chain, and the contract of carriage concerned (carrier haulage or merchant haulage). Carriers, for instance, attach relatively more importance to hinterland connections as they integrate in land-based segments of supplychains. The increased use of carrier haulage may explain the relative overall similarity in preferences. Freight forwarders, through their grouping role, clearly look for the presence of outbound cargo, which is the reason why they value Antwerp higher than the two other ports.

Our results may be helpful in formulating port policies, as they can inform policy makers in making investment decisions by specifying which selection criteria are most crucial in the eyes of the principal groups of port users. For Hamburg for instance, which gets ranked third overall by all actors, some more thought should be given to port costs. Hamburg is located further away from the main connecting route between Europe and other continents, and it needs to compensate for this through adapted tariffs. Other important points of attention are keeping hinterland connections up to date and developing the local cargo base, as a way of exploiting maximally the location close to sea.

Furthermore, our findings may contribute to more efficient Public Private Partnerships (PPP's) in port investment. The findings suggest that, in order for a port to enhance its competitive position, it must contribute primarily to lower overall transport costs, for example, through improved technical and operational expertise. PPPs in that sense usually allow for using the operational experience

and efficiency of the private sector, with guarantees offered by the public sector. Terminal concessions are a good example of this: making their running times shorter and more flexible, subject to evaluation, should help. In Antwerp, the recently-built Deurganck dock lock combines private construction expertise with public planning and guarantees.

However, it must also be noted that these conclusions are valid only for the ports under review. In this respect, they reflect the unique characteristics, organization and ownership structures of those three ports. Hence, further case studies are essential before our findings can assume a more general applicability.

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

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Appendix A

Questionnaire 1: Factor priority

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

Part 1: Introduction

The purpose of this survey is to gauge your opinion, by means of pairwise comparison, regarding five factors relevant to the competitiveness of a container transport system. The following factors are extracted from the literature:

1. *Port capacity*

   ✓ Available berths, cranes, storage and so on.
   ✓ Probability of losing time (while berthing, crossing locks and so on)
   ✓ Free capacity

2. *Port costs*

   ✓ Port charges (port dues, pilot cost, towage and so on.)
   ✓ Terminal charges
   ✓ Storage cost and dwell time

3. *Port productivity*

   ✓ Container yard efficiency
   ✓ The number of TEU and/or tonnes handled per crane per hour
   ✓ Customs efficiency

4. *Quality of hinterland connection*

   ✓ Land cost (inland transhipment freight rates and other land transport costs associated with the port)
   ✓ International connectivity
   ✓ Intermodal connectivity (rail, highway, barges)

5. *Geographical location*

   ✓ Proximity to the markets (demand)
   ✓ Distance of shippers from the port (supply)

You are requested to indicate how important each of these factors is to your selection of a port/shipping line by ticking the corresponding number on the scale.

How to weight your choice:

‘1’: absolute priority to the factor on the left
‘3’: strong priority to the factor on the left
‘5’: equal priority to the factors on the left and the right
‘7’: strong priority to the factor on the right
‘9’: absolute priority to the factor on the right.

You may use the even numbers in between to give a more qualified response.

An example:

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

(if *port capacity* has *absolute* priority):

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

(if *port capacity* has *strong* priority):

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

(if *port capacity* has *slight* priority):

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

(if *port capacity* and *port cost* have *equal priority*):

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

(if *port cost* has *slight* priority):

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

(if *port cost* has *strong* priority):

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

(if *port cost* has *absolute* priority):

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

Part 2: General questions

1-Which of the following best describes the organization you are representing?
( ) Shipping company
( ) Exporting/Importing company
( ) Manufacturing company
( ) Retailer
( ) Freight forwarder

2-How many containers do you trade annually?
( ) Under 500 ( ) 500–1000 ( ) 1000–2000
( ) Over 2000

3-Which of the following ports is your main European trading port?
( ) Antwerp ( ) Hamburg ( ) Rotterdam ( ) Others

4-What percentage increase in your total transport costs because of the imposition of road toll (either at destination or origin) may alter your current port and shipping networks utilizations?
( ) 0–0.5 ( ) 0.5–1 ( ) 1–1.5 ( ) 1.5–2

Appendix B

Questionnaire 2: Port choice

Questionnaire for determining *port and shipping network selection* by shippers, carriers, and freight forwarders.

Part 1: Introduction

The purpose of this survey is to gauge your opinion, by means of pairwise comparison, regarding the relative importance of key criteria in port and shipping network selection. In this study, three ports are considered: *Antwerp*, *Rotterdam* and *Hamburg*. These ports are used in a pairwise comparison in respect of the weighted factors.

An example:

Q: Which port would you chose when it comes to '*port capacity*'?
(if you have an *absolute* preference for the port of *Antwerp*):

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

(if you have a *strong* preference for the port of *Antwerp*):

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

(if you have a *slight* preference for the port of *Antwerp*):

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

(if you have an *equal* preference for the ports of *Antwerp* and *Hamburg*):

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

(if you have a *slight* preference for the port of *Hamburg*):

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

(if you have a *strong* preference for the port of *Hamburg*):

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

(if you have an *absolute* preference for the port of *Hamburg*):

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

Appendix C

Methodology description:

Pairwise comparisons and judgment scales
Two sets of questionnaires were distributed to evaluate the preferences and port selection with respect to prioritized criteria. Having five criteria to be evaluated by respondents generates 10 questions for the criteria priorities questionnaire and 15 questions for the port choice questionnaire. The following formula gives the number of questions generated:

$$Q(n,\,2) = \frac{n(n-1)}{2} \tag{C.1}$$

where Q, is the number of questions and n refers to the number of attitudes to be evaluated. To avoid that respondents would experience difficulties in

Table A1: Random indices

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

Source: Saaty (1986)

distinguishing between the scales (Kasperczyk and Knickel (2014); Belton (1986); Belton and Gear (1983); Triantaphyllou (2001)), we apply a 5-point scale in the questionnaires.

Consistency

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

$$a_{ij} = a_{ik}.a_{kj} \tag{C.2}$$

Since the real world is inconsistent, the case of perfect consistency in pairwise comparison matrices occurs rarely. On the other hand, to acquire reliability, a minimum consistency is required. Therefore, a consistency test must be conducted using equation (C.3).

$$CI = \frac{(\lambda_{\text{Max}} - n)}{(n-1)} \tag{C.3}$$

where λ_{Max} is maximal eigenvalue. The consistency ratio is driven by equation (C.4).

$$CR = \frac{CI}{RI} \tag{C.4}$$

where *RI* is the random index.

The acceptable consistency of the matrix is considered for *CR* less than 10 per cent. In addition to Saaty (1977), some other researchers (Lane and Verdini, 1989; Forman, 1990; Tummala and Wan, 1994; Alonso and Lamata, 2006) have suggested simulations with different numbers of matrices which are similar to the indices carried out by Saaty. Table A1 shows the random indices calculated by Saaty (1977).

Aggregation

The final step is to determine the global priority by synthesizing local priorities, using equation (C.5).

$$p_i = \sum_j w_j.l_{ij} \tag{C.5}$$

where p_i represents global priorities of the alternatives, l_{ij} represents local priority, and w_j stands for the weight of criterion j.

As we collect individual questionnaires, the overall pairwise comparison is obtained through agglomeration. The following formula is used to this end:

$$\overline{A} = \frac{1}{n}(A_1 + A_2 + \cdots + A_n) \tag{C.6}$$