Available online at www.sciencedirect.com

ScienceDirect

Transportation Research Procedia 00 (2018) 000–000

Transportation Research Procedia

www.elsevier.com/locate/procedia

World Conference on Transport Research - WCTR 2019 Mumbai 26-31 May 2019

Cooperation in the hinterland of adjacent seaport authorities, empiricalization for the European TEN-T core ports

Anonymous*

Adres to be added

Abstract

One area for ports to cooperate is the development of hinterland connectivity. By bundling streams, a volume can be reached that allows a modal shift to a more efficient transport with lower external costs, thus increasing the attractiveness of the cooperating ports. This paper empiricalizes these concepts on all 104 European core TEN_T ports and finishes with a case study for the newly created North Sea port, a transnational merger of the ports of Ghent, Vlissingen and Terneuzen. It shows that bundling between neighbouring ports results in a volume that makes a modal shift economically viable, at the same time lower the cost of the hinterland connection.

Keywords: Type your keywords here, separated by semicolons ;

1. Introduction

Port cooperation has received occasional attention in the scientific maritime literature over the years. Although the literature review of Pallis at al. (2010) does not mention cooperation as a separate topic, nor does Woe et al. (2012), still the publication of Ports in proximity (Notteboom, Ducruet, & De Langen, 2009) and the more recent special issue of RTBM on port cooperation (Notteboom, Knatz, & Parola, 2018) indicate that the topic has received some academic interest. But it is much more apparent in the professional publications. The recent merger of the mid-sized ports of Zeeland in the Netherlands with the port of Ghent in Belgium (Vandevoorde, 2017) as well as the mega merger of Ningbo and Zhoushan (Knowler, 2015), amongst the biggest ports of China, and even the world, as well as the are intensified cooperation between the ports of Seattle and Tacoma (‘Seattle-Tacoma Complete Port Alliance’, 2015) are a few examples amongst many that have received extensive attention in the professional journals. Also, less intensive cooperation projects, like e.g. the Alameda corridor, organized in cooperation between the port authorities of Los

* Corresponding author. xxx

2352-1465

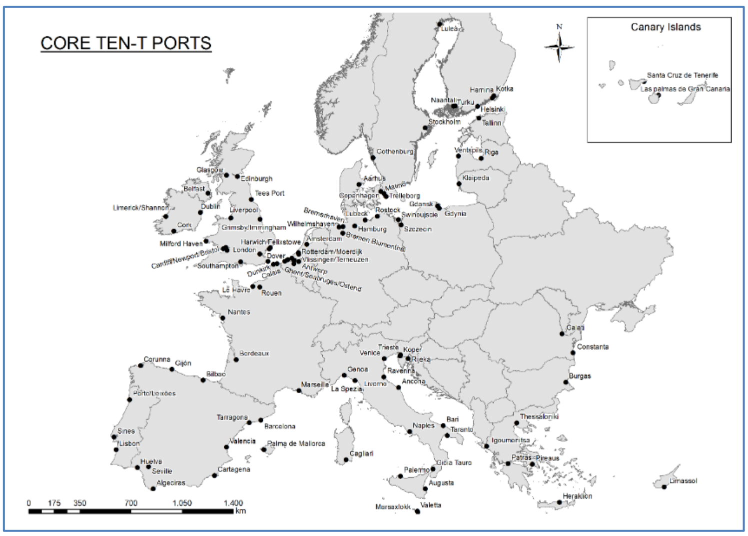
Angeles and Long Beach (‘Alameda Corridor Transportation Authority’, 2016), or the Y-trasse, which is still a project for the ports of Hamburg and Bremen (‘Hamburg und Bremen zahlen für Y-Trasse’, 2010), are part of the long-term strategies of major ports all around the globe. The list of cooperation projects between competing ports over the world is endless.

Academically, already in 1983 Fleming wrote about the need for ports to rise above community pride and use complementary characteristics to search for economies of scale and scope (Fleming, 1983). As early as 1938 a book was written to advocate the cooperation between Antwerp and Rotterdam as a balancing force against the German ports (Lambreghts, 1938).

The competitive position of the port is under pressure from the increase in scale of and the cooperation agreements between shipping lines. The vertical integration between shipping lines and terminal operators even increases this pressure. Port authorities must find a new role in this changing environment (Heaver et al., 2000; Notteboom & Winkelmans, 2001; Van der Lugt, 2015; Verhoeven, 2010). Cooperation between ports might be a way to create economies of scale but, especially in the case of larger ports, this might be viewed as anti-competitive (Heaver, Meersman, & Van de Voorde, 2001). But it is questionable if cooperation between port authorities, especially of the landlord type with limited operational responsibilities, would run afoul of anti-trust authorities (AAPA, 2008; Deutscher Bundestag, 2016). Since ports become interchangeable and because port costs grow relatively to shipping costs, it is necessary for ports and port operators to cooperate as to increase efficiencies but without lowering competition (Musso, Ferrari, & Benacchio, 2000). Ports are part of a supply chain but the process of cargo moving through a port is a supply (sub)chain in itself (Coppens et al., 2007). Horizontal cooperation is taking place on all levels in the supply chain that is a port, which reduces the power of the port authority (Van de Voorde & Vanelslander, 2008). Vitsounis and Pallis (2012) see co-creation between players in the port value chain, and the port authorities in particular, as a way to pool interdependencies to create either economies of scale or economies of scope depending on the resources being identical or similar. Heaver (2011) advocates the coordination between port actors and the integration of investments and operations. This can increase visibility and reliability in a variable and uncertain environment.

This paper focuses on one particular field where ports can co-operate: the hinterland, both geographically and functional. The research question can by stated as follows. Where can seaport authorities find inland destinations (or origins) with road freight volumes that can be bundled with neighbouring seaports in sufficient volumes to make a modal shift economically viable, thus increasing the consumer surplus of their customers while at the same time increasing their attractiveness and the resulting throughput volumes? In its empirical application, the paper focuses on the European TEN-T ports. The EU has defined nine corridors in the TEN-T project and these corridors connect over 300 ports of which 104 have been defined as core ports.

Figure 1 – 104 Core TEN-T ports



Source: author based on European Commission (2014)

The paper is structured as follows. First, after the introduction, the relevant literature on port cooperation is reviewed, Next, the methodology to calculate the social effects of port cooperation is described. The fourth section describes the available data on the scale of the European Union (EU). It lists the road freight volume data, the direct costs of road freight and rail transport and the relevant external costs. The fifth section explains the assumptions and aggregations that are necessary to come to an empirical model. In the sixth section, this model is applied to the newly created North Sea port. The paper concludes and describes remaining questions in the seventh part and ends with the references.

2. Literature review

The effects of port cooperation on welfare economics can be many. They can be categorized in lower internal costs, lower external costs and lower indirect costs. Through the bundling of streams, a higher degree of occupation of the port infrastructure can lead to lower internal costs. Joint investment plans can optimize (government) investments, by the sharing of commercial, ICT and R&D services economies of scale can be realised. Specialisation can lead to advantages of scale and scope. External costs can be reduced through an optimised use of hinterland infrastructure and through bundling; joint R&D can accelerate innovation. Indirectly, cooperation can increase the critical mass of ports thus increasing the competitiveness which allows attracting additional cargo and/or increasing port dues. A national government can facilitate or even require the decrease or internalisation of external costs through cooperation while at the same time guaranteeing competition. (Wortelboer-Van Donselaar & Kolkman, 2008).

Stevens et al. (2012) build a typology of port cooperation starting from the different motives that drive cooperation between port authorities : industrial-economic (efficiency and market position) and societal. The authors also list the barriers against cooperation: legislation, funding, cultural differences and differing standards.

The situation where organisations cooperate and at the same time compete, has been identified as coopetition (Brandenburger & Nalebuff, 1996). The seminal article on port coopetition is surely written by Song (2003). While the author does not really specify his focus, he is actually describing port operators and terminal operators in particular, rather than port authorities. He sees co-opetition as an instrument to establish a countervailing power against the ever-growing market power of shipping lines. Coopetition can bring economies of scale and additional sales through expanded services or increased customer service. It can reduce the bargaining power of the customers and/or the competition among current competitors as defined by Porter (Porter, 1980). Many authors expand on the ideas of Song (M. R. Brooks, McCalla, Pallis, & Van der Lugt, 2010; Magala, 2004; Verhoeven, 2010; Walley, 2007; Woo et al., 2012; Wortelboer-Van Donselaer & Kolkman, 2010).

The concept of coopetition is applied to several port regions. Song (2003) describes the case of Hong Kong and South China and sees many joint ventures between operators in the different ports of the region. He also describes the situation in Korea (D. W. Song, 2004). Brooks et al. (2011; 2010) study the case of coopetition for the Canadian Atlantic Ports.

Mclaughlin and Fearon (2013) adapt the updated concepts of Bengtsson and Kock, that also use the term coopetition but with a slightly different, more marketing-oriented, meaning (Bengtsson, Eriksson, & Wincent, 2010; Bengtsson, Hinttu, & Kock, 2003), to seaports and conclude that a) direct competition is not a sustainable strategy, b) ports co-existing beside each other will need to find complementary synergies and c) short and medium term opportunities for collaboration is one way but long term partnerships are also possible.

Wortelboer-Van Donselaer & Kolkman (2008) find half of the Dutch port community in favour of cooperation at a commercial level and suggest a national promotion service of all Dutch ports. For neighbouring ports to cooperate, there must be a delicate balance between complementarity and substitutability. Raue and Walleburg (2013) state that, in the case of horizontal cooperation between supply chains partners (like ports are), similarities have a positive influence on the outcome of the partnership. But similarity also increases the competitive forces that inhibit cooperation. If this is applied on the concept of complementarity and substitutability of ports (Notteboom, 2009) it becomes clear that to cooperate, ports that are complementary have less inhibitors but also have less opportunities of scale. They do however have opportunities of scope. Substitutable ports are in the inverse situation with possibilities for economies of scale but with strong competitive forces that limit the drive for cooperation.

Brooks and Pallis (2012) see the need for all types of port authorities to cooperate so they can optimise economic development, local or national. This is, according to the authors, the most frequently chosen objective. This cooperation can be within the geographic region or even beyond and can optimize the port performance in the supply chain. Hall and Jacobs (2010) apply the concepts of the paper of Boschma (2005) to ports and conclude that the many dimensions of proximity, many non-spatial, have shrunk in the era of global supply chains leading to collective actions between ports and port companies. Port regions vie for ever increasingly distant contestable hinterlands, which has led to regional cooperation between ports on the foreland, through cooperative marketing efforts, as well as on the hinterland, through corridor formation (Notteboom, 2010).

This literature review shows that cooperation is a house with many rooms, but one domain shows a lot of potential for a positive outcome of cooperation between competing seaport authorities: the hinterland. Many authors have already emphasized the importance of the hinterland for a port. The more extensive the hinterland of a port(region), the more attractive it is as a gateway port(region) (European Commission, 2014b; Fleming & Hayuth, 1994; Meersman & Van de Voorde, 2014). Containerization resulted, among other effects, in the extension of the hinterland. Containerised goods can be transported to or from the hinterland more efficiently, faster and at lower cost. The longest distances and cheapest transport modes demand bundling of flows so that bigger transport vehicles like trains and barges can be used. For smaller ports or for more distant destinations and origins, the volumes of one port might not be large enough to make bundling a possibility, thus actually marking the border of the hinterland for this port. By cooperating, PAs can facilitate the combining of flows thus arriving at larger volumes and enabling bundling. PAs can facilitate or even organise the final mile of railroad transport in their ports and by combining the final mile part of two adjacent ports, the increased handled volume will lead to an economy of scale inside the port part of the railroad while at the same time bringing together larger volumes of freight which enables more long-distance train connections to be economically viable.

Eventually, these bundled streams of train and inland shipping need to be handled somewhere closer to their final destination. These inland ports, be they dry or wet, need minimum volumes to be economically viable. Cooperation between PAs can facilitate the bundling of streams to inland ports thus creating sufficient volumes to facilitate additional and more distant inland ports. In the case of existing inland ports, cooperation can create economies of scale and make more use of what are largely fixed costs in infrastructure. The expansion of the use of an existing inland port through cooperation will result in a more efficient use and the resulting economies, if transferred to the user, will reduce the generalised cost. If a new inland port is created where without cooperation there would not have been enough volume to make this possible, then the result will be an increased attractiveness of the concerned ports through an expansion of the market and the hinterland, while at the same time the bundling will allow expensive road transport to be replaced by cheaper (internal as well as external costs) rail or barge transport.

As part of the global supply chain, the attractiveness of a port is eventually defined by the generalised logistics cost of the supply chain of which said port is a part. Thus, the attractiveness of the port is related to the attractiveness of the supply chain of which it is a part. This supply chain is more efficient and thus more attractive if the hinterland part of the chain is more efficient. This is making port authorities realise that they have an interest in facilitating the development of the hinterland of their port. When the hinterland increases, the throughput increases, and the welfare grows, ceteris paribus. The increased interest in the hinterland is driven by the force that has changed the face of maritime shipping since the 50's of the last century: containerisation (Heaver et al., 2001; Kuipers, 2014; Levinson, 2008). Containerisation changed the role of the port from a destination to a link in a supply chain and had a strong influence on the development of the hinterland of the ports, making the hinterland the remaining battlefield for the port authority to differentiate from the competition. The resulting shift from captive to contested hinterland lead to the whole of continental Europe becoming a contested hinterland for all major European ports, (De Langen & Chouly, 2004; Magala & Sammons, 2008; Meersman, Van de Voorde, & Vanelslander, 2007; OECD, 2008; Robinson, 2002; Van der Lugt, 2015). The changing role of the port consequently changed the role of the port authority (Van der Lugt, De Langen, & Hagdorn, 2013; Verhoeven, 2010).

This hinterland can be extended by the development of infrastructure, for instance the Alameda Corridor. But most infrastructure is financed by national and/or supranational governments and PAs can cooperate in lobbying for their common projects. Ports can cooperate in developing inland ports and dry ports. The Port of Antwerp and the Port of Rotterdam tried to acquire together the German inland port of Duisburg in 2010. The German ports and national authorities did not favour the idea of the foreign "west ports" acquiring a controlling interest in what they consider is a critical part of German infrastructure.

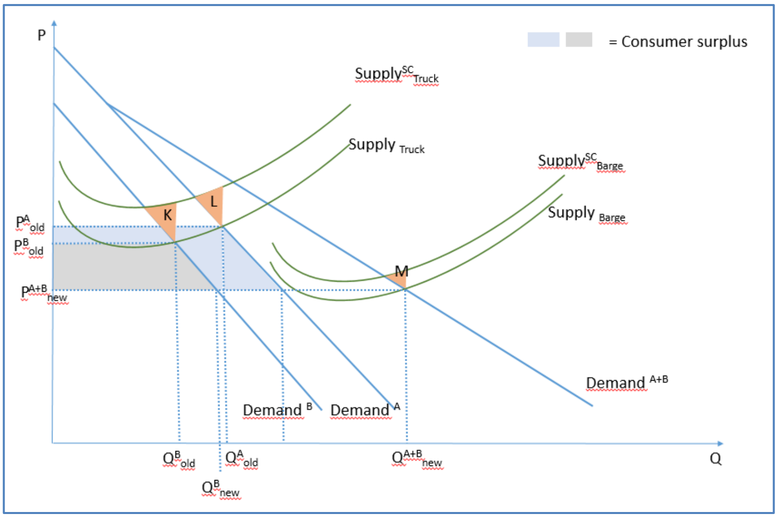
Landlord port authorities do not offer services linking the port to the hinterland, but they can facilitate their offering. PAs can financially support the launch of new, bundled, service to the hinterland or the operation of transfer points where flows from two or more ports can be bundled. An example can be found at the port of Antwerp where the PA helps in kick-starting a new barge hinterland connection (‘Antwerpen wil kleine containervolumes in binnenvaart helpen bundelen’, 2015). In cases where one port cannot generate enough cargo on its own it might be profitable to combine cargo with a neighbouring port.

This paper focuses on quantifying the extent to which such volume combination actually leads to increased profitability, and where in Europe there is potential for such combination.

3. Methodology

The concept of developing the welfare of a port region through hinterland cooperation by adjacent seaport authorities has been described extensively in a recent paper. Hintjens (2018) shows (see Graph 1) how cooperation between two ports can bring cargo streams together and reach a critical volume that allows a modal switch. The resulting economies of scale lead to a larger consumer surplus, reinforced by an increase in volume, through lower direct costs, and a potential drop in external costs.

Graph 1 - Increased consumer surplus and reduced external costs through cooperative bundling



Source: Hintjens (2018)

The lower cost will lead to an increased attractiveness for a specific hinterland due to a lower generalised cost for the supply chain of which the port in question is a part, this will increase its market share as is shown in the following formula.

$$P_A = \frac{e^{-\alpha(HC_A+OC_A)}}{\sum_i e^{-\alpha(HC_i+OC_i)}}$$

This discrete choice probability calculation starts from the triptych concept of the port (Vigarié, 1979) where a port has a foreland, with its associated costs, the port operations, with their respective costs and a hinterland. The foreland cost and the port cost of port A are represented together by OC_A and the hinterland cost is singled out with the term HC_A which stands for the generalised hinterland connection cost from port A to the region and HC_i is the similar cost for every port (i) connected to the region. OC_A stands for all other supply chain costs linking the Port A with the studied region and OC_i is the similar for all gateway ports (i) to the region.

4. Case study: available data

The following section will describe the data, their sources and the limits of their validity. First, the road freight data are covered, next the direct costs and the value of time, then follow the transhipment costs and eventually the external costs.

4.1. Available road freight data

Eurostat collects and provides OD data on NUTS3 level of road transport. The tonnes, tonne-kilometres and vehicle kilometres are detailed by product at NST 2007 level and the cargo type is given based on a list of 10 different types which is close to but not identical to the five cargo types used in port statistics (see Table 1). These data are quarterly collected by the member states based on the nationality of the vehicle (the license plate) and parts of it are available on the Eurostat website † (Eurostat, 2018a). The full dataset is not publicly available.

The reliability of these data is somewhat limited because it is collected by the Member States during a one-week period based on a 5% sample where every country collects the data for its own licence plates, independent of the country where the truck in question is driving (European Commission & Eurostat, 2011, 2016). But, as specified in the reference manual and the pertaining EU regulation, the reliability must be commensurate with the needs of the data users (European Commission & Eurostat, 2005, 2005; Regulation (EU) No 70/2012, 2012). As can be learned from the detailed instructions and publications of the different Member States, the reliability of the result is very high with a standard error, with a 95% confidence, of less than 5% in most countries. A few, smaller, countries still achieve a standard error of less than 10% (European Commission & Eurostat, 2014; Eurostat, 2013).These data are relatively up-to-date; the most recent available year is 2016. The dataset of 2016 uses the nuts classification of 2013 which became officially in use in 2015. The whole dataset of 2016 is extremely large (37 MB) because it lists all road transport between all 1 342 NUTS3 regions thus creating over 1 800 000 OD cells (not all them filled), and every cell is further disaggregated by either the type of goods (based on the NST 2007 classifications of 20 categories of goods) or by the type of cargo.

Table 1- Cargo types

0	No cargo unit (liquid bulk goods)
1	No cargo unit (solid bulk goods)
2	Large freight containers
3	Other freight containers
4	Palletized
5	Pre-slung
6	Mobile self-propelled units
7	Other mobile units
8	(Reserved)
9	Other cargo types

Source: Eurostat, 2017a

The database lists tonnes, tonne-kilometres and vehicle kilometres. The full dataset of 2016 with detailed cargo types has an average cell value of 42 958 tonnes of cargo transported by road, with a standard deviation of 381 561 tonnes, the median is 5 876 tonnes. When looking at the largest cells, it is obvious and logical that the largest cells are all recursive, they have the largest cargo stream inside their own NUTS3 region. But some of these are outliers in the

† These data can be found on the Eurostat website under de references road_go_na_ru3g and road_go_na_rl3g respectively for the unloaded and loaded cargo at NUTS3 level

sense that they are unexpected smaller NUTS3 regions that, according to the data, have large cargo movements that are out of proportion to the local economy.

Of this massive dataset, only those cells that refer to a NUTS3 region with a core TEN-T port are needed. Therefore, a reduced dataset is extracted which contains those OD pairs where at least one of the two points has a port. This results in a dataset with over 58 000 OD pairs. From this set, only the cargo streams that are containerable are needed. The data is disaggregated by cargo type as shown in Table 1. Category 2 (Large freight containers) is collected in TEU and in tonnes. However, for this research, all cargo that can be containerised must be considered, which consists of the classes 2 to 5. The other classes are much less, if at all, suited for bundling. Categories 2, 3, 4 and 5 could all be in containers if a competitive container service would be available; thus far they have been loaded in or on trucks (often tractor and trailer type) and all could just as well be loaded in containers.

After extracting the OD pairs that have at least one element in a NUTS 3 region with a core TEN-T port, and only those observations that concern containerable cargo, the result is a database which consists of two subsets. One set of all the import streams originating in one of the 104 core TEN-T ports and terminating in one of the NUTS 3 regions and another subset with the export cargo streams, originating in one of the NUTS 3 regions and terminating in one of the core TEN-T ports. These databases have still over 30 000 observations but with a lower average and standard deviation of respectively 35 070 tonnes and 299 379 tonnes for the 2016 observations.

4.2. Direct cost data

Contrary to external costs (see further), there is no generally accepted set of time and distance costs for cargo transport in Europe. Grosso (2011) made an analysis of costs and speeds of intermodal transport in her doctoral thesis. It compares a tractor-trailer combination with a train and a 2000 tonnes barge and is based on average European salaries. Panteia (2017) publishes an extensive analysis of all types of road vehicles with their respective costs and with scenario's for the different services. For this research, the data for truck and container chassis are used. This is part of series with a yearly update that goes as far back as 2004 (Nea, 2004). The original NEA data have also costs for rail transport where the shunting time is amortised over the hourly cost. It works with costs relevant for the Dutch trucking industry. Van Hassel et al. (2018) made a study on the greening of transport through the Rhine Alpine corridor which uses cost data for train and truck and that are based on a truck speed that increases asymptotically with the distance towards 80kms/hour, it also has train costs and speeds and inland water way (IWW) time and distance costs (Van Hassel, Vanelslander, & Doll, 2018). The seminal work of Blauwens et al. (2016) has since its 2011 edition time and distance costs for the different transport modes. In their maritime global chain model, Van Hassel et al. (2016) calculated the costs of the different hinterland transport modes.

All these different sources give, of course, different costs and have different time stamps. When all costs are put together and when an average, estimated, 2% p.a. inflation is taken into account to actualise all data to the same base year, the following table emerges (see Table 2). Although not exactly the same, all sources are in the same order of magnitude.

Table 2 - Actualised transport costs

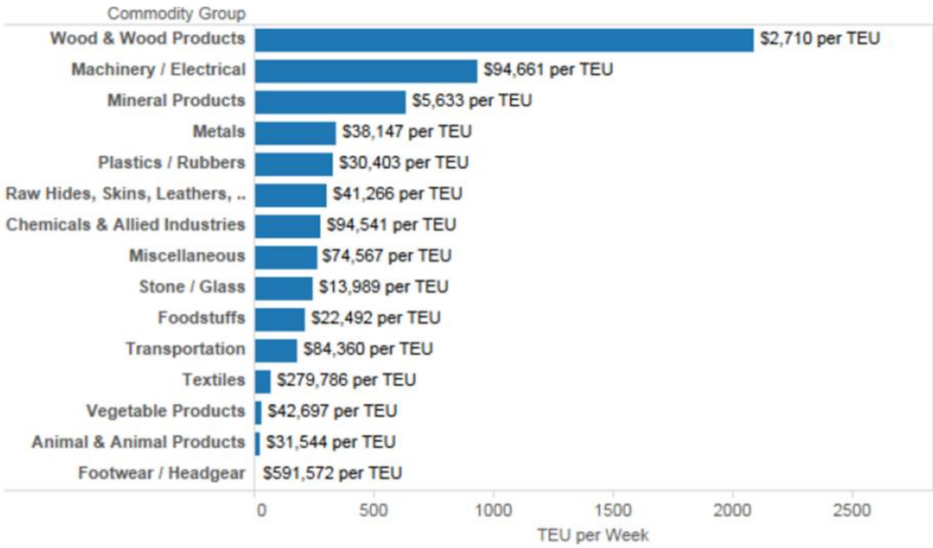
		Van Hassel, 2018	Van Hassel, 2016	Grosso	Panteia	Blauwens	NEA	Conclusion
Year of data		2015	2015	2010	2017	2011	2002	2018
Actualised costs data	2018							
Annual cost inflation	2%							
# years		3	3	8	1	7	16	
distance road	€/km	0.88	0.68	0.52	0.42	0.57	0.38	0.6
time road	€/h	37.57	44.35	46.54	43.07	33.61	50.16	43
distance rail	€/km	5.83	5.83	7.85	-	-	6.25	6
time rail	€/h	2,326.17	1,273.45	246.63	-	-	1,031.65	1000
Fix cost rail	€	2,069.36	981.17	-	-	-	-	1000

For further use in this research, a rounded-off average is concluded, influenced by the recency of each dataset.

4.3. *Value of time (VoT)*

The value of time is derived from the value of the cargo. This value features a very large variation. IHS Markit (2017) even starts with a container (TEU) filled with diamonds and a value of almost 1,2 billion USD). TEU values are mostly interesting for insurers who, with the ever-increasing size of container vessels, try to estimate their increasing exposure (Cowie, 2007). Graph 2 shows the value of the cargo per TEU for the 15 most common commodities as well as their importance for maritime shipping, similar data for inland transport has not been found.

Graph 2 - Value per TEU and global weekly maritime volumes



Source: HIS Markit, 2017

The world shipping council reports a total value of maritime shipping containerised cargo for the EU of 1.41 trillion Euro in 60-65 million TEU, for the year 2017. Which makes an average value of 23 500 – 21 700 Euro/TEU for each loaded container (World Shipping Council, 2018). This contrasts starkly with the numbers presented by O'Sullivan, who posts an average value of 80 000 USD per TEU in the 'top international ports' with figures going from 150 000 USD/TEU in Japan to 40 000 USD/TEU in Africa and the Middle-East (O'Sullivan, 2010). A more in-depth analysis can be found in the Ocean Trade database of Seabury (2018). **Error! Reference source not found.** shows the value in USD per TEU for maritime import in BeNeLux, France and Germany for the year 2017. The export data are similar.

Table 3 - USD per TEU imported in BeNeLux, France and Germany

USD per TEU	Africa	Asia Pacific	Europe	Latin America	Middle East & South Asia	North America	All partner countries
Capital Equipment & Machinery	160,177	64,920	71,886	60,628	51,921	81,500	68,360
Chemicals & Products	20,837	52,619	24,403	42,023	33,936	53,548	48,197
Consumer Fashion Goods	242,498	72,845	186,946	70,078	82,998	100,409	78,988
Consumer personal & household goods	58,732	30,862	26,351	43,253	25,189	50,524	30,745
High Technology	176,606	147,785	406,923	134,375	132,018	305,074	155,834
Land Vehicles & Parts	79,704	46,867	44,120	52,081	33,961	40,414	46,159
Machinery parts. Components, supplies & manufactures n.e.s.	84,953	54,335	36,368	66,817	45,052	100,735	58,448
Raw Materials, Industrial consumables & Foods	36,379	28,642	24,321	28,616	20,731	25,272	27,108
Secure or Special Handling	402,530	77,187	1,681,809	167,379	136,347	318,049	142,399
Temperature or Climate Control	16,172	37,836	56,737	17,699	23,944	33,942	21,765
All commodity groups	**41,963**	**48,435**	**27,753**	**27,559**	**34,134**	**45,404**	**43,080**

Source: Seabury, 2018

The total average of all countries and all commodities is a weighted average that considers the different volumes for all categories and regions. An approximative, rounded off, average overall of 43 000 USD, or 35 800 EURO (at 1,2 EUR/USD on 31/12/2017) will be used in the following analysis.

The effect of time on the value of the cargo has two aspects. Firstly, there is the financing of the cargo whilst en route and secondly, there is the loss of value over time of said cargo. The cost of financing is, of course, very much depending on the situation on the financial markets and the resulting price of money. At the time of writing (summer 2018) with the ECB still using quantitative easing and with persisting below par inflation rates, the price of money on the European money market is historically low. The evolution of interest rates by monetary financial institutions to households and non-financial corporations for revolving loans has been decreasing since 2000 (ECB, 2018). It is well below 2.5 % p.a.. A cost of money of 2.5% will be used in the following calculations. This is consistent with a -0.325 % p.a. EURIBOR interest rate (Eurostat, 2018b).

The depreciation of the cargo over time is largely dependent on the type of goods that make up the cargo (Blauwens & Van de Voorde, 1988). Foodstuffs have a short to very short lifespan, fashion and high-end electronics depreciate still fast but slower than foodstuffs and technical components can usually be sold even after a longer period. Dry bulks like iron ore and coal have, of course, a nearly unlimited shelf life but since the focus is on containerable cargo, these commodities are not relevant. The loss of value over time should be calculated differently for every commodity in Table 3. But since it is impossible to know which cargo streams will be bundled, an overall average needs to be used. Taking an average shelf life of four years, an annual depreciation of 25% seems acceptable. The value of 10% used by van Hassel et al. (2018) and based on the ASTRA model (Schade, 2005) implies a shelf life of 10 year which is unrealistic for containerable cargo.

Combining the 25% p.a. depreciation and a 2.5% p.a. financing cost with a value per TEU of 35 800 EURO, the VoT is 26.97 EURO/day per TEU equivalent to 1.124 EURO/hour.TEU.

The time spent on the way is of course a function of speed plus the time needed for the loading, unloading and bundling. The above-mentioned chain model (Van Hassel et al., 2016) cites a truck speed of 80 kms/hour, which seems a bit optimistic in today's congestion, the other sources vary between 52 (NEA, 2004) and 69 (Grosso, 2011). An average of 65 km/hour seems realistic. For train speeds, there is much more consensus with a value of 50kms/hour, only Grosso (2011) gives 55 kms/hour. The time needed for loading, unloading and bundling is only mentioned by Van Hassel (2018) at a realistic 1.5 hour for a truck and 20 hours for a train. Important: the time for a truck while waiting to be loaded is at full cost, the driver will be standing nearby. This time for the train is important for the cargo, who is sitting idle, but the train does have to be paid during this time. Rail operators work with an average cost of train assembly of 1 000 EURO.

4.4. Transshipment and bundling costs

If containerized cargo is shipped by road straight from/to the port to/from the hinterland destination/origin, it will be loaded, for instance by a reach stacker, onto the trailer and in a similar way offloaded at the destination. This is the baseline scenario. If the container is part of a multi-modal, bundled, chain then a few additional manipulations need to be added. When using a reach stacker, loading a container on a truck-trailer combination or on a train wagon has the same cost. In the hinterland, to cover the first/last mile, the container will need to be transferred to/from a train wagon from/to a road tractor-trailer combination. This is an additional cost, which is estimated at 50 EURO/TEU. This amount was fixed as a result of interviews with several terminal en rail operators. The most important bundling cost is the assembly of the train, this cost is estimated by van Hassel et al. (2018) at 1 165.21 EURO/train. Following interviews with operators, an amount of 1 000 EURO will be used in the following calculations.

The additional costs for bundling can be summarized as follows: 50 EURO/TEU for one additional loading and 1 000 EURO/train fixed costs for composing the train.

4.5. Distances

Eurostat provides what they call flat files, with distances between NUTS regions (Eurostat, 2017a). At the time of writing, two sets are available. One set dates from 2010 gives distances between NUTS 1, 2, 3 regions. In this set, the distances are calculated between the gravity points based on populations. The more recent set of 2013 only gives distances between NUTS 3 regions and these are based on the geographical centre. This last set contains a few striking errors. A new set is promised for July 2018 but was not available at the time of writing. Even if the set of 2010 uses 2010 NUTS definitions which are not the ones that are used in the road freight data of 2016, which have NUTS 2013 definitions, the fact that it uses population density to calculate the gravity points makes them a better source for the distances needed for the following calculations.

4.6. External costs

Contrary to the disparate sources on direct costs, there is a European manual for calculation external costs which is publicly available and used by many academics and consultants. The "Update of the Handbook on External Costs of Transport", produced by Ricardo-EAE and commissioned by DG Move of the European Commission has an in-depth analysis of all external costs (Gibson, Korzhenevych, & Bröcker, 2014). These are costs that are not carried by the LSP and thus even less by his customer, the shipper (Blauwens et al., 2016). Table 4 list the sources of these extremal costs that are carried by society at large.

Table 4 - Sources of external costs

1.Congestion
2. Accidents
3. Noise
4. Air pollution
5. Climate change
6. Other environmental impacts (costs of up- and downstream processes)
7. Infrastructure wear and tear for road and rail

Source: Gibson et al.(2014)

The amount of each of these external costs is dependent on time and place of occurrence. Noise pollution in a densely populated region, at night, is much more disturbing than during the day on a lonely rural country road. It is, of course, a function of the mode of transport and the size and motorisation of the vehicle. For the following calculations the comparison will be between a heavy goods vehicle (HGV) consisting of a truck tractor and a chassis for containers on the one hand and a train with an electric locomotive capable of pulling a 700-meter cargo train, with wagons for up to 80 TEU on the other hand. As the subject is long distance, port-oriented traffic and because an average is needed that can be applied any time of the day and all across Europe the value for rural motorway at near capacity will be used.

Congestion is a cost that presently only needs to be factored in case of road haulage, it is not present in rail transport, and where it would be present, the Europe-wide introduction of the ERMTS safety measures should result in a sharp reduction of waiting time between trains, thus eliminating any congestion that might be present (Gibson et al., 2014).

Also, the external costs caused by accidents only apply to road transport; in the case of rail the external costs are negligible. The costs are strongly influenced by the value of statistical life which depends on the GDP pro capita, thus giving strongly divergent values for the different European countries. A weighted average will be used as the objective is to cover all EU core ports.

Also, the externals costs caused by noise, air pollution and climate change, very much depend on time, place, vehicle and engine type. The same scenarios as mentioned above are withheld. For rail transport, the air pollution depends on the type of locomotive, and in the case of an electric locomotive, the pollution depends on the proportion of the different types of electricity generation that is used. These indirect emissions are covered in the upstream/downstream other environmental impacts (see further). There are non-exhaust emissions of electric freight trains that are estimated by Ricardo-EAE. Electric freight trains have no direct climate change costs.

Other environmental impacts are upstream and downstream originating external costs, they too are scenario-dependent and for electrical freight trains they are based on the weighted means of all technologies in use in the EU for electricity production.

Lastly, for wear and tear of the infrastructure, this research diverges from the manual produced by Ricardo-EAE. Trucks, of course, cause wear and tear, depending on their axle weight. This is calculated but the wear and tear for trains mentioned in the manual is overestimated, in this author's view. In today's market, rail operators will pay for the use of the infrastructure to a separate (sometimes independent) infrastructure manager. It can be reasonably assumed that this payment will, amongst others, cover the wear and tear. This makes this factor no longer an external cost, so it can be ignored for rail freight. (Gibson et al., 2014)

Table 5 - External costs

	Unit	HGV	Electric freight train
Congestion	€ct/vkm	45.46	0

Accidents	€ct/vkm	1.4	0
Noise	€ct/vkm	0.71	11.7
Air pollution	€ct/vkm	2.3	49.4
Climate change	€ct/vkm	6.44	0
Other environmental	€ct/vkm	2.8	212
Wear and tear	€ct/vkm	2.6	0
Total external costs	**€ct/vkm**	**61.71**	**273.1**

Source: author, based on Gibson et al. (2014)

5. Generic assumptions

To be able to apply these data for a specific case, some assumptions and aggregations need to be made. This section describes how the above data can be used in an empirical way.

5.1. General assumptions

The first assumption that needs to be made is that every port can form trains. This is realistic since all it needs are rails and a reach stacker. Of course, this assumes also that all 104 core TEN-T ports are accessible by rail but that is the objective of the TEN-T project anyway.

It is also assumed that the port equals the NUTS 3 region of which the port is part, which is also realistic since NUTS 3 regions are fairly small with a population between 150 000 and 800 000.(Eurostat, 2017b).

The third assumption is that bundling will take place at the port nearest to the hinterland destination. It might be that an in-between point might be more efficient but, indeed, only if the nearest port is on a straight line between the furthest port and the hinterland, is this configuration optimal. But this means that if the sub-optimal bundling solution is already cost efficient, then the end result can even be improved by further optimization.

The last/first mile in the hinterland is not counted because it does not differ between the bundled or unbundled solution. Even unimodal road cargo will have to brought to the final destination. By counting the transhipment cost linked to the bundling, all additional costs vis-à-vis the unbundled scenario, are taken into account.

IWW is not considered because the aim is to cover all 104 TEN-T core ports and IWW has only a limited geographical coverage.

Finally, it is assumed that the road distance is equal to the train distance: as the hinterland bundling is more relevant for longer distances and that for these distances, the difference between road and rail is relatively small.

5.2. Load factors

The analysis will be done per TEU, and for this, tonnes need to be recalculated in TEU. The ports of Antwerp, Rotterdam and Hamburg respectively reported the following loads per non-empty container in 2015: 13.99 ton/TEU, 12.86 ton/TEU and 12.1 ton/TEU. These weights include an average tare weight of 2,23 ton/TEU for the container. Based on these average weights of a non-empty container, it can be presumed that 11 tonnes are equivalent to one TEU (Hafen Hamburg, 2016; Havenbedrijf Antwerpen, 2016; Port of Rotterdam, 2016).

When working with the annual data that are available, one needs to be circumspect when using them for detailed operational analysis. It is presumed that there is little fluctuation in the weekly volumes. Analysis by Rashed (2016) shows that the difference between the busiest month and the least busy month in the container throughput of the port of Antwerp is less than 10%. So, one can assume that the annual data can be used as an approximation for weekly data by simply dividing them by 52.

In literature, more attention is given to the break-even distance for a modal shift than to the break-even volume. As Meers's (2016) literature review shows, different authors estimate the break-even point between the extremes of 57 km to 1 400 km. This very large interval shows that local conditions have a large impact on the feasibility of the modal shift. Even for a short distance, when sufficient volume is available, a modal shift can be advantageous, especially in regions which are plagued with congestion and when taking external cost savings into account. From this, it can be concluded that no distance, however small, should be excluded from the analysis. This is supported by analysis of the European Commission's (2011) white paper: 'Roadmap to a Single European Transport Area' where the plan is to have only 11% of the road transport go beyond 300 km (Tavasszy & Van Meijeren, 2011). The cost-benefit comparison for every case will indicate whether bundling makes sense.

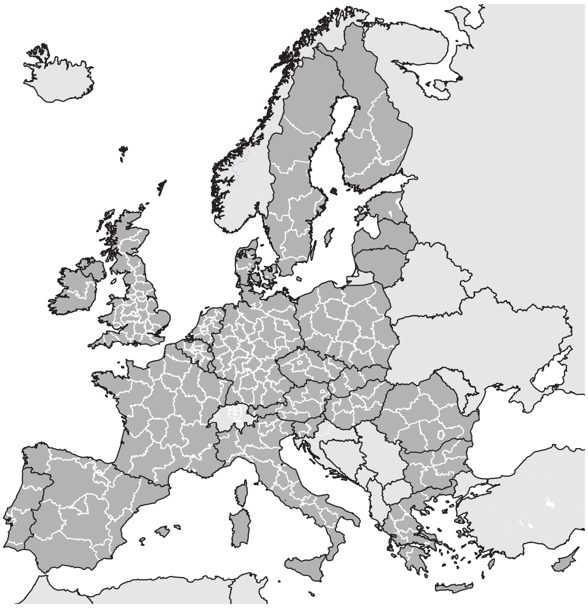
To be able to offer a competitive service in a bundled hinterland multimodal transport mode, a sufficient volume needs to be attained. To make sure the market follows the shift from road to rail, a twice-weekly service would be a minimum. The resulting average waiting time before departure of 1.75 days is in proportion to the average dwell time of a container. Based on a train with 80 TEU capacity and with an 80% occupation degree, this would mean that a weekly volume of 1,408 tonnes (11 tonnes/TEU * 80 TEU/train * 2 trains/week * 80% occupation rate) each way should be attained by bundling, or 73 216 tonnes on an annual basis. Rounded off this makes 75 000 tonnes per year.

The bundling between two (or more) adjacent ports offers the additional advantage of the possibility to balance import and export streams. If one seaport is an import port (which would result in empty containers coming back to the port) and the neighbouring port has an export stream (which results in empty containers going to the hinterland for loading), then the vehicle and container use can be optimized by combining the flows of the two ports.

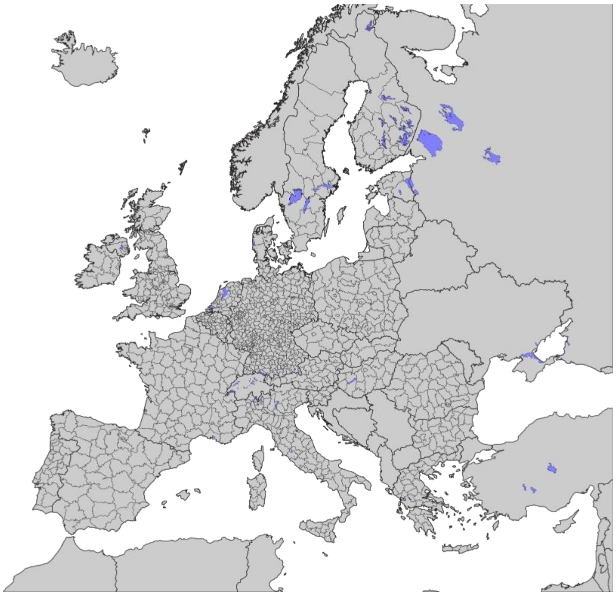
5.3. Aggregating the hinterland

The available data are collected per NUTS3 region, but the object of analysis will be all the EU hinterland regions at NUTS2 level and this for two reasons. Firstly, there are 1 348 NUTS3 regions defined by Eurostat, which makes each of them rather small in surface, population and economic and logistic capacity. This large number would result in such a long list of small opportunities that it would be hard to prioritise. Secondly, the NUTS3 regions that make up one NUTS2 regions are so closely together that the organisation for final mile from/to the assembly point can be used to serve all the local NUTS3 regions. With 'only' 281 NUTS2 regions, the potential cooperation projects become much clearer. (Eurostat, 2016)

Graph 4 - 281 NUTS 2 regions



Graph 3 - 1 348 NUTS 3 regions



6. Case study: empirical application to North Sea Port

A port authority that wants to look for opportunities by expanding its hinterland needs first, in the above-mentioned database, to look for hinterland regions that have volumes in road freight transport that are too small for bundling in a daily rail service. Following the capacity of a rail service as described above, this is a volume of less than five times weekly of 80 TEU at 80% capacity at 11 ton/TEU comes down to 183 040 tonnes annually. Rounded off this makes 185 000 tonnes annually. If this volume is not reached, then a daily rail service will not be feasible and will this hinterland only be of marginal importance for the port. Next, for those regions that are identified, the port authority must look at the volumes that neighbouring ports transport by road to the hinterland in question. If these volumes fall below the same levels, then an opportunity for cooperation might be available. All this, of course, needs to be done twice, once for the import and once for the export streams.

Then, it needs to be verified if, by combining the volumes, sufficient volumes are reached to justify bundling. This means that the combined volume needs at least to reach a level necessary for two trains per week. This level is set at, as shown above, 75 000 tonnes annually. Ideally, between two neighbouring ports, more than one hinterland destination falls within these criteria which makes the cost of bundling lower because it will already be a bundle of several hinterland destinations.

Once the opportunities for cooperation are identified, it needs to be seen whether they are economically viable. For this, the generalised cost of bundling and rail transport should be lower than the original generalised cost for road transport. Additionally, the potential benefits in external costs savings needs to be calculated. In some cases, the direct cost saving might be minimal, or even slightly negative, but the external costs savings can justify some financial support from a landlord port authority that can thus internalise a part of the external costs savings and increase the welfare of the port region.

By way of example, the above methodology will now be applied to the newly created North Sea Port which, as mentioned earlier, is a merger of the Belgian/Flemish Port of Ghent with the Dutch Zeeland Seaports, which itself is a merger of the ports of Flushing (Vlissingen) and Terneuzen. By way of illustration, only the import stream towards the hinterland will be analysed. For the export streams, the analysis could be done in the same way.

6.1. Road freight volumes from North Sea Port

The following analysis will search for hinterland regions where the ports individually lack volume to organise a daily regular rail service but together they have enough cargo to organise at least twice a week a connection per rail. Of course, whether these services are also economically viable will be calculated as well as the savings in external costs. The figures 2-5 show the road freight hinterland of the different ports, with a detail of only the larger streams for the port of Ghent in figure 3. Only the darker NUTS2 regions have sufficient volume for at least a twice weekly rail service. All the light regions have a volume of (a lot) less than 75 000 tonnes road freight from the port, annually.

Figure 2 - Road freight hinterland of the port of Ghent

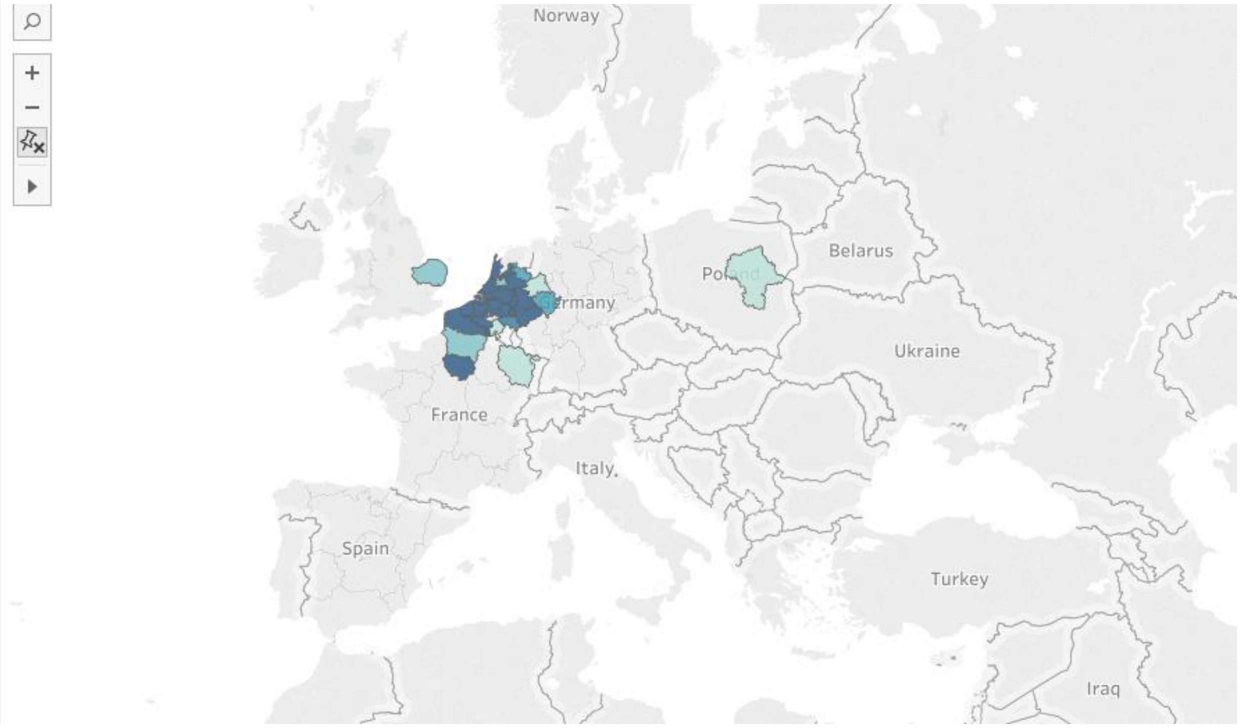
Figure 5 - Road freight hinterland of the port of Ghent with a volume of > 75 000 tonne annually

Figure 4 - Road freight hinterland of the port of Flushing

Figure 3 - Road freight hinterland of the port of Terneuzen

When combining the road flows that are too small for one port to be bundled into flows large enough for an at least twice weekly rail service the result is shown in Figure 6.

Figure 6 - NUTS2 regions with an annual road freight volume of the three ports combined which exceeds 75 000



When these graphical representations are presented in a numerical format, focusing only those NUTS 2 regions where bundling brings additional modal shift opportunities, the following table 6 emerges (the flow with UK was dropped because this is, obviously, roro traffic).

Table 6 - Bundling opportunities in the North Sea Port (tonnes/year)

	Gent (Ghent)	Terneuzen	Flushing	Bundling
BE10	60,891	8,204	9,402	78,498
BE33	125,939	1,108	15,758	142,805
BE35	69,361	5,835		75,196
DEA1	76,670	59,226	67,590	203,486
DEA2	65,642	8,009	112,286	185,937
DEA3	20,201	9,038	51,936	81,175
DEA5	97,600	8,640	23,543	129,783
FR10	140,780	3,357	17,609	161,745
FR22	99,491	1,863	6,509	107,863
FR41	32,997		51,304	84,300
NL21	35,811	22,726	67,804	126,341

NL22	108,236	81,041	120,478	309,756
NL23	127,159	7,676	55,292	190,127
NL31	13,937	26,759	55,934	96,630
NL42	85,552	60,958	137,713	284,223
PL12	36,120	55,800		91,920

For these regions, each of the port sites, making up North Sea Port, does not have enough road traffic to organize a five times weekly rail service, by bundling they reach at least enough volume to have a twice weekly service. Especially the regions in Germany (DEA1 (Düsseldorf), DEA2 (Köln), DEA3 (Münster), DEA5 (Arnsberg)) look promising because each port has an important stream but, on its own, not enough to facilitate a modal shift. The regions in France (FR10 (Île de France), FR22 (Picardie)) look interesting too but the port of Ghent is the dominant provider of cargo. The region in Poland (PL12 (Mazowieckie)) shows promise (even it needs only two out of the three ports) because with the eastwards-moving centre of economic gravity of Europe (Hintjens, Vanelslander, Van Der Horst, & Kuipers, 2015) it can be expected that it will gain importance. The longer distance will also make a positive business case more likely.

For this case study, the biggest cooperation potential (DEA1 (Düsseldorf)) will be analysed in detail. Theoretically, the bundling would take place in Terneuzen because, based on the Eurostat distance data, it is slightly closer to Düsseldorf, and it is located between the two other ports (see table 7). But the volume from Ghent is bigger and it does makes sense, especially when the difference in distance is so small, to do the bundling at the biggest node. Theoretically, the first leg of the trip would be executed by rail, especially if at the same time other bundling streams would be combined (for example.: the ones towards France, Poland or other German regions) but there is no rail connection under the river Scheldt, so for this example the first leg, towards Ghent, will be executed by road. But the cargo originating in Ghent will be put directly on a train wagon.

Table 7 - Distances (km)

Distance in km		DEA1	NL341	NL342
Ghent	BE234	267.2	37.1	66.4
Terneuzen	NL341	264.8		29.3
Vlissingen	NL342	288.4		

Source: Eurostat (2016)

6.2. All road (import) from North Sea Port to NUTS 2 Düsseldorf

When all the above is put together, the following table 8 emerges for the unimodal road scenario

Table 8 - Costs for unimodal road freight

All road (import) towards DEA1 (Düsseldorf)	Distance (km)	Time (H)	Volume (tonnes)	Volume (TEU)	Trucks (number)	Truck.km	Truck.hours	Direct cost	VOT	External cost
Gent	267.2	5.34	76,670	6,970	3,485	931,189	19,553	1,399,513	43,946	574,637
Terneuzen	264.8	5.30	59,226	5,384	2,692	712,864	15,005	1,072,945	33,724	439,908
Vlissingen	288.4	5.77	67,590	6,145	3,072	886,044	18,240	1,315,941	40,994	546,778
Total			**203,486**	**18,499**	**9,249**	**2,530,098**	**52,799**	**3,788,399**	**118,665**	**1,561,323**

Using the values below in table 9, the total direct cost for the whole annual volume amounts to 3 788 399 EURO, a value of time of 118 665 EURO and an external cost of 1 561 323 EURO.

Table 9 - Unit values for road freight

Truck speed	km/hour	65
Truck waiting time	hour/truck	1.5
Truck direct cost (distance)	€/km	0.6
Truck direct cost (time)	€/hour	43
Truck external	€ct/km	61.71
VOT	€/TEU.hour	1.12

6.3. Multimodal, road/rail from North Sea Port to NUTS 2 Düsseldorf

When all the cargo for Düsseldorf is trucked from Flushing and Terneuzen to Ghent and there it is joined on a train with the cargo already in Ghent with the same destination, then the following image emerges.

Table 10 – Costs for multimodal road/rail freight

Mulimodal road/rail (import) towards DEA1 (Düsseldorf)										
First leg (road)	Distance (km)	Time (H)	Volume (tonnes)	Volume (TEU)	Trucks (number)	Truck.km	Truck.hours	Direct cost	VOT	external cost
Gent	0	0.00	76,670	-	-	-	-	-	-	-
Terneuzen	37.1	0.67	59,226	5,384	2,692	99,876	5,575	568,846	12,529	61,634
Vlissingen	66.4	1.21	67,590	6,145	3,072	203,999	7,747	762,742	17,411	125,888
Total (first leg)			203,486	18,499	5,764	303,875	13,322	1,331,588	29,940	187,522
Second leg (rail)	Distance (km)	Time (H)	Volume (tonnes)	Volume (TEU)	Trains (number)	Train.km	Train.hours	Direct cost	VOT	external cost
Gent	267.2		203,486	18,499	289	77,232	1,404	1,867,612	516,750	47,660
Grand total								**3,199,200**	**546,690**	**235,181**

Table 11 – Unit values for multimodal road/rail freight

Train speed	km/hour	55
Train waiting time	hour/truck	20
Train direct cost (distance)	€/km	6
Train direct cost (time)	€/hour	1000
Truck external cost	€ct/km	61.71
VOT	€/TEU.hour	1.12
Transshipment cost	€/TEU	50

Using the unit values of table 11 and a train forming cost of 1 000 EURO, the result is a total direct cost of 3 199 200 EURO, an increased value of time of 546 690 EURO and a substantially lower external cost of 235 181 EURO. The volume would be sufficient for a daily service.

There is a gain in direct cost of 18%, this amount is, unfortunately, for 73% lost through an increased value of time. Still, a decrease of direct generalized costs of 4% remains. But, at the same time the external costs drop from 1,561,323 to a low 235,181. This is an amount that could be used to cover, at least a part of, the bundling costs thus making the business case even more attractive.

7. Conclusion and remaining questions

Starting from an EU-wide dataset on road freight and extracting those flows that originate, or terminate, in one of the 104 core TEN-T ports, it is shown that by combining streams of neighbouring seaports a combined volume can be reached that makes a modal shift not only possible but even economicly viable. The case study of the North Sea Port shows that, even for a distance of less than 300 km, the generalized cost of multimodal transport is more advantageous than that of unimodal road transport. But neighbouring ports will need to combine their cargo to specific hinterlands to reach a volume that makes bundling possible, volume wise.

For the above example, IWW might be an even more economical scenario, this also could be calculated in a similar way, but the increased cargo capacity of a barge, while resulting in lower costs, would lead to a lower frequency, which reduces the attractiveness of this solution.

The effect on the port attractiveness, with a shift in market share for the chosen hinterland, has not been calculated, but with a reduction of only 4% of the generalized cost, the effect must not be overstated, but it will be positive.

It remains to be calculated how this lower transport cost will influence the market share of the concerned ports

The most striking effect of the bundling is the radical drop in external costs. The increasing internalisation of external costs tickles the imagination when one considers the impact of the modal share.

8. References

AAPA. (2008). Testimony of Jean Godwin before the House Transportation and Infrastructure Subcommittee on Coast Guard and Maritime Transportation.

Alameda Corridor Transportation Authority. (2016). Retrieved from http://www.acta.org/

Antwerpen wil kleine containervolumes in binnenvaart helpen bundelen. (2015, April 8). *Flows*. Retrieved from http://www.flows.be/nl/shipping/antwerpen-wil-kleine-containervolumes-binnenvaart-helpen-bundelen

Bengtsson, M., Eriksson, J., & Wincent, J. (2010). Co-opetition dynamics – an outline for further inquiry. *Competitiveness Review*, *20*(2), 194–214. https://doi.org/10.1108/10595421011029893

Bengtsson, M., Hinttu, S., & Kock, S. (2003). Relationships of cooperation and competition between competitors. In *19th annual IMP conference*. Retrieved from http://impgroup.org/uploads/papers/4294.pdf

Blauwens, G., & Van de Voorde, E. (1988). The valuation of time savings in commodity transport. *International Journal of Transport Economics / Rivista Internazionale Di Economia Dei Trasporti*, *15*(1), 77–87.

Blauwens, G., Van de Voorde, E., & De Baere, P. (2016). *Transport economics*. Berchem, De Boeck.

Boschma, R. (2005). Proximity and Innovation: A Critical Assessment. *Regional Studies*, *39*(1), 61–74.

Brandenburger, A., & Nalebuff, B. (1996). *Co-opetition*. New York: Doubleday.

Brooks, M., McCalla, R. J., Palla, A. A., & van der Lugt, L. (2011). Strategic Cooperation in Peripheral Ports: The Case of Atlantic Canada's Ports. *Canadian Journal of Transportation; Vol 4, No 1 (2010)*.

Brooks, M. R., McCalla, R. J., Pallis, A. A., & Van der Lugt, L. (2010). Coordination and cooperation in strategic port management: The case of Atlantic Canada's ports. Dalhousie University Centre for International Trade and Transportation. f

Brooks, M. R., & Pallis, A. A. (2012). Port Governance. In W. K. Talley (Ed.), *The Blackwell Companion to Maritime Economics* (pp. 491–516). Wiley-Blackwell.

Coppens, F., Lagneaux, F., Meersman, H., Sellekaerts, N., Van de Voorde, E., Van Gastel, G., … Verhetsel, A. (2007). *Economic impact of port activity: a disaggregate analysis: the case of Antwerp*. Brussels: NBB. Retrieved from http://www.vliz.be/imisdocs/publications/134776.pdf

Cowie, A. (2007, September). *Cargo accumulation*. Presented at the AIMU/IMUA Seminar, New York, NY.

De Langen, P. W., & Chouly, A. (2004). Hinterland access regimes in seaports. *European Journal of Transport and Infrastructure Research*, *4*(4), 361–380.

Deutscher Bundestag. (2016). *Hafenkooperation in Norddeutschland im Lichte des EU-Kartellrechts*. Deutscher Bundestag.

ECB. (2018, March). Loans - Interest rates - Bank interest rates - ECB Statistical Data Warehouse. Retrieved 30 March 2018, from

European Commission. (2011). *White paper on transport: roadmap to a single European transport area : towards a competitive and resource-efficient transport system*. Luxembourg:

European Commission. (2014a). List of Sea Ports in the Core and Comprehensive Networks.

European Commission. (2014b, April 28). Ports 2030 Gateways for the TEN-T Network.

European Commission, & Eurostat. (2005). *Road freight transport methodology Vol. 1, Vol. 1,*. Luxembourg: Publications Office.

European Commission, & Eurostat. (2011). *Road freight transport methodology Reference Manual for the implementation of Council Regulation No 1172/98 on statistics on the carriage of goods by road*. Luxembourg: Publications Office of the European Union.

European Commission, & Eurostat. (2014). *Methodologies used in surveys of road freight transport in Member States, EFTA and Candidate Countries.* Luxembourg:

European Commission, & Eurostat. (2016). *Road freight transport methodology 2016 edition.* Luxembourg: Publications Office.

Eurostat. (2013). *Anonymised Road Carriage (RC) micro-data - user manual*. Eurostat.

Eurostat. (2017a). Nuts distances. Retrieved 14 March 2016, from http://ec.europa.eu/eurostat/tercet/flatfiles.do

Eurostat. (2017b). NUTS Overview - Eurostat.

Eurostat. (2018a). Database - Eurostat. Retrieved 23 March 2017, from http://ec.europa.eu/eurostat/data/database

Eurostat. (2018b, March). 3-month-interest rate - Eurostat.

Fleming, D. K. (1983). Port rivarly, co-operation, merger. *Maritime Policy & Management*, *10*(3), 207–210. https://doi.org/10.1080/03088838300000032

Fleming, D. K., & Hayuth, Y. (1994). Concepts of strategic commercial location: the case of container ports. *Maritime Policy & Management*, *21*.

Gibson, G., Korzhenevych, A., & Bröcker, J. (2014). *Update of the Handbook on External Costs of Transport*. Ricardo AEA.

Grosso, M. (2011). *Improving the competitiveness of intermodal transport_Applications on european corridors tesi di dottorato*. Genova.

Hafen Hamburg. (2016). Daten & Fakten. Retrieved 10 January 2017, from http://www.hafen-hamburg.de/figures/facts

Hall, P. V., & Jacobs, W. (2010). Shifting Proximities: The Maritime Ports Sector in an Era of Global Supply Chains. *Regional Studies*, *44*(9), 1103–1115. https://doi.org/10.1080/00343400903365110

Hamburg und Bremen zahlen für Y-Trasse. (2010, December 21). Retrieved 26 September 2014, from http://www.schiffundhafen.de/de/news/haefen/single-view/view/hamburg-und-bremen-zahlen-fuer-y-trasse.html?sword_list%5B%5D=Y-trasse&no_cache=1

Havenbedrijf Antwerpen. (2016). Statistisch Jaarboek 2015.

Heaver, T. D. (2011). Improving efficiency the role of collaborative relationships. Presented at the First Annual International Workshop on Port Economics, Singapore.

Heaver, T. D., Meersman, H., Moglia, F., & Van de Voorde, E. (2000). Do mergers and alliances influence European shipping and port competition? *Maritime Policy & Management*, *27*(4), 363–373.

Heaver, T. D., Meersman, H., & Van de Voorde, E. (2001). Co-operation and competition in international container transport: strategies for ports. *Maritime Policy & Management*, *28*(3), 293–305.

Hintjens, J. (2018). A conceptual framework for cooperation in hinterland development between neighbouring seaport authorities. *Maritime Policy & Management*. Retrieved from

Hintjens, J., Vanelslander, T., Van Der Horst, M., & Kuipers, B. (2015). The evolution of the economic centre of gravity and the consequences for gateway ports and hinterland connections The case of the Flemish-Dutch Delta. In *IAME 2015 Conference Kuala Lumpur, Malaysia*. Kuala Lumpur, Malaysia.

IHS Markit. (2017). *Vessel Accumulation and Cargo Value Estimation*.

Knowler, G. (2015, September 30). Ningbo-Zhoushan officially merged into one port. *JOC*. l

Kuipers, B. (2014). De container is de beste uitvinding van de laatste 100 jaar. In *Prijsvraag 2014: bekroonde essays*. Haarlem: Koninklijke Hollandse Maatschappij der Wetenschappen.
Lambreghts, M. (1938). *Antwerpen-Rotterdam; een pleidooi voor samenwerking*. Tielt: Lannoo. Retrieved from http://anet.be/record/opacuantwerpen/c:lvd:305770
Levinson, M. (2008). *The Box: How the Shipping Container Made the World Smaller and The World Economy Bigger*. Princeton: Princeton University Press.
Magala, M. (2004). *Opportunity Capture and Growth Strategies for Regional Ports: A Modelling Approach* (phd). Victoria University. Retrieved from http://www.vu.edu.au/research
Magala, M., & Sammons, A. (2008). A new approach to port choice modelling. *Maritime Economics & Logistics*, *10*(1), 9–34.
Mclaughlin, H., & Fearon, C. (2013). Understanding the development of port and regional relationships: a new cooperation/competition matrix. *Maritime Policy & Management*, *40*(3), 278–294.
Meers, D. (2016). *From mental to modal shift: decision support for intermodal transport*. VUB.
Meersman, H., & Van de Voorde, E. (2014). Implementing strategies towards port development options and market requirements. In T. Vanelslander & C. Sys (Eds.), *Port business. market challenges and management actions*. Brussels, UPA.
Meersman, H., Van de Voorde, E., & Vanelslander, T. (2007). Zeehavens en maritiem transport cruciale schakels voor logistiek succes. Steunpunt Goederenstromen.
Musso, E., Ferrari, C., & Benacchio, M. (2000). Cooperation in maritime and port industry and its effects. *Maritime Engineering and Ports, II*.
Nea. (2004). *Factorkosten van het goederenvervoer : een analyse van de ontwikkeling in de tijd* -. Rijswijk: Nea Transportonderzoek en -opleiding. Retrieved from http://publicaties.minienm.nl/documenten/factorkosten-van-het-goederenvervoer-een-analyse-van-de-ontwikke
Notteboom, T. (2009). Complementarity and substitutability among adjacent gateway ports. *Environment and Planning. A*, *41*(3), 743.
Notteboom, T. (2010). Concentration and the formation of multi-port gateway regions in the European container port system: an update. *Journal of Transport Geography*, *18*(4), 567–583.
Notteboom, T., Ducruet, C., & De Langen, P. W. (2009). *Ports in Proximity: Competition and Coordination Among Adjacent Seaports*. Ashgate Publishing, Ltd.
Notteboom, T., Knatz, G., & Parola, F. (2018). Port co-operation: types, drivers and impediments. *Research in Transportation Business & Management*, *26*, 1–4. https://doi.org/10.1016/j.rtbm.2018.04.004
Notteboom, T., & Winkelmans, W. (2001). Structural changes in logistics: how will port authorities face the challenge? *Maritime Policy & Management*, *28*(1), 71–89. https://doi.org/10.1080/03088830119197
OECD. (2008). Port competition and hinterland connections (Vol. 2008–19). Presented at the Joint Transport Research Centre, International Transport Forum.
O'Sullivan, M. (2010, 15/09). *Container Cargo Insurance*. Presented at the IUMI 2010, Zurich.
Pallis, A. A., Vitsounis, T. K., & De Langen, P. W. (2010). Port Economics, Policy and Management: Review of an Emerging Research Field. *Transport Reviews*, *30*(1), 115–161.
Panteia. (2017). *Kostencalculaties in het beroepsgoederenvervoer over de weg*. Zoetermeer, The Netherlands: Panteia.
Port of Rotterdam. (2016). Port Statistics A wealth of Information.
Porter, M. E. (1980). *Competitive strategy: techniques for analyzing industries and competitors*. New York: Free Press.
Rashed, Y. (2016). *Container throughput modelling and forecasting. an empirical dynamic econometric time series approach : proefschrift*. Antwerp, 2016.
Raue, J. S., & Wallenburg, C. M. (2013). Alike or not? Partner similarity and its outcome in horizontal cooperations between logistics service providers. *Logistics Research*, *6*(4), 217–230.
Regulation (EU) No 70/2012 of the European Parliament and of the Council of 18 January 2012 on statistical returns in respect of the carriage of goods by road Text with EEA relevance, Pub. L. No. 32012R0070, 032 OJ L (2012).
Robinson, R. (2002). Ports as elements in value-driven chain systems: the new paradigm. *Maritime Policy & Management*, *29*(3), 241–255. https://doi.org/10.1080/03088830210132623
Schade, W. (2005). *Strategic sustainability analysis: concept and application for the assessment of european*

transport policy. Nomos.
Seabury. (2018). Seabury Ocean Trade Database.
Seattle-Tacoma Complete Port Alliance. (2015, May 8). Retrieved 24 May 2016, from https://www.porttechnology.org/news/seattle_tacoma_complete_port_alliance
Song, D. W. (2004). The Motivation for Port Co-opetition: Strategic Implications to Korea. *Journal of Shipping and Logistics*, *43*, 141–156.
Song, D.-W. (2003). Port co-opetition in concept and practice. *Maritime Policy & Management*, *30*(1), 29–44.
Stevens, L., Sys, C., Van de Voorde, E., & Vanelslander, T. (2012). Port cooperation: motives, forms and results. Presented at the IAME 2012, Taipei, Taiwan.
Tavasszy, L., & Van Meijeren, J. (2011). Modal shift target for freight transport above 300 km: an assessment. *Brussels: ACEA*.
Van de Voorde, E., & Vanelslander, T. (2008). *Market power and vertical and horizontal integration in the maritime shipping and port industry*. OECD/ITF Joint Transport Research Centre Discussion Paper.
Van der Lugt, L. (2015). *Beyond the landlord - A strategic management perspective on the port authority*. Vrije Universiteit Amsterdam, Amsterdam.
Van der Lugt, L., De Langen, P. W., & Hagdorn, L. (2013). Beyond the landlord: typologies of port authority strategies. Presented at the IAME 2013, Marseille.
Van Hassel, E., Meersman, H., Van de Voorde, E., & Vanelslander, T. (2016). Impact of scale increase of container ships on the generalised chain cost. *Maritime Policy & Management*, *43*(2), 192–208.
Van Hassel, E., Vanelslander, T., & Doll, C. (2018). *LowCarb RFC - European Rail Freight Corridors Going Carbon Neutral*. Antwerp: Universiteit Antwerpen, Departement Transport en Ruimtelijke Economie.
Vandevoorde, J.-L. (2017, December 8). Havens Gent en Zeeland ‘samen slimmer’ als “North Sea Port”. *Flows*.
Verhoeven, P. (2010). A review of port authority functions: towards a renaissance? *Maritime Policy & Management*, *37*(3), 247–270.
Vigarié, A. (1979). *Ports de commerce et vie littorale*. Paris: Hachette.
Vitsounis, T. K., & Pallis, A. A. (2012). Port Value Chains and the Role of Interdependencies. *Maritime Logistics: Contemporary Issues*, 155.
Walley, K. (2007). Coopetition: An Introduction to the Subject and an Agenda for Research. *International Studies of Management & Organization*, *37*(2), 11–31.
Woo, S.-H., Pettit, S., Beresford, A., & Kwak, D.-W. (2012). Seaport Research: A Decadal Analysis of Trends and Themes Since the 1980s. *Transport Reviews*, *32*(3), 351–377.
World Shipping Council. (2018). *liner shipping in the eu facts*. Retrieved from http://www.worldshipping.org/liner-shipping-in-the-eu-facts.pdf
Wortelboer-Van Donselaar, P., & Kolkman, J. (2008). Samenwerking tussen zeehavens. Kennisinstituut voor Mobiliteitsbeleid, Den Haag.
Wortelboer-Van Donselaer, P.-V. D., & Kolkman, J. (2010). Societal costs and benefits of cooperation between port authorities. *Maritime Policy & Management*, *37*(3), 271–284.