A kaleidoscopic view of the future of the Rhine-Scheldt delta port system

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A KALEIDOSCOPIC VIEW OF THE FUTURE OF THE RHINE-SCHELDT DELTA PORT SYSTEM

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DISCLAIMER

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Table of Contents

Foreword

At ING, our mission is to empower companies and entrepreneurs to do business. To be able to achieve this mission with our business customers, our bankers must speak their language and understand their world in order to accompany them even better.

ING's strategy is built along three differentiators. First of all, we are local experts with a global reach. ING has strong local roots embedded in the Belgian economy and combines this with a strong global footprint and presence in 23 countries. Secondly we are sector experts. ING is differentiating itself by its sector approach and the Transport and Logistics sector is one of our key sectors that ING has been supporting both in Belgium as abroad for many years. Finally we are sustainable pioneers. ING is not just a thought-leader, we work hand in hand with our clients to address one of the most pressing issues in the world today providing sustainable financing and advice. That's the reason why, more than other banks, we will stay by your side to help you grow your business.

ING is proud to team up with University of Antwerp to conduct an eighth extensive study on a maritime and logistical topic. The goal of these studies is to contribute to a better understanding, development and growth of our transport and logistics ecosystem. Sharing knowledge is a key element of our customer promise.

This year, Theo Notteboom, Professor of Port and Maritime Economics and the author of this report, looked at the future of the Rhine-Scheldt Delta ports, critically examining a wide range of important developments.

Geopolitical and climatic changes will have a major impact on logistics activities around the Rhine-Scheldt Delta ports. On the other hand, the attractiveness of Rhine-Scheldt delta ports is questioned by regional competition and nearshoring. In a changing and insecure world, everyone needs a compass. That is precisely what this study proposes: to expose the reality and try to enlighten the future with a rational and scientific approach.

The many challenges that the sector will have to face, but also the opportunities, will require important investments to modernize the infrastructures, to digitalize the operations and to meet the objectives of sustainable development.

We are convinced that the research and the conclusions of this study are relevant for all kind of maritime companies, port authorities and all the partners and stakeholders of this ecosystem.

We want to thank Professor Theo Notteboom for his energy and knowhow. The members of the editorial board were a committed and powerful sounding board. Without them, the study would not be as thorough as the actual final result.

Bram Debruyne

Head of Corporate Sector Coverage Belux

Saskia Bauters

Head of Business Banking Sales Belgium

1. Introduction

The industrial-economic complex in the Rhine-Scheldt Delta is one the largest port systems in the world, partly thanks to its location, including the appropriate space for industry and hinterland access, and the cluster effects in the form of the presence of knowledge networks and hinterland markets. The Rhine-Scheldt Delta fulfills an important function as gateway to the vast European hinterland. The region is home to an array of seaports, each displaying specific characteristics in terms of history, dimension and specialization. The ports in the Rhine-Scheldt Delta are strongly linked in a functional sense, which was further strengthened by recent integration movements into larger administrative units. The economic significance of the ports for citizens and businesses in the national economy is substantial. For example, seaports play an essential role in the open economies of the Low Countries, and they play an important role in shaping the energy transition, the circular economy and the pursuit of more sustainable and resilient logistics chains.

Figure 1.1. Overview of previous ING studies on ports in the Rhine-Scheldt Delta

Since 2011, the University of Antwerp and partners have prepared a total of seven port studies commissioned by ING Bank, each addressing a series of themes in relation to the ports in the Rhine-Scheldt Delta or, occasionally, only the Belgian ports within the Delta (Figure 1.1):

1. NOTTEBOOM, T., VAN DER LUGT, L., VAN SAASE, N., SEL, S., NEYENS, K., 2019, Green supply chains: implications and challenges for Rhine-Scheldt Delta seaports, final report prepared for ING Belgium, UAntwerpen/VIL/Erasmus Universiteit Rotterdam, 17 July 2019, 121 p.
2. NOTTEBOOM, T., NEYENS, K., 2017, The future of port logistics: meeting the challenges of supply chain integration, final report prepared for ING Bank, UAntwerpen and VIL, 87 p.
3. VONCK, I., NOTTEBOOM, T., 2015, Strategic evaluation of the Belgian port sector and accompanying services, final report prepared for ING Belgium, ITMMA-UAntwerpen, Bietlot:Gilly, ISBN 978-94-9135-90-40, 91 p.

4. VONCK, I., NOTTEBOOM, T., 2013, Economic analysis of volatility and uncertainty in seaports: tools and strategies towards greater flexibility, resilience and agility of port authorities and port companies, final report prepared for ING Belgium, ITMMA-UAntwerpen, Bietlot:Gilly, ISBN 978-94-9135-90-33, 89 p.
5. VONCK, I., NOTTEBOOM, T., 2012, Economic analysis of the warehousing and distribution market in Northwest Europe, final report prepared for ING Belgium, ITMMA-UAntwerpen, JCBGAM: Wavre, ISBN 978 94 9135 902 6, 88 p.
6. VONCK, I., NOTTEBOOM, T., 2012, Economic analysis of break bulk flows and activities in Belgian ports, final report prepared for ING Belgium, ITMMA-UAntwerpen, JCBGAM: Wavre, ISBN 978 94 9135 901 9, 97 p.
7. NOTTEBOOM, T., VONCK, I., 2011, An economic analysis of the Rhine-Scheldt Delta port region, final report prepared for ING Belgium, ITMMA-UAntwerpen, Bietlot: Gilly, ISBN 978-94-9135-900-2, 130 p.

The previous studies thus covered a very broad spectrum of important port themes. This report does not focus on introducing a new overall theme. Instead, the aim of the study is to examine the future of seaports in the Rhine-Scheldt Delta by critically analyzing a range of important developments.

The term kaleidoscope in the report's title is used as a metaphor for the followed approach. The user looks into a kaleidoscope from one side and the light creates reflections in mirrors from the other side. These reflections create multicolored patterns, which can then change when the tube is shaken. In a figurative sense, the term kaleidoscope denotes the possible presence of a wide range of aspects, opinions and points of view in a particular domain.

In following the kaleidoscopic approach, we will mainly look for trends and developments about which there is still a lot of uncertainty, or about which visions and opinions differ greatly. These possible trends and developments are divided into a number of major themes which are also interconnected. The following main themes are distinguished in relation to the Rhine-Scheldt Delta ports:

1. Ports and international trade
2. Port competition in a European perspective
3. Ports and the organization of (maritime) supply chains
4. The role and functioning of managing bodies of ports
5. Sustainable ports

Many of the above themes have already been addressed in previous ING studies in some manner. Therefore, instead of presenting long drawn-out discussions per main theme, this report contains shorter and focused analyses. For each main theme, a selection of critical propositions are posited, which are discussed with attention to the different visions and perspectives that exist in that area, the arguments and data that support the proposition and possible arguments that undermine it. These arguments for and against are supported as much as possible by findings in the existing literature, but also supplemented with own insights. The report therefore mainly looks for future trends about which the various experts and sources are much less unequivocal. To keep things manageable, the number of propositions being addressed is limited to an average of two to four per main theme. The study focuses in particular on the ports and port companies in the Rhine-Scheldt Delta, but the detailed analysis can be of relevance to other seaports as well.

In view of guiding the drafting of this report, an editorial board was composed with representatives from port companies, port authorities and ING. During consultation moments with the editorial board, the members critically assessed the progress of the study and provided valuable inputs and suggestions.

The report is structured as follows. The next section introduces the Rhine-Scheldt Delta port system by focusing on cargo volumes, dynamics in port governance, economic and strategic impact and advances in sustainability, energy transition and the circular economy. In section 3, the five themes covering possible trends and developments relevant to the Rhine-Scheldt Delta port system are presented, as well as a series of selected propositions. The formulated propositions are analyzed in sections 4 to 8. The discussion of each proposition consist of a theme setting part, several sub-headings in which different aspects are being analyzed in more detail and a summary table which brings together the arguments and observations in support of the proposition, the arguments and observations going against the proposition and the overall implications on the Rhine-Scheldt Delta port system. Section 9 includes a structured summary of the findings and some final remarks with respect to the presented research.

2. The Rhine-Scheldt Delta port system at a glance

2.1. Economic activities and traffic volumes

This report focuses on the Rhine-Scheldt Delta port system. This region includes all ports located in the estuary systems of the Rhine, Meuse, and Scheldt rivers (Figure 2.1). In 2021, this port system handled a total maritime cargo volume of about **924 million tons** (+5.2% compared to 2020) and a container traffic of about 29.9 million TEU (+5%). The two largest ports in Europe, i.e. Rotterdam and Antwerp-Bruges, are located in this Delta as well as Europe's fourth-largest port (the Amsterdam/Velsen/Ijmuiden port area along the North Sea Canal) and tenth-largest port (North Sea Port).

Figure 2.1. Maritime traffic handled by ports in the Rhine-Scheldt Delta

Source: own compilation based on port authority data

Figure 2.2 provides an overview of the **cargo volume mix** handled in 2021 in a selection of ports of the Rhine-Scheldt Delta seaports. Antwerp-Bruges, Rotterdam, North Sea Port, and Moerdijk are home to large interconnected (petro-)chemical industry clusters. While Rotterdam and Antwerp are generally considered as highly diversified ports, containers and liquid bulk combined represent three quarters of Rotterdam's maritime traffic and even 87% in the Antwerp port area. Rotterdam is the undisputed market leader in the Delta when it comes to crude oil and oil products, coal and iron ore. The container volumes of Antwerp and Zeebrugge combined amount to 159 million tons in 2021, or slightly above Rotterdam's container volume. In TEU terms, Rotterdam and Antwerp-Bruges are the top two EU container ports handling 15.3 million TEU and 14.2 million TEU respectively in 2021. Amsterdam and North Sea Port have a strong focus on dry and liquid bulk. Steel plants can be found in North Sea Port (ArcelorMittal) and Ijmuiden (Tata Steel). Despite much lower volume, roll on roll off and other general cargo flows remain important for most Rhine-Scheldt Delta ports. The coastal port area of Zeebrugge (since April 2022 managed by Port of Antwerp-Bruges) is the largest car handling port in the world with about three million new cars handled each year, and a major energy hub for gas transported by pipelines and LNG carriers. The gas facilities in Zeebrugge have a combined import capacity of 55 billion cubic meters per year.

Figure 2.2. Maritime traffic mix for the four largest ports in the Rhine Scheldt-Delta (figures for 2021)

ROTTERDAM	million tons	share
Crude oil and oil products	164.2	35.0%
Containers	154.5	33.0%
Other liquid bulk	33.3	7.1%
Iron ore and scrap	30.3	6.5%
Coal	24.6	5.2%
Roro	24.0	5.1%
Other dry bulk	15.3	3.3%
Agribulk	8.6	1.8%
LNG	7.0	1.5%
Other general cargo	6.9	1.5%

ANTWERP	million tons	share
Containers	138.4	57.7%
Crude oil and oil products	54.6	22.7%
Other liquid bulk	16.7	7.0%
Other general cargo	12.5	5.2%
Other dry bulk	5.7	2.4%
Agribulk	5.3	2.2%
Roro	4.3	1.8%
Ores	1.4	0.6%
Coal	0.9	0.4%

AMSTERDAM	million tons	share
Crude oil and oil products	35.7	50.0%
Other dry bulk	11.7	16.4%
Coal	10.4	14.6%
Agribulk	6.6	9.2%
Other liquid bulk	4.1	5.7%
Roro and other general cargo	1.5	2.1%
Containers	1.4	2.0%

NORTH SEA PORT	million tons	share
Dry bulk	36.4	52.9%
Liquid bulk	16.7	24.3%
Other general cargo	9.5	13.8%
Roro	3.6	5.2%
Containers	2.6	3.8%

Note: 2021 was the last year before the merger of Port of Antwerp and MBZ to form Port of Antwerp-Bruges. Therefore, the figures for Antwerp only relate to the Antwerp port area.

Source: own compilation based on port authority data

2.2. Port governance

Port governance in the region underwent several major changes since the 1990s which resulted in more autonomous port authorities acting as public limited companies, with ownership in most cases residing with the respective municipalities. For example, North Sea Port has eight public shareholders: Province of Zeeland (25%), the municipalities of Borsele, Terneuzen and Flushing (each 8.33%) in the Netherlands, the city of Ghent (48.52%) and the municipalities of Evergem (0.03%) and Zelzate (0.005%) in Belgium and the province of East Flanders (1.444%). Port of Antwerp-Bruges is a municipal port authority with 80% of the shares held by the City of Antwerp and 20% by the City of Bruges. The shares of Port of Rotterdam are held by the City of Rotterdam (about 70%) and the Dutch State (about 30%). Port of Amsterdam is fully owned by the City of Amsterdam. Port of Amsterdam can be considered the main port in a cluster of ports along the North Sea Canal which includes Amsterdam, Velsen/IJmuiden, Zaanstad, and Beverwijk. Also Port Oostende is a limited company of Public Law with full ownership by the city.

In the 1990s and early 2000s, national port (investment) coordination and exchanges between the port authorities and the relevant government agencies were promoted through the Flemish Port Commission in the Flanders region of Belgium and the National Port Council in the Netherlands. In recent decades these commissions/councils have either been absorbed or disappeared. In particular, the Flemish Port Commission was integrated in the Mobility Council or MORA in late 2018 while the National Port Council held its last meeting in late 2011. In recent years, the ports in the region have developed a wide range of bilateral and multilateral bottom-up cooperation initiatives in relevant fields such as sustainability, energy transition, digital transformation, nautical issues and safety and security. The Delta has also grown into a leading port system in the world when it comes to **port authority mergers**:

- The cross-border port authority North Sea Port was formed in 2018 after the merger between the port authority of Ghent (Belgium) and Zeeland Seaports (ports of Flushing and Terneuzen in the Netherlands). North Sea Port is the second cross-border port merger in Europe after the creation of Copenhagen-Malmo port (Denmark/Sweden) in 2001;
- The merger port authority Port of Antwerp-Bruges was announced in February 2021 and formally installed on 22 April 2022. It is the result of the merger between the Antwerp Port Authority and MBZ, the port authority of Zeebrugge. It is one of the largest port mergers in the world in terms of cargo volume. Discussion about the merger started in early 2018 between the City of Antwerp and the City of Bruges with a view to closer collaboration. However, there have been several earlier attempts to reach a closer collaboration between both ports in the past decades, particularly focusing on the container business. Next to further strengthening its position in cargo handling and logistics, the merged entity also aims to become Europe's most important hub for hydrogen, a center for energy transition and the circular economy, and overall a resilient, sustainable, and diversified port ecosystem.
- In 2013, the Port of Rotterdam Authority adopted responsibility for the operation and development of Dordrecht's port area. The port authority is working closely with the Municipality of Dordrecht and local companies to exploit the full potential of the 290-hectare port area and the neighboring industrial estate, under the brand name Dordrecht Inland Seaport.

Port integration and mergers have become key strategic enablers to respond to consolidation and vertical integration in the logistics market, to increase port resilience by moving to a more diversified offer to port users, and to enhance capacity building in view of dealing with energy transition and climate change challenges faced by managing bodies of ports and broader port communities.

2.3. Economic impact

The seaports in the Delta are **economic catalysts** for the regions they serve. Policymakers and public authorities typically approach the macro-economic impacts of ports from a national or regional competitiveness perspective. Thus, most available reports and figures on the economic impact of seaports portray the national or regional economic effects. There exists no unique standard methodology in Europe or even within the Rhine-Scheldt Delta on the definition of the types of economic impacts, which makes port comparisons difficult. Detailed studies on port impacts are however available for Dutch ports and Belgian ports separately. The figures for Flemish and Dutch ports can therefore not be compared on an equal basis.

The National Bank of Belgium (NBB) provides detailed data on the economic impact of Belgian seaports and larger inland ports. The reports assess the economic situation within ports based on three criteria: employment, added value and investments. It considers all ports in Belgium, not only seaports, namely: Antwerp, North Sea Port Flanders (Ghent port area), Zeebrugge and Ostend, but also the inland ports of Liège and Brussels which occasionally receive coasters. For most of the studies there is a time lag of about two years. Thus, the study with figures for 2020 were presented in May 2022 (NBB, 2022). An important aspect of the Belgian methodology is that the inclusion is based on a functional and a geographical criterion. This means that not only companies based in the port are taken into account, but also companies located outside the port but with a functional link towards the maritime industry. In assessing the added value of a port, a division is made between the maritime and non-maritime cluster. The non-maritime cluster is further subdivided in trade, industry, land transport and other logistics services. The added value of a port is a measure of the contribution to the GDP of the country in which it is located. The calculation is obtained by summing the personnel costs, depreciation and amortization, annual results, provisions for risks and charges and certain operating expenses; x employment in full-time equivalents (FTE). Direct employment only covers salaried employees in the companies considered, indirect employment also includes the self-employed workers.

The Ministry of Infrastructure and the Environment in the Netherlands regularly commissions a 'Havenmonitor' report (Port Monitor). The Port Monitor looks at the economic significance of seaport-related activities in four Dutch port areas: the sea ports in the North (Delfszijl, Eemsmond, Harlingen, Den Helder), the North sea canal area (Amsterdam, Velsen/Ijmuiden), the Rhine and Meuse estuary area (with specific attention to Rotterdam-Rijnmond) and the Scheldt basin (Flushing, Terneuzen, Borssele). The economic significance is defined in terms of added value, employment, number of business establishments and business dynamics and private investments. An activity is a seaport activity once it meets one of the following criteria: logistics and transport directly related to the import, export and transit of goods by sea; industrial activities that significantly use the port for the loading and unloading of their goods; other services related to functions of seaports, such as other government and business services. The latest available report dates back to November 2021 containing figures up to 2020 (Erasmus UPT, 2021).

Table 2.1 provides an overview of the main results for employment (direct and indirect) and value added (direct and indirect). The Dutch seaports generate a direct and indirect employment of 354,470 FTE of which about 150,000 can be linked to Rotterdam. Total direct and indirect value added amounted to 44 billion euro in 2021, of which about half is attributable to Rotterdam. The industry and wholesaling business is the most significant sector both in terms of direct employment and direct value added.

Direct and indirect employment in Flemish ports amounted to some 235,000 in 2021, of which more than half on the account of the Antwerp port area. Total direct and indirect value added reached about 30 billion euro. The maritime and non-maritime activities are fairly equally important in Antwerp in terms of direct employment, but the non-maritime part generates significantly more direct value added. In North Sea Port Flanders the non-maritime sector dominates both in terms of direct employment and value added, while in the coastal port area Zeebrugge the maritime activities are slightly more important, particularly in terms of employment.

Simultaneously, the economic effects of the seaport activities in the Rhine-Scheldt Delta are no longer limited to the local environment. Ports impact the wider economic space and international trade. They are increasingly spread over a much wider geographical area and among a large number of international players. In other words, the economic benefits of port activities are expanding from the local port system towards a much larger economic system.

The changing distribution of benefits is also illustrated by the **development of logistics zones in the vicinity of seaports or inland locations along the main corridors towards the hinterland**. This trend has been supported by growing containerization and intermodal transport systems. In many cases, these logistics sites and zones generate considerable economic benefits by providing low-end and high-end value-added logistics services (VALS) to the cargo and only using ports as a transit point. However, it is unlikely that these sites and zones would have developed if it were not for seaports.

Table 2.1. Direct and indirect economic effects of the ports in the Rhine-Scheldt Delta, figures for 2020

	Direct employment (FTE)	Indirect employment (FTE)	Direct & indirect (FTE)	Direct value added (billion euro)	Indirect value added (billion euro)	Direct & indirect (billion euro)
Northern Seaports	10936	9855	20791	1.94	1.08	3.02
North Sea Canal Area	37849	29644	67493	3.78	2.36	6.14
Rhine- and Maasmond	134050	95749	229799	18.84	9.37	28.21
of which Rotterdam	*88018*	*62312*	*150330*	*14.61*	*7.17*	*21.78*
North Sea Port (the Netherlands)	20741	15646	36387	2.65	4.04	6.69
Total Dutch ports	**203576**	**150894**	**354470**	**27.21**	**16.85**	**44.06**

ALL DUTCH SEAPORTS

per sector	Direct employment (FTE)	Direct value added (billion euro)
Inland navigation	9935	1.01
Trucking	38319	2.36
Rail transport	1361	0.08
Transport by pipeline	71	0.17
Transport, cargo handling & warehousing	31740	3.96
Industry and wholesale	69970	10.55
Other public and private services	52180	9.07
Total Dutch ports	**203576**	**27.2**

	Direct employment (FTE)	Indirect employment (FTE)	Direct & indirect (FTE)	Direct value added (billion euro)	Indirect value added (billion euro)	Direct & indirect (billion euro)
Antwerp	62781	79166	141947	11.18	7.71	18.89
Zeebrugge	9825	9761	19586	1.09	0.78	1.87
North Sea Port (Flanders)	28877	35780	64657	4.15	3.79	7.93
Ostend	5086	4292	9378	0.71	0.52	1.23
Total Flemish ports	**106569**	**128999**	**235568**	**17.12**	**12.81**	**29.92**

ALL FLEMISH SEAPORTS

	Direct employment (FTE)			Direct value added (billion euro)		
	Antwerp	Zeebrugge	North Sea Port (Flanders)	Antwerp	Zeebrugge	North Sea Port (Flanders)
Maritime (*)	27940	6146	2964	3.929	0.584	0.36
Non-maritime (**)	34841	3679	25913	7.248	0.503	3.78
TOTAL	**62781**	**9825**	**28877**	**11.176**	**1.086**	**4.15**

(*) Cargo handling, shipping companies, port authority, shipping agents and forwarders, port consutrction and dredging, public sector
(**) Trade, chemical industry, car manufcaturing, melworking industry, fuel production, energy, inland transport

Source: own compilation based on data NBB (2022) and Erasmus UPT (2021)

By providing cost-efficient, reliable, and frequent connections to overseas and inland markets, the seaports in the Rhine-Scheldt Delta play an essential role in facilitating trade and increasing the competitiveness of a nation or region. This **strategic value** manifests itself in different ways. First, the proximity of efficient seaports can be an important factor in the location decisions of firms. Second, the availability of a competitive seaport system can reduce reliance on foreign ports for trade and can reduce the total logistics costs for firms located in the region. Third, seaports can substantially contribute to the international competitiveness of firms in a region or country, mainly through existing innovation and advanced business networks and management.

The 2015 ING report on '*Strategic evaluation of the Belgian port sector and accompanying services*' (Vonck and Notteboom, 2015) estimated the strategic value of Belgian seaports by adding three elements to the classic economic evaluation of the ports' economic impact by the National bank of

Belgium: (1) the increase of transport cost when the ports would disappear; (2) the estimated increase in qualitative value for the remainder of the economy and (3) the potential loss of economic activity by relocation. This exercise resulted in a total estimation of the strategic value of Belgian ports of 45 billion euro in 2014. This is 50 to 60% more than the classic economic impact as estimated by the National Bank of Belgium.

2.4. Hubs in sustainability, energy transition and the circular economy

The Rhine-Scheldt Delta ports are also rapidly growing into hotspots for **sustainability, energy transition and the circular economy**. These appear as key action fields in the strategic plans and business plans of the individual port authorities. The seaports in the Delta contribute to the overall emissions in the low countries given the presence of large-scale industrial and logistics clusters and their role as turntables in extensive maritime and land-based transport networks. However, because of their nodal position in industrial ecosystems and global supply chains and the presence of relevant expertise, they also hold the key to substantially contributing to sustainability and energy transition solutions in the region, Europe and even on a global scale.

The 2019 ING report entitled '*Green supply chains: implications and challenges for Rhine-Scheldt Delta seaports*' (Notteboom et al., 2019) provided a comprehensive overview of the initiatives developed in the areas of green shipping; green port development and operations; green inland logistics; seaports and the circular economy; and, actions in the field of knowledge development and information sharing. The analysis demonstrated that the Delta ports are hotbeds for these initiatives, but progress in some areas remains slow or extremely challenging. Obviously, in the past few years additional large-scale and smaller initiatives have been announced or implemented bringing the region a few steps further in their development path towards sustainability, energy transition and the circular economy. The 2019 study also presented the results of a large-scale survey conducted in the Belgian and Dutch logistics and port industry. That survey revealed that greening has been put massively on the agenda by the firms and identified the diverse drivers and impediments towards the greening of supply chains. The survey further elaborated on the role of governments as catalysts or soft enforcers for change, and called for continuity and coherence in government policy.

The recent geopolitical tensions linked to the war in Ukraine have further increased the sense of urgency in energy transition to non-fossil fuels in the medium term. However, the pressure to guarantee energy supply at reasonable prices in the short term has also impacts on fossil fuel imports. For example, the Ukraine crisis and associated sanctions against Russia have resulted in an increased demand in Europe for coal and non-Russian gas and oil imported from the Middle East and North America (shale gas and oil) or via pipeline from the Norwegian gas fields or the UK.

3. Themes and propositions

Possible trends and developments relevant to the Rhine-Scheldt Delta port system are divided into a number of major themes: (1) Ports and international trade; (2) Port competition in a European perspective; (3) Ports and the organization of (maritime) supply chains; (4) The role and functioning of managing bodies of ports; (5) Sustainable ports. These themes are not mutually exclusive, as strong interdependencies might be observed between them. For the purpose of this study, 13 propositions have been formulated (Table 3.1).

Table 3.1. Themes and propositions addressed in the report

Theme 1: Ports and international trade
Proposition 1.1. The worldwide trade relations of the Rhine-Scheldt Delta ports will fundamentally change due to geopolitical changes, the energy transition and sustainability goals.
Proposition 1.2. Trends in nearshoring do not necessarily undermine the market position of the Rhine-Scheldt Delta ports.
Theme 2. Port competition in a European perspective
Proposition 2.1. The rise of Mediterranean seaports will only lead to a limited maritime cargo shift from north to south.
Proposition 2.2. The battle for the European hinterland will increasingly be shaped by the role of rail, barge transport and shortsea/coastal shipping as part of ports' modal split.
***Proposition* 2.3.** Centralized European distribution with XXL warehouses and liquid bulk storage hubs is the dominant model for the future favoring the competitive position of the Rhine-Scheldt Delta ports
Theme 3. Ports and the organization of (maritime) supply chains
Proposition 3.1. Vertical integration in (maritime) supply chains will increase further, resulting in increased competition for the orchestration of these chains.
Proposition 3.2. The era of alliances between container shipping companies is gradually coming to an end.
Proposition 3.3. Small and medium-sized freight forwarders without a strong digital backbone will struggle to survive.
Proposition 3.4. Conventional general cargo will remain an important market for the Rhine-Scheldt Delta ports.
Theme 4. The role and operation of managing bodies of ports
Proposition 4.1. The role adopted by managing bodies of ports in the Rhine-Scheldt Delta should not go beyond the role of 'facilitator'.
Proposition 4.2. Concession policy in ports should focus more on sustainability while guaranteeing flexible business development for new and existing concessionaires.
Theme 5. Sustainable ports
Proposition 5.1. In the medium term, any large-scale hydrogen adoption will rely on blue hydrogen and less on green hydrogen.
Proposition 5.2. Sustainable finance is becoming an important lever for making ports more sustainable.

In the remainder of this report, each of the propositions will be discussed with attention to the different visions and perspectives that exist in that area, the arguments and data that support the proposition and possible arguments that undermine it. These arguments for and against are supported as much as possible by findings in the existing literature, but also supplemented with own insights. The results are particularly relevant to the ports and port companies in the Rhine-Scheldt Delta, but can be of interest to other seaports and port-related actors as well.

4. Theme 1: Ports and international trade

4.1. Proposition 1.1

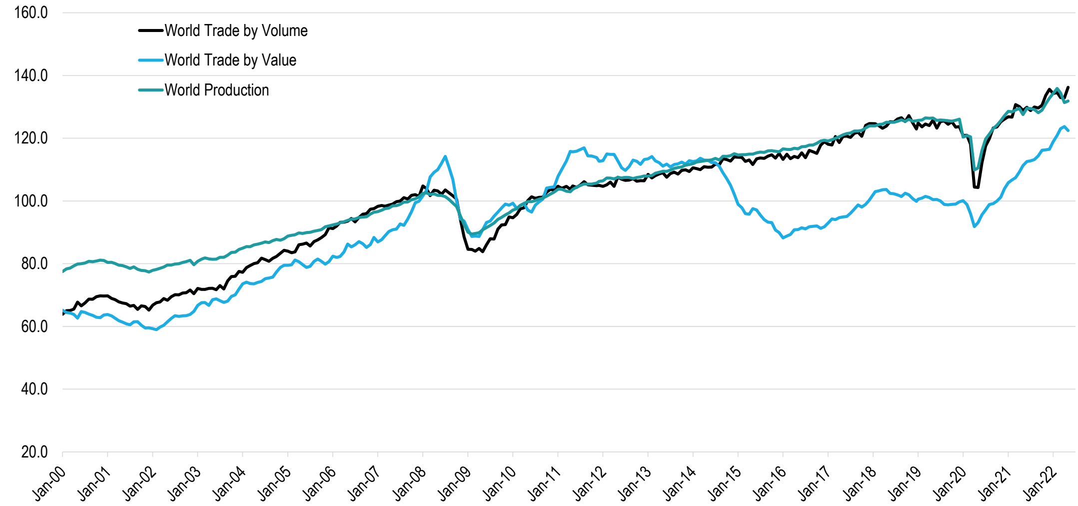
Proposition 1.1. The worldwide trade relations of the Rhine-Scheldt Delta ports will fundamentally change due to geopolitical changes, the energy transition and sustainability goals.

4.1.1. Global trade

The Rhine-Scheldt Delta ports are affected by a wide range of economic, technological and geopolitical developments. The demand for port activities is for a large part determined by global economic activities and world trade. World trade has experienced an important increase since the 1950s. International trade represents a growing share of global output. Several factors explained this growth: income growth, falling transport costs, trade liberalization and the associated tariff rate reductions, economic convergence of countries and the increase of intermediate goods trade in the context of global production chains (Feenstra, 1998). In general, the increasing integration of the global economy is a key development behind the rising significance of trade. Under the banner 'World Peace through World Trade', legal and cultural obstacles to trade have been diminishing in the post Word War 2 period. Integration has occurred both at the regional level and the global level. Regional trading blocks have been formed with differing levels of trade liberalization, such as NAFTA in North America, the EU Single Market in Europe, ASEAN in Southeast Asia, Mercosur in South America and Ecowas in West-Africa. An important share of international trade occurs within economic blocs, especially the European Union and NAFTA. At the global level, global trade is supported by the continuing evolution of the World Trade Organization (WTO) and initiatives by organizations such as UNCTAD/United Nations or the World Bank. After World War 2, a number of international corporations sought the support of intergovernmental organizations such as the United Nations for regulatory frameworks that enabled the pursuit of international corporate operations. As a result, it might be argued that the slogan 'World Peace through World Trade' slowly shifted to 'World Peace for World Trade'. At present, inter-governmental organizations still play an essential role in shaping the rules of the game in international competition and global trade. For most of the past quarter century, no region of the world has been more economically dynamic than East Asia. The unprecedented economic growth of East Asia transformed the patterns of world trade.

Global trade is impossible without transportation, making efficient transport a key trade facilitator. Transport costs (both freights costs and time costs) constitute a key component of total trade costs. These trade costs also include other costs incurred in getting a good to a final user other than the marginal cost of producing the good itself, such as policy barriers, information costs, legal and regulatory costs and so on (Anderson and van Wincoop, 2004). Lower trade costs contribute to trade growth. The container box and the associated maritime and inland transport systems proved to be very instrumental to the consecutive waves of globalization and the growth of global trade since the 1970s. Bernhofen et al. (2016) estimated the effects of the container revolution on world trade and used a quantitative methodology to lend support for the view of containerization being a key driver of twentieth-century economic globalization. Emerging worldwide container shipping networks allowed changes in the economic and transport geography as they significantly shortened the maritime cost distances between production and consumption centers around the world. Container shipping also became an essential driver in reshaping global supply chain practices, allowing global sourcing strategies of multinational enterprises, pull logistics solutions and the development of global production networks.

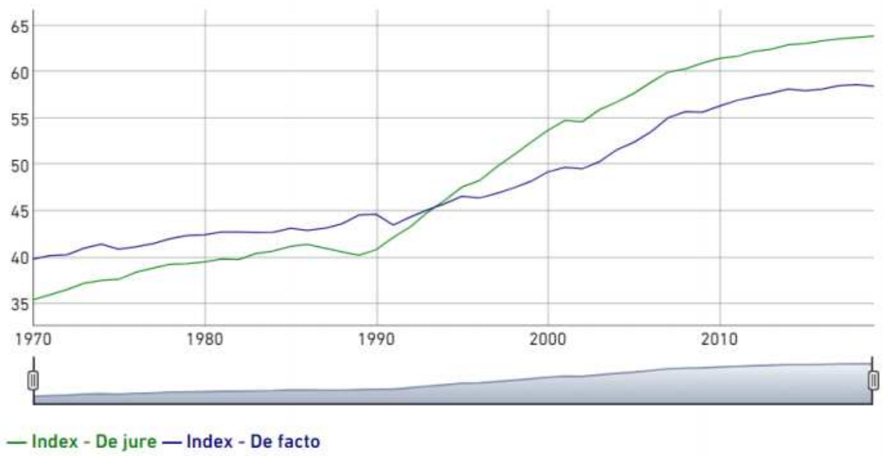
Figure 4.1. CPB World Trade Index by Volume, Jan 2000-June 2022 (May 2010=100)



Source: based on data CPB World Trade Monitor

Figure 4.2. KOF Globalization index – 1970 to 2019 (World, Belgium and the Netherlands)

WORLD



BELGIUM

THE NETHERLANDS

Source: KOF Swiss Economic Institute, for data and methodology see https://kof.ethz.ch/

Global trade is still growing in volume terms be it at a lower growth rate than before the 2008-2009 crisis (Figure 4.1). The KOF Globalization index shows that the globalization trend peaked between the early 1990s and the economic-financial crisis of 2008-2009, but is leveling off since then. This also applies to very open economies such as Belgium and the Netherlands (Figure 4.2).

There are several explanations for this development. First, the world economy is increasingly influenced by developing countries and economies in transition. Emerging economies play an increasing role in global trade, but their growth is typically less trade-intensive. Other regions of the world have seen much faster population growth than Western Europe or North America. Eventually this will lead to economic areas shifting in the direction of these concentrations of people with an increasing income profile. The shift in trade and GDP growth from advanced economies towards emerging market economies implies a weaker relationship between trade and economic activity at the global level. The gradual shift of activity towards emerging market economies is widely anticipated to persist. The demographic evolution also has an important impact on the economic growth potential of regions around the world. The middle class in the developing countries will increase and will drive consumption of technological and luxury products. This will increase the need for raw materials and manufacturing, push global logistics needs for manufactured goods and support the shift towards the production of higher-value goods around the world. As Africa will gradually replace Asia as the region with the highest population and economic growth rate, the role of Africa in the world economy will increase. Furthermore, rapid industrialization and increasing wages, coupled with maturing consumer demand in many of the countries in Asia, Africa and South America are driving different types of global trade growth. For example, countries such as Vietnam and Bangladesh have shifted from basic commodities trading to become a refiner or producer of branded goods. In many of the developed markets there is a shift towards increasingly specialized sectors such as chemicals and pharmaceutical products as companies seek opportunities for higher returns. By expanding their operations into new, higher value sectors, emerging economies are driving more developed nations to specialize and diversify to compete.

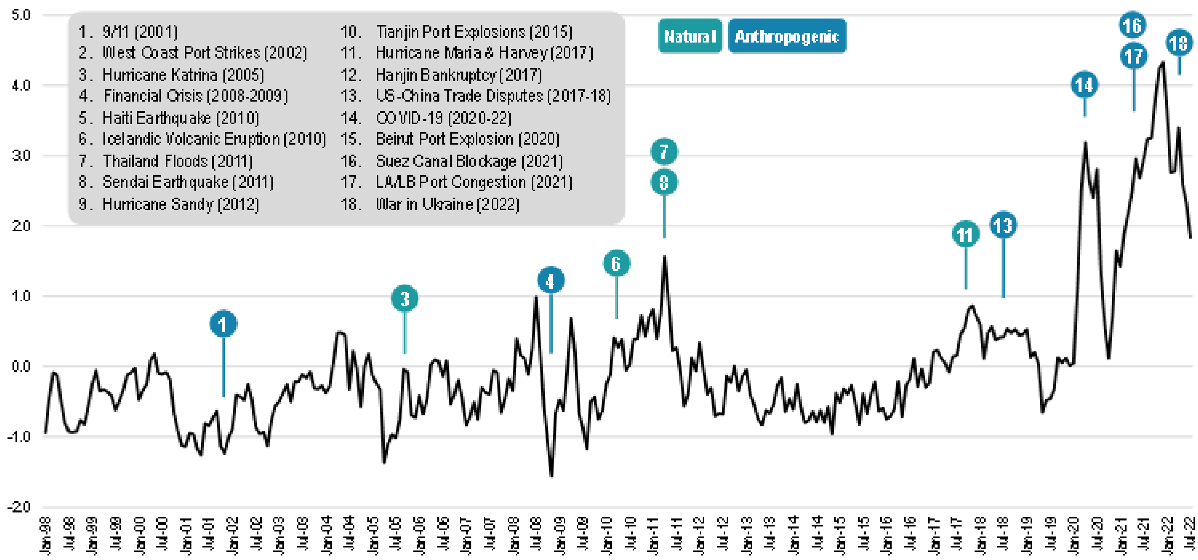
Second, various structural factors that boosted trade growth in the past, including falling transportation costs and the removal of trade barriers, appear to have become weaker. High transport rates following the supply chain crisis which started in the Summer of 2020 are also not beneficial to trade in the longer term. The growing fragmentation of production processes across international borders had significantly supported trade, particularly in the 1990s and early 2000s when intermediate components were increasingly shipped multiple times between economies along their production chains. The entry of China to the WTO in 2001 gave an additional boost to international trade. It appears that the sharp rise in global production chains has stalled and possibly even reversed after 2011. Increasing protectionist measures at the national level can induce firms to increasingly source and produce in their export markets (see the discussion on nearshoring in proposition 1.2). Also, the belief in a free trade environment started to show cracks in the past decades, and especially since the financial and economic crisis which started in late 2008. Some countries and political pressure groups question the global free trade model or at least want to rebalance/redefine its meaning and practical implementation (e.g. trade policy under former US president Donald Trump). Even the role and function of multi-country trading blocks are being scrutinized (e.g. the Brexit with the UK no longer a member state of the European Union).

Third, the developments in the financial sector may also have contributed to the slowdown in global trade growth. Substantial financial deepening in the last three decades in many countries was associated with increasing trade openness. However, as financial sectors have matured and got more scrutinized in the wake of the financial-economic crisis, the positive impact of further financial deepening on trade has weakened.

In summary, the structural developments that boosted trade in the past – falling transportation costs, trade liberalization, expanding global production chains and financial deepening – are not expected to support trade to the same extent over the medium term.

On top of this come the shocks and major disruptions negatively affecting global trade, production processes, transit times in global supply chains and the availability of components and finished products. Shocks are events that are by and large unexpected and bring out changes in real economic growth and global trade. All countries are exposed to some degree to external economic shocks. Lower and middle-income developing nations generally are more vulnerable partly because they have a less diversified economy with a narrow range of production and export. Economic shocks can occur at the demand or supply side of the economy. Demand-side shocks affect one or more of the components of aggregate demand. Supply-side shocks affect short run aggregate supply and can also affect a country's long-run productive potential. An economic shock can be caused by many different events, some caused by human activity and some simply caused by chance. Natural disasters can cause economic shocks by destroying inventories of goods, destroying various means of production, or causing a sudden demand for various construction or medical supplies. The introduction of new technology can also lead to an economic shock as new technology can, in some cases, drastically increase the supply of a given product.

Figure 4.3. Global Supply Chain Pressure Index (GSCPI) and Major Supply Chain Disruptions



Source: own compilation by Notteboom et al. (2022) based on Federal Reserve Bank of New York, Global Supply Chain Pressure Index (GSCPI) https://www.newyorkfed.org/research/policy/gscpi#/interactive. For methodology, see Benigno, G., J. di Giovanni, J. J. Groen, and A.I. Noble, (2022) "A New Barometer of Global Supply Chain Pressures" Federal Reserve Bank of New York Liberty Street Economics, January 4, 2022.

Figure 4.3 shows some of the main shocks and disruptions in recent times and their overall impact on global supply chain pressure. Obviously, economic shocks can have a significant impact on bilateral or even global trade, and the demand for and supply of shipping and port activities. Companies and corporations have always had to accept risk-taking as an inherent part of business. What has changed however is the quotient of risk needed to deliver the target reward and the way in which the risk is structured, perceived and managed. Unpredictable trade-related conditions demand a resilient, flexible and adaptive strategy that can adjust to uncertainty and change. Companies generally adapt well to a constant rate of changes, but when the rate is accelerating or fluctuating, the rate of response must change as well.

Seaports are exposed to economic shocks and related uncertainty. Economic shocks are part of the set of risk factors. Risk assessment and mitigation is vital, particularly for port authorities and asset-based port operators. The risks for economic shocks make long-term growth projections becoming more unstable. Globalization and increased communication allow to monitor the situation on a global level.

4.1.2. Maritime trade

Total international maritime trade volume amounted to 10.65 billion tons in 2020 (UNCTAD, 2021). Around two-thirds of global trade in goods takes place in developing countries. Some 60% of global goods loaded (exports) and 70% of goods discharged (imports) are linked to developing countries.

Of the 10.65 billion tons of international maritime trade, close to 3 billion tons relates to tanker trade and about 5.2 billion tons to dry bulk (Table 4.1). China is responsible for more than three quarters of all maritime iron ore imports in the worlds, while Australia and Brazil are the largest iron ore exporters. China, India and Japan combined are responsible for more than half of all coal imports. Asia also dominates in grain imports. China is by far the biggest steel producer in the world, as well as the largest steel user. The balance between steel supply and demand in China has far-reaching ramifications on world steel trade. Steel shortages in China trigger massive exports from the EU and other regions, while overproduction in China risks of resulting in the dumping of (cheap) Chinese steel on western markets. The shares of the EU as a whole or some key EU countries such as Germany in world dry bulk trades are rather modest compared to Asia, and China in particular.

Table 4.1. Total tanker and dry bulk trade (2020, in million tons) and share of countries/regions in total exports and imports of specific bulk commodities

	million tons		million tons
Crude oil	1716	Iron Ore	1503
Other tanker trade	1202	Coal	1165
		Grain	512
		Steel products	354
		Forest products	365
		Other bulk	1267
Total tanker trade	**2918**	**Total dry bulk**	**5166**

Steel producers		Steel users	
China	56	China	56
India	5	India	6
Japan	4	US	5
US	4	Japan	5
Russia	4	South Korea	4
South Korea	4	Russia	4
Turkey	2	Germany	2
Germany	2	Turkey	2
Brazil	2	Vietnam	1
Iran	2	Other	15
Other	15		

Coal exporters		Coal importers	
Indonesia	35	China	20
Australia	31	India	19
Russia	13	Japan	14
US	5	South Korea	10
South Africa	6	EU	6
Colombia	5	Taiwan	6
Canada	2	Malaysia	3
Other	3	Other	22

Iron ore exporters		Iron ore importers	
Australia	58	China	76
Brazil	23	Japan	7
South Africa	5	Europe	6
Canada	4	South Korea	5
India	3	Other	6
Sweden	1		
Other	6		

Grain exporters		Grain importers	
US	26	East & South Asia	49
Brazil	23	Africa	14
Argentina	11	South & Central America	10
Ukraine	10	Western Asia	9
EU	9	EU	9
Russia	7	North America	1
Canada	6	Other	8
Australia	3		
Other	5		

Source: own compilation based on UNCTAD (2021)

The trade of containerized cargo forms another major part of global maritime trade. Containerization began in 1956 when the American entrepreneur McLean launched the first containership. A decade later, in 1966, transatlantic container services marked the entry of the container as an infrastructure system enabling international trade (Levinson, 2016). Once the advantages of the container as a multimodal load unit became more apparent in the 1980s, containerization diffused rapidly across maritime and inland freight transport systems. Global container port throughput experienced an ongoing growth from 36 million TEU in 1980 to 237 million TEU in 2000. It accelerated from 545 million TEU in 2010 to about 849 million TEU in 2021 (UNCTAD, 2021). Some 108 million TEU of this total was handled in European ports (see section 5, proposition 2.1). The Rhine-Scheldt Delta ports combined handled a container traffic of about 29.9 million TEU in 2021 (see earlier).

Global containerized trade (i.e. the number of laden containers shipped around the world) also saw a steep increase from around 60 million TEU in 2000 to about 160 million TEU in 2021. The trans-Atlantic trade route, the cradle of international containerization, is still recording volume growth but its share in global containerized trade continues to erode reaching about 5.1% in 2020 (Table 4.2). The shares of the trans-Pacific and Asia-Europe trade routes peaked in 2008 at 18.7% and 18% respectively. After the financial-economic crisis of 2008-2009 these two routes saw a modest decline of their relative shares, despite further volume growth. This implies that non-mainline routes and intra-regional flows are gaining in importance. In particular, intra-regional routes in Asia have seen strong volume growth in the past decade.

The changing geography of container trade is also reflected in individual container ports in the Rhine-Scheldt Delta. Figure 4.4 presents the situation for the port of Antwerp, prior to its merger with the port of Zeebrugge. The overall share of North America in Antwerp's total container traffic declined sharply from 40% in 1990 to 20% in 2021. Intra-European trade is getting more important, as well as trade with the Middle East, the Far East and South America. Part of these shifts can be attributed to global trade dynamics, while also inter-port competitive forces play a role. For example, the declining share of Africa is partly the result of more intense competition market leader Antwerp faces on African trade routes.

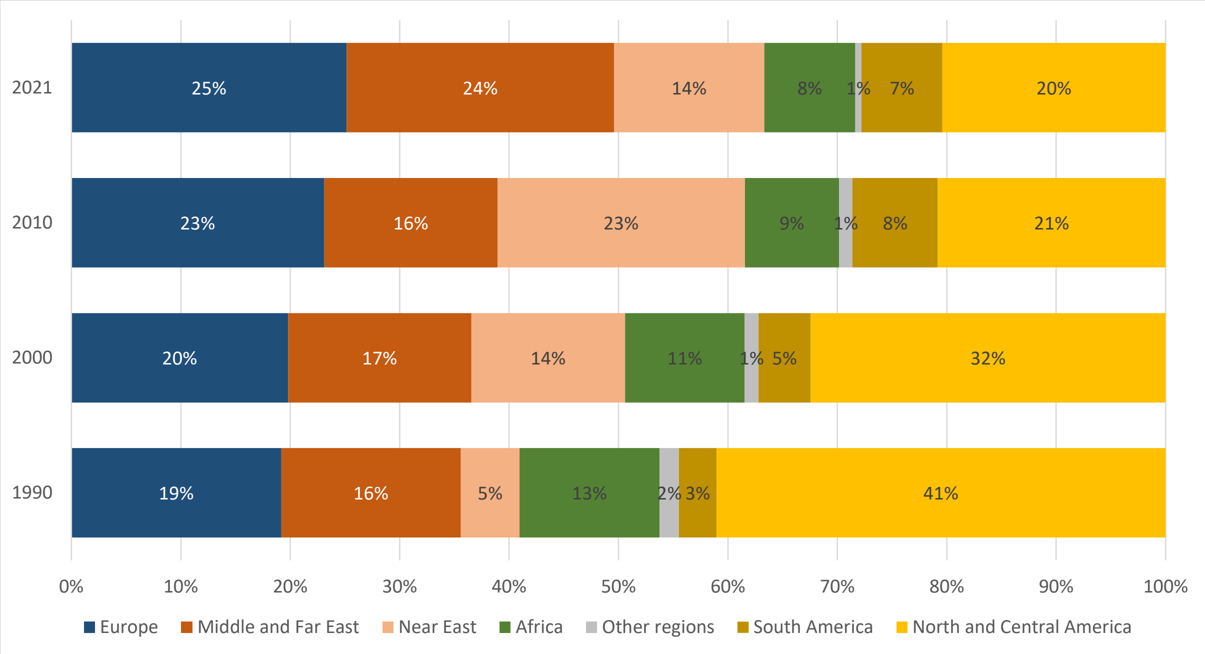
Table 4.2. Share of routes in total containerized container trade (laden containers, in million TEU)

	1996	2002	2008	2016	2020
Trans-Pacific	7.6	11.7	19.3	25.4	27.5
Asia-Europe	4.8	7.7	18.5	22.1	24.1
Trans-Atlantic	3.3	4.1	6.0	6.9	7.6
Other	32.2	47.5	59.2	80.9	90.0
of which: Non-mainline East-West				*18.0*	*19.3*
North-South				*11.1*	*11.9*
South-South				*15.5*	*18.4*
Intra-regional				*36.2*	*40.4*
Total	48.0	71.0	103.0	135.3	149.2

	1996	2002	2008	2016	2020
Trans-Pacific	15.9%	16.5%	18.7%	18.8%	18.4%
Asia-Europe	10.0%	10.9%	18.0%	16.3%	16.1%
Trans-Atlantic	6.9%	5.7%	5.8%	5.1%	5.1%
Other	67.1%	66.9%	57.5%	59.8%	60.3%
Total	100%	100%	100%	100%	100%

Source: own compilation based on UNCTAD (2021) and MDS Transmodal

Figure 4.4. Share of regions in total container traffic of port of Antwerp (based on laden containers in TEU)



Source: own compilation based on Yearbook of Statistics 2021 of Port of Antwerp

4.1.3. Key developments affecting future maritime trade flow patterns in the Delta

A multitude of factors will affect the future maritime trade flows handled by the ports in the Rhine-Scheldt Delta. Quite a few ports have implemented forecasting techniques and scenario analysis to estimate future maritime traffic based on a wide range of economic, technological and social developments, also taking account the expected future competitive position and market share of the port concerned. This section of the report does not aim to present forecasts or scenarios, but given proposition 1.1 wants to explore whether there are reasons to assume that worldwide trade relations of the Rhine-Scheldt Delta ports will fundamentally change in the future.

Taking a historical perspective, worldwide trade relations have never been stable for an extended period of time. Thus, the global trade system is by definition dynamic in nature. However, the intensity of change might differ when comparing different periods. At present, global trade is subject to intense changes due to the convergence of quite a few major developments. The following factors are expected to have a fundamental impact on future trade flows in the ports of the Rhine-Scheldt Delta, although differences between ports will obviously continue to exist.

Geo-economic dynamics: World trade will feel a growing impact of the rise of emerging economies beyond China (such as Vietnam, Bangladesh, East Africa, etc.) supported by favorable demographics in these countries. The changing balance between onshoring, nearshoring, and offshoring will also affect maritime trade flows, both for containerized cargo and raw materials (see also proposition 1.2).

Geopolitical dynamics: The war in Ukraine has given rise to an emerging new world order where Russia and Western countries are getting increasingly disconnected in political and economic terms. At the same time, growing pressures between China's command economy/socialist market economy and the free market economy are expected to further trouble trade relations between China and the western world.

Sustainability goals: The global trade model and the focus on economic growth has given rise to the emergence of new lines of thought aimed at fundamentally rethinking the basic drivers of economic activity. In the past few decades, traditional economic principles and ideas (such as the unilateral focus on untamed economic growth) are being scrutinized. At supranational level, sustainability goals have been developed. The EU is a frontrunner in the decarbonization of the economy, supported by the Green Deal and Fit for 55 programs. As a result, EU trade policy is expected to somewhat disconnect from countries or regions where sustainability is not high on the agenda, and is expected to seek tools such as carbon pricing or other forms of trade barriers to find a level playing field in fair trade relations with such countries. The push for a greener mobility is pushing the search for minerals and raw materials for the production of batteries and other technological components. Quite a few of these mining products can also be found in parts of the world which were less at the forefront of international trade (such as South American countries like Chile and Bolivia). Furthermore, the maritime decarbonization targets of IMO and the EU will affect the transition to other ship fuels (hydrogen, ammonia, methanol, batteries, etc.) and the cost of maritime shipping through the inclusion of shipping in the Emission Trading Scheme (ETS) and/or the emergence of a CO_2 tax. Implementing projects like green corridor pilots to attract investment and create entry points for first movers presents further opportunities. It is expected that there will not be one single ship fuel solution for the long-term future, but a range of possible green fuels adapted to the routes and ship types (for example, a battery-operated ferry on a shorter route vs. a methanol or ammonia powered ultra-large container vessel on the Asia-Europe trade).

Energy transition: Given the importance of coal, gas and tanker trade for the Rhine-Scheldt Delta ports, the unfolding energy transition will have a deep structural impact on the long-term development of maritime traffic in these ports. These impacts are multiple.

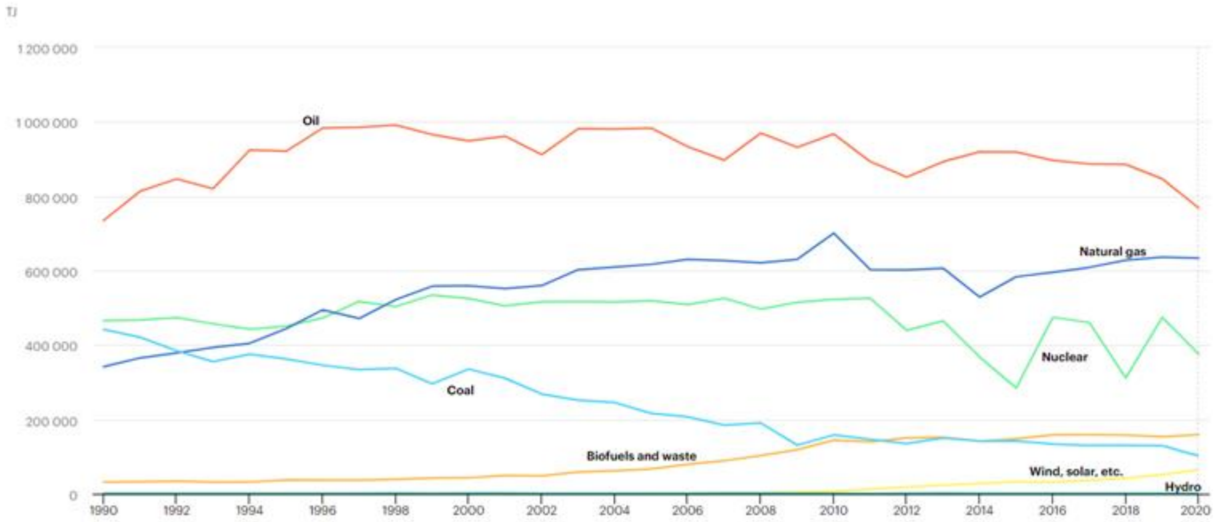
- The demand for coal currently is spiking in some European countries due to looming energy shortages and the goal of becoming energy-independent from Russia. Still, in the medium to long-term, coal-powered plants will gradually be phased out, thereby evaporating a large part of the coal imports via Rhine-Scheldt Delta ports. Figures 4.5 and 4.6 show that the share of coal in total energy supply in the low countries has declined in the past decades. Reducing the dependency on crude oil as energy source and as source for distillates and feedstock is expected to take more time;
- Natural gas remains one of the most important sources in the total energy supply. The Ukraine crisis has triggered a search for additional non-Russian gas volumes from existing gas suppliers such as Qatar and possible new suppliers (piped or shipped). In the medium-term gas imports via maritime LNG terminals (Zeebrugge, Rotterdam) and via non-Russian pipelines are expected to increase, thereby also fundamentally altering the geographical distribution of gas trading partners away from Russia;
- Renewable wind and solar energy, and biofuels and waste have seen growth in the overall energy supply in the low countries and Europe as a whole, but they still have a very long way to go in order to reach the supply levels of oil and gas. Still, the installation of wind and solar parks has grown into a major industry with some ports playing a key role as logistics hubs for the installation of (offshore) wind parks. The ports of Ostend, North Sea Port and Groningen are notable examples in this respect;

- According to the International Renewable Energy Agency (IRENA), hydrogen is likely to influence the geography of energy trade, further regionalizing energy relations, with the emergence of new centers of geopolitical influence built on the production and use of hydrogen (IRENA, 2022). At present, over 30 countries and regions are planning for active growth in cross-border hydrogen trade. IRENA estimates that over 30% of hydrogen could be traded across borders by 2050, a higher share than natural gas today. A more detailed analysis of the possible geo-economic implications of a hydrogen economy is provided in section 8 (see proposition 5.1 for a detailed discussion).

Circular economy: The transition to a circular economy, in which the value of products is maintained within the economy for the longest possible time whilst minimizing the generation of waste and using them as possible alternative raw materials as input for new production (feedstock concept), is gaining ground, both in production processes, thus impacting consumption behavior and patterns, and supply chains. A main driver for this shift consists of the short supply of raw materials and the subsequent soaring commodity prices. Transitioning towards a circular economy also protects companies from major and unexpected market fluctuations and geopolitical risks. Consumer preferences are also shifting away from the ownership concept towards models where they are willing to share or use products instead of owning them outright. Therefore, this shift from a linear economy towards a circular economy should lead to the recuperation of used materials and resources at the end of the lifecycle of products, and this with a minimum of loss of quality. It requires the reverse supply chain to be completely closed. The European Commission has adopted a “Circular Economy Package” laid down in an action plan “Closing the loop – An EU action plan for the Circular Economy”, that next to a set of legislative proposals on waste to stimulate Europe’s transition towards a circular economy. As long as the logistic chain cannot be closed in an efficient way, the circular economy model will not be “sustainable”. In other words, the transition to a circular economy comprises both production and logistic processes. In reality, however, logistics often struggles with the collection of materials because of volume and cost constraints, as well as regulatory complexities. Seaports can be considered to be clusters of transport, trade and industrial activities. Therefore, it is only logical that they present a unique platform to attract material flows and develop a portfolio of recycling activities, for example in the case of the (petro)chemical cluster. For the Rhine-Scheldt Delta ports, the further implementation of circular economy initiatives (for example, the Nextgen district in the Antwerp port area), of which smart and innovative logistic concepts are an integral part, will secure their position in an ever more integrated and circular supply chain reality, and will leverage their competitiveness and attractiveness to invest.

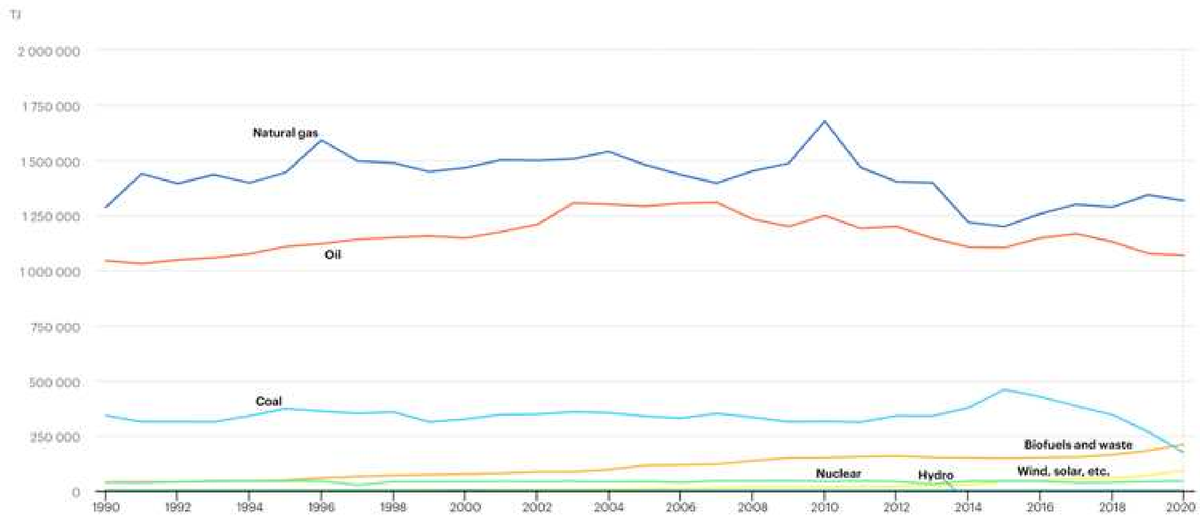
Technology: The fourth industrial revolution (also called Industry 4.0) is unfolding and is mostly based on robotization and automation (with supporting IT structures forming cyber-physical systems) and methods of additive manufacturing (such as 3D printing). These technological developments confer a higher level of flexibility in terms of the locations, the manufacturing processes, the scale and scope of the output, and the customization of the products. In such of context, the importance of input costs, particularly labor, are rebalanced. Technology advances such as robotization implies that the flexibility of manufacturing becomes more reliant on easy access to suppliers and customers. Under such circumstances, areas with access to global and regional distribution systems have an important advantage in the fourth industrial revolution. Logistics zones near large terminal facilities such as ports, airports, and intermodal terminals in the hinterland offer an attractive proposition for the emerging manufacturing landscape of the fourth industrial revolution and therefore have the potential to assume a growing share of manufacturing. Industry 4.0 affects transport and logistics demands as more manufacturing will be regional, be it in local factories, independent manufacturing farms or even a new role for logistics service providers that will offer production services and integrate them with their transport, storage and distribution services. All the above developments will affect global trade patterns.

Figure 4.5. Total energy supply (TES) by source, Belgium 1990-2020



Source: based on data International Energy Agency

Figure 4.6. Total energy supply (TES) by source, The Netherlands, 1990-2020



Source: based on data International Energy Agency

4.1.4. Structured summary on proposition 1.1

Proposition 1.1. "The worldwide trade relations of the Rhine-Scheldt Delta ports will fundamentally change due to geopolitical changes, the energy transition and sustainability goals."

Overall evaluation: Accept

Arguments & observations in support of the proposition	Arguments & observations going against the proposition
1. Globalization is leveling off, but with new trade linkages and emerging countries participating in the new geo-economic landscape. 2. The changing balance between onshoring, nearshoring, and offshoring will affect maritime trade flows, both for containerized cargo and raw materials. 3. A new world order is emerging where Russia and Western countries are getting increasingly disconnected in political and economic terms. 4. Growing pressures between China's command economy/socialist market economy and the free market economy. 5. Energy transition and sustainability goals present a fundamental transformation of the existing status quo, supported by international regulation and massive investments. 6. Industry 4.0 relies strongly on robotization, automation and methods of additive manufacturing, resulting in a higher level of flexibility in terms of locations. Logistics zones near large terminal facilities offer an attractive proposition, thereby affecting the global manufacturing and trade landscape.	1. Geopolitical tensions can ease over time, thereby potentially leading to the re-establishment of 'old' trade relations. 2. Change needs to be facilitated by massive investments and capacity, and these take a lot of resources and time. Thus, changes in worldwide trade relations can only gradually materialize instead of suddenly/abruptly.

4.2. Proposition 1.2

Proposition 1.2. Trends in nearshoring do not necessarily undermine the market position of the Rhine-Scheldt Delta ports.

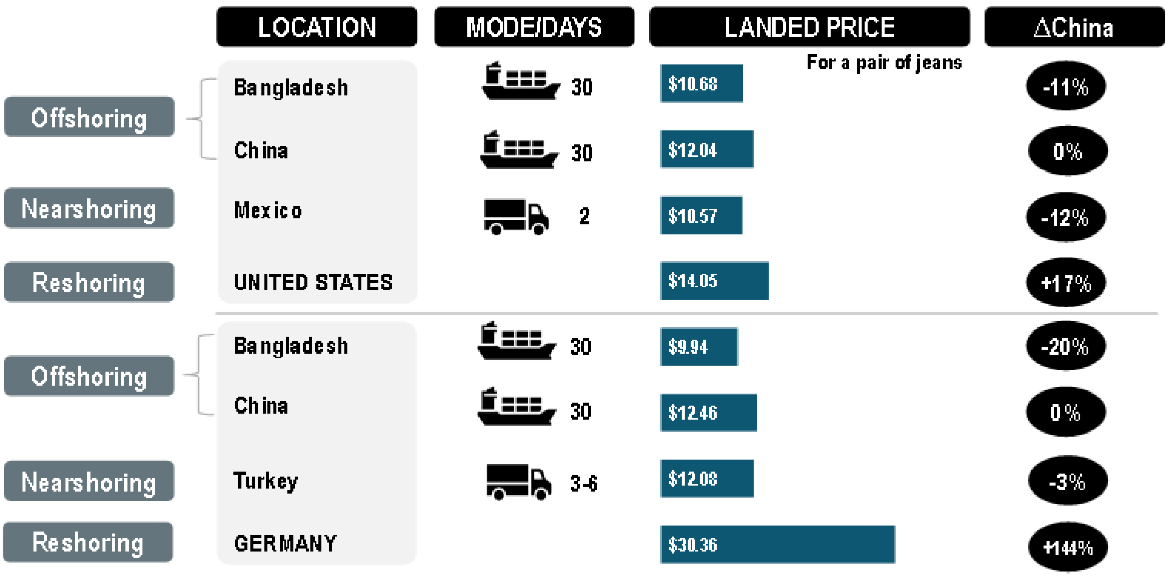
4.2.1. The notion of onshoring, nearshoring and farshoring

Nearshoring is the concept of sourcing work to a foreign, lower-wage country that is relatively close in distance and/or time zone. The customer expects to benefit from one or more of the following constructs of proximity: geographic, temporal, cultural, linguistic, economic, political and historical linkages. The relocation of an outsourced activity from a farshore location to a nearshore location, is also defined as nearshoring. The motivation for companies to nearshore is more than the sum of cost elements alone. Elements such as quality, market or risk related drivers often lie at the foundation of a nearshore decision. However, many companies still only consider the "total cost of ownership" components, without evaluating the qualitative aspects.

Thus nearshoring is said to come with some advantages such as the close proximity to home country/markets, similar time zones, fewer cultural discrepancies than offshore locations and an overall cost that is typically lower than for the home country. Compared to an offshore location, trade barriers and transport costs generally are lower as well (see example for a pair of Jeans in Figure 4.7).

Robotization and automation in production and the rise of additive manufacturing techniques (such as 3D printing) can help nearshoring as these technologies provide higher level of flexibility in terms of the locations, the manufacturing processes, the scale and scope of the output, and the customization of the products. Also, these technologies to some extent rebalance the importance of input costs, particularly labor.

Figure 4.7. Offshoring vs. nearshoring vs. reshoring in the case of Jeans productions – examples for the US and Germany



Note that a 2021 survey found that 71% of apparel and fashion brands are planning to surge their nearshoring share by 2025 (McKinsey & Company).

Source: own compilation based on McKinsey & Company (2018)

Economic policy can also support nearshoring decisions by firms. For example, the EU has developed the European Chips Act (see COM(2022) 45 final of 8 February 2022), a European semiconductor law, to defend its technological sovereignty: by 2030, the EU aims to produce 20% of semiconductors worldwide, doubling its current share. Similar efforts are made to ensure battery production in Europe.

However, nearshoring also has its limitations. First, a complete nearshoring of an entire supply chain often is not feasible due to the complexity of global supply chains. Just because a company moves a supplier out of Asia, does not necessarily mean the company moves the supply chain out of Asia. If components are sourced from a dozen locations mainly in Asia, nearshoring of the final assembly to a location in say Central Europe could make things more complex and more sensitive to disruptions, even though that nearshoring location is closer to the European end users. Furthermore, many companies are not relying on a single source strategy, but opt for a double or multiple source strategy.

Second, disconnecting a supply chain from China is not always possible given the country's dominance as a manufacturing site in many industries. For the near future, China is likely to remain a leading manufacturing site. China's share in total world exports exceeds 25% in quite a few industries such as household appliances, games and toys (Figure 4.8). Even though relocation of a part of the production capacity away from China is real, this does not result in a production "renaissance". Within a further growing global economy this relocation growth even can be superseded by the total growth. It is clear however that evolutions in Asia, with concepts such as "local for local" or "China plus one" (China offshoring within the Far East and Pacific region) will further develop and impact global supply chains.

Third, successful nearshoring partly depends on the availability of advanced infrastructure, cluster effects and local available expertise and skilled human resources. Some nearshoring projects might look good on paper, but fail due to critical shortages and deficiencies in one or more of these areas.

Fourth, while nearshoring in most cases should lead to lower transport and distribution costs between the production facility and regional markets, the relationships between transport distance and cost and between transport distance and transit time are not always linear. An overseas offshore production site near a major seaport could therefore be more favorable from a transport and distribution standpoint than a nearshore location in a landlocked country. This is particularly the case when the offshore location is well connected to the exporting port via a transport corridor (if possible in combination with an efficient inland terminal) and when the importing port is very well located and connected to the regional hinterland markets.

In summary, effective opportunities for nearshoring strongly depend on the various industries and its specific characteristics. These characteristics are more or less sensitive to the drivers for nearshoring and to negative aspects related to offshoring. This means that certain industries are more suited to nearshoring than others, and that the cost/benefit balance of nearshoring evolves over time depending on comparative costs and imperatives brought by production and distribution. Exploring the possibilities to implement nearshoring thus remains a time-dependent individual exercise.

4.2.2. Nearshoring and the Rhine-Scheldt Delta ports

The demand for port activity is affected by location decisions of production companies and possible shifts therein, such as through nearshoring. For example, large-scale nearshoring activity would typically shift the spatial distribution of a port's demand from a very global to a more regional level. Shipping lines would then react to a nearshoring trend by adjusting their liner service networks: they increase the fleet capacity and/or frequency of short-haul services while at the same time reducing the container transport supply on the long-haul trade routes.

Figure 4.8. China's impact on manufacturing of medium-tech items, share of total world exports

Product	India	Indonesia	Korea	Malaysia	Philippines	Singapore	Thailand	Vietnam	USA	China	ASEAN
Lighting fixtures & fittings, n.e.s.	0	0	1	0	0	0	0	0	4	55	1
Baby carriages, toys, games & sporting goods	0	0	0	0	0	0	1	1	6	49	3
Household type equipment, electrical or not, n.e.s.	0	1	3	1	0	0	3	1	3	35	6
Electric power machinery, and parts thereof	1	1	2	1	2	1	2	1	6	27	7
Sanitary, plumbing, heating fixtures, fittings, n.e.s.	1	0	1	0	0	0	1	1	3	25	2
Articles, n.e.s., of plastics	1	0	2	1	0	1	1	1	9	24	5
Vapour generating boilers, auxiliary plant; parts	4	0	14	1	0	0	1	2	5	24	4
Electrical machinery & apparatus, n.e.s.	1	1	4	2	4	3	2	1	7	23	11
Textile & leather machinery, & parts thereof, n.e.s.	2	0	7	1	0	2	2	2	5	21	6
Rotating electric plant & parts thereof, n.e.s.	1	0	2	0	0	1	2	2	7	21	5
Heating & cooling equipment & parts thereof, n.e.s.	1	0	4	2	0	1	5	0	8	20	8
Rubber tyres, tyre treads or flaps & inner tubes	2	2	5	0	0	0	5	1	6	19	9
Equipment for distributing electricity, n.e.s.	1	1	2	1	2	1	1	3	8	18	8
Prefabricated buildings	0	0	1	1	0	0	0	2	5	17	4
Non-electric parts & accessor. of machinery, n.e.s.	1	0	6	1	0	2	1	0	8	17	4
Appliances for pipes, boiler shells, tanks, vats, etc.	1	0	2	0	0	1	1	1	13	17	3
Mechanical handling equipment, & parts, n.e.s.	0	0	3	0	0	1	1	0	8	16	2
Metalworking machinery (excludingmachine-tools) & parts	1	0	4	0	0	1	1	0	8	16	2
Apparatus for electrical circuits; board, panels	1	0	5	2	1	2	2	1	9	16	7
Ball or roller bearings	2	1	3	1	0	3	2	0	7	16	6
Pumps (excluding liquid), gas compressors & fans; centr.	1	0	3	1	0	1	2	0	12	15	5
Other non-electr. machinery, tools & mechan. appar.	1	0	1	0	0	1	0	0	8	15	2
Paper mill, pulp mill machinery; paper articles man.	1	0	1	0	0	0	0	0	6	13	1
Transmis. shafts	1	0	3	0	0	1	1	0	10	13	2
Civil engineering & contractors' plant & equipment	1	1	6	1	0	3	1	0	11	12	5
Pumps for liquids	1	0	2	0	0	1	1	0	13	11	2
Steam turbines & other vapour turbin., parts, n.e.s.	2	0	4	0	0	0	0	0	8	11	1
Other power generating machinery & parts, n.e.s.	1	0	4	0	0	1	0	0	14	10	2
Articles of rubber, n.e.s.	2	1	2	1	0	1	3	1	10	10	7
Mach.-tools for working metal, excluding removing mate.	1	0	5	1	0	0	0	0	6	9	2
Agricultural machinery (excluding tractors) & parts	1	0	0	1	0	0	1	0	13	9	2
Other machinery for particular industries, n.e.s.	1	0	6	2	0	6	0	0	13	9	8
Food-processing machines (excluding domestic)	1	0	1	1	0	0	1	0	7	8	2
Parts & accessories of vehicles of 722, 781, 782, 783	1	1	5	0	0	0	2	0	11	8	4
Electro-diagnostic appa. for medical sciences, etc.	1	0	3	1	0	2	0	0	22	8	4
Road motor vehicles, n.e.s.	1	0	2	0	0	0	0	0	6	6	1
Internal combustion piston engines, parts, n.e.s.	1	1	3	0	0	1	2	0	12	8	4
Machine-tools working by removing material	0	0	5	0	0	2	1	0	5	6	3
Materials of rubber (pastes, plates, sheets, etc.)	1	0	2	2	0	1	8	1	10	6	12
Printing & bookbinding machinery, & parts thereof	1	1	1	1	1	2	0	0	6	5	5
Parts, n.e.s., & accessories for machines of 731, 733	1	0	3	2	0	2	1	1	9	4	6
Engines & motors, non-electric; parts, n.e.s.	2	0	1	0	0	5	0	0	9	3	6
Motor vehic. for transport of goods, special purpo.	1	0	1	0	0	0	6	0	12	3	6
Tractors (excluding those of 71414 & 74415)	3	0	3	0	0	0	1	0	14	3	2
Motor vehicles for the transport of persons	1	0	5	0	0	0	1	0	7	1	2

Source: based on data Natixis and UNCTAD

The changing international trade climate and the global supply chain crisis that occurred in the wake of the COVID-19 pandemic (including major supply chain disruptions and high freight rates) have made managers more susceptible to considering nearshoring in Europe to de-risk supply chains. Moving from international supply chains to regional or local ones is a way to avoid supply issues, to guarantee efficient and timely deliveries to market and to achieve more resilient supply chains. Not only supply and cost issues would matter but also a stronger focus on the environmental impact of transport. Thus, some nearshoring will be driven by sustainability.

For now, existing evidence points much more to a regional offshoring from west to east Europe than a nearshoring trend from Asia to Europe (De la Bassetière, 2021). When looking at the European situation, a clear pattern of movement can be observed with, predominantly, Western European countries significantly tending to offshore to Eastern countries, whereas the opposite is much rarer. A good indicator of the evolution of offshoring through time is the Foreign Direct Investment (FDI) of a country, which refers to the international movements of capital made for the purpose of creating, developing, or maintaining a subsidiary abroad. Following the collapse of the Soviet Union, the six EU countries that used to be part of the Warsaw Pact (Romania, Poland, Bulgaria, Czechia, Slovakia, and Hungary) have considerably evolved in their economic structure and production. Their entry in the European Union has accelerated the development of their infrastructures, reducing year after year the gap that they had with Western Europe. This development of infrastructure and political stability allowed for investors from more developed European countries to focus on this region, as those factors are crucial for acquiring the trust of investors from abroad. The CEE zone (Central and Eastern European countries) has quickly become a privileged destination for foreign investors. In 2019, Poland reached an FDI inflow of 15.97 billion USD, Hungary 32 billion USD, the Czech Republic 9.3 USD, Romania 6.9 billion USD, Estonia 2.96 billion USD and Slovakia 2.31 billion USD[1].

The above observation does not imply there is no nearshoring taking place from Asia. Although we still cannot speak of a major nearshoring pivot, there are plenty of proponents of moving supply chains closer to home. This is evidenced by IKEA, who recently announced its plan to nearshore production of some of its product lines to Turkey to streamline the supply chain of its European stores. Also Central Europe appears primed to take advantage of any nearshoring to Europe, partly because of rising costs in Asia (e.g. wages are increasing at a faster rate than in Europe). The growing interest in nearshoring is also inspired by the steep increase in transportation and logistics costs on the Asia-Europe trade since late 2020, and longer and less predictable transportation time on the Asia-Europe leg and associated risk. The latter rises product availability concerns.

However, the biggest challenge logistics faces in such a nearshoring scenario is growth and constrained land availability. In a resource-constrained market, any decision for nearshoring implies careful planning and ensuring that all segments of the redesigned supply chains have sufficient resources and assets available to run smooth and efficient operations. As long as there is big uncertainty about such availability issues, inertia emerges and nearshoring strategies are going to be delayed or shelved. At present, many companies seem to be hesitant to push through nearshoring decisions as there is still a lot of uncertainty on the medium-term evolution of the freight rates in relation to Europe, the overall easing of the capacity situation in container shipping, ports and hinterland transportation in Europe and the broader dynamics in the global trade environment.

Any large-scale nearshoring trend in the medium to longer term is expected to have various ramifications for the Rhine-Scheldt Delta ports.

First, the most likely nearshoring locations from a European perspective include North Africa (Morocco, Tunesia), Turkey and East and Central Europe. The cargo flows linked to the **sourcing of raw materials and components** are most likely going to transit seaports that are in close proximity to these locations, i.e. Tanger Med and smaller local ports for North Africa; Turkish ports (Ambarli, Mersin, etc..) for the Turkish locations; and North Adriatic ports (Trieste, Koper, etc.), Greek ports (Piraeus and Thessaloniki), Polish ports and also Hamburg for Central and Eastern Europe. However, for Central and East Europe it is unclear what share of such import flows would be shipped directly to the mentioned ports of entry, and what share will be transshipped in other locations (such as the Rhine-Scheldt Delta) before being feedered to the ports of entry. As global supply chains are often complex, long-distance traffic of raw materials and components will still be needed in most cases, and this provides an opportunity for the big hubs in the Rhine-Scheldt Delta to insert themselves in these chains.

Second, the European distribution patterns of products fabricated in nearshoring locations will not necessarily rely on **European distribution centers (EDCs)** located in close proximity of these nearshore locations. Still, nearshoring could affect the location decisions for EDCs making German and Central European sites more attractive than they are today. Thus, a large-scale nearshoring trend could move the center of gravity for European distribution somewhat further East and Southeast from the low countries (for a more detailed discussion see proposition 2.3 in section 5).

[1] Data.worldbank.org. 2020. Foreign Direct Investment, Net Inflows (Bop, Current US$) – European Union

In general, any major nearshoring activity to Central and East Europe and the associated rise of economic centers in these areas poses risks but also creates opportunities for the Rhine-Scheldt Delta ports to further develop **water-based and land-based transport networks** to these areas. At present, the hinterland market position of container ports such as Rotterdam and Antwerp-Bruges in East and Central Europe remains rather modest, especially when compared to North Adriatic, Polish ports and Hamburg (note that a further discussion is included in section 5). A strong corridor-based strategy mostly relying on rail could help the Rhine-Scheldt Delta ports to strengthen their hinterland reach towards East and Central Europe. At the same time, an even stronger focus on shortsea and feeder routes to North Africa, Turkey and the Adriatic could help to secure the position of the Rhine-Scheldt Delta as major transit hubs in relation to emerging nearshoring regions in Europe and North Africa.

4.2.3. Structured summary on proposition 1.2

Proposition 1.2. "Trends in nearshoring do not necessarily undermine the market position of the Rhine-Scheldt Delta ports."	
Overall evaluation: Accept conditionally	
Arguments & observations in support of the proposition	**Arguments & observations going against the proposition**
1. Global supply chains are complex, so nearshoring does not exclude long-distance intercontinental shipping to major hub ports. 2. Opportunities for nearshoring are very dependent on the market conditions and on the industry. Although some nearshoring to Europe is materializing, we still cannot speak of a major nearshoring pivot. 3. A large-scale nearshoring trend is not expected to make the Rhine-Scheldt Delta irrelevant in terms of European distribution. It would only move the center of gravity for European distribution somewhat further East and Southeast from the low countries. 4. It is unclear what share of import flows would be shipped directly to ports of entry near the nearshoring locations, and what share will be transshipped in other locations (such as the Rhine-Scheldt Delta) before being feedered to the ports of entry. 5. A strong corridor-based strategy mostly relying on rail could help the Rhine-Scheldt Delta ports to strengthen their hinterland reach towards East and Central Europe. At the same time, an even stronger focus on shortsea and feeder routes to North Africa, Turkey and the Adriatic could help to secure the position of the Rhine-Scheldt Delta as major transit hubs in relation to emerging nearshoring regions in Europe and North Africa.	1. The Rhine-Scheldt Delta ports are not natural ports of entry for nearshoring locations in North Africa (Morocco, Tunesia), Turkey and East and Central Europe. 2. At present, the hinterland market position of the Rhine-Scheldt Delta ports in CEE countries is weak compared to Hamburg, and Polish, Adriatic and Greek ports. 3. Nearshoring could bring a stronger focus on intra-regional shipping compared to inter-regional shipping, thereby giving more room for smaller port regions to develop and accommodate smaller vessels.

5. Theme 2: Port competition in a European perspective

5.1. Proposition 2.1

Proposition 2.1. The rise of Mediterranean seaports will only lead to a limited maritime cargo shift from north to south.

5.1.1. The European container port system

To accommodate maritime extra-EU and intra-EU trade flows, Europe is blessed with a long coastline reaching from the Baltic all the way to the Med and the Black Sea. The European port system cannot be considered as a homogenous set of ports. It features established large gateway ports, hub ports as well as a whole series of medium-sized to smaller ports each with specific characteristics in terms of hinterland markets served, commodities handled and location qualities. This unique blend of different port types and sizes combined with a vast economic hinterland shapes port competition in the region. There is no lack of port competition in Europe. Battles are fought on many fronts: maritime and hinterland access, terminal capacity, but above all the accommodation of supply chains.

With a total maritime container throughput of an estimated 108 million TEU in 2021 (Notteboom, 2022), the European container port system ranks among the busiest container port systems in the world. Europe counts about 130 seaports handling containers of which around 60 accommodate intercontinental container services. Table 5.1 provides an overview of the fifteen largest container ports in the European Union. A number of these ports act as almost pure sea-sea transshipment hubs with a transshipment incidence of 75% or more (i.e. Gioia Tauro, Marsaxlokk, Algeciras) while other ports can be considered as almost pure gateways (e.g. Genoa, La Spezia, Marseille) or a combination of a dominant gateway function with sea-sea transshipment activities (e.g. Hamburg, Rotterdam, Le Havre, Valencia, Barcelona, Gdansk and Antwerp-Bruges). In 2021, about 74% of the total container throughput in the European port system passed through the top fifteen EU ports, compared to 61% in 1985. About 35% of all containers is handled by the top three ports, whereas this figure was 29% in 1985. Still, the European port scene is becoming more diverse in terms of number of ports involved and the scope of port functions and services, leading to more routing options available to shippers.

In particular, in the past decade a number of Mediterranean and Baltic ports have joined the top league in Europe (see Figure 5.1. and ranking in Table 5.1). The changing competitive landscape becomes even clearer when looking at the main multi-port gateway regions in Europe as well as transshipment hubs and stand-alone gateways (Figure 5.2).

The **Rhine-Scheldt Delta and the German ports**, both part of the so-called Le Havre-Hamburg range, together represent 40% of the total European container throughput. The market share of the Rhine-Scheldt Delta is quite stable at around 27% in the past 10 years, while the North German ports initially gained market share in the early 2000s, mainly because of Hamburg's pivotal role in feeder flows to the Baltic and land-based flows to the developing economies in East and Central Europe. However, in the past decade, German ports lost market share, mainly to the Rhine-Scheldt Delta ports and **Polish ports** (Gdansk in particular). Gdansk has taken up a prominent position with several direct mainline calls on the Asia-Europe route. From a functional port network perspective, it is therefore relevant to refer to the emergence of a Le Havre-Gdansk range.

The **Seine Estuary**, the third region in the Le Havre-Hamburg range, suffered from a long decline in its market share. In the past few years, the tide is turning a bit as a result of congestion problems in major north-European hub ports. Le Havre's revival goes hand and hand with the ambition of the port to stretch its hinterland reach beyond the Seine basin (its core hinterland) and even across the French border, mainly supported by rail services.

Among the major winners, we find the **Spanish Med ports** (from a share of 5% in total European TEU throughput in 1989 to 8.4% in 2019) and the **Polish ports** in the Gdansk bay (from virtually no traffic to a market share of 2.7% in 2019). For a long time, the Polish ports were bound by their feeder port status. At present, they welcome mainline services from Asia and other overseas regions and are competing heavily with main port Hamburg for the Polish hinterland.

Portuguese ports Lisbon and Sines are expanding their business by developing a transshipment role as well as tapping into the market surrounding Madrid through rail corridor formation and dry port development (e.g. Lisbon's Puerta del Atlantico logistical platform in Mostoles near Madrid).

Many **Ligurian and North-Adriatic ports** were typically challenged by the physical limitations to terminal capacity extensions (i.e. the locked-in geographical situation of the respective coastal port cities) and by the limited success so far in attracting a lot of business from the Alpine region and Southern Germany. In more recent years, new terminals have been opened (such as in Vado Ligure) and a more aggressive rail strategy is helping these ports to gain markets share in the Alpine region and Central and Eastern Europe (see discussion further in this section).

Many of the ports along the **Southeast coast of the United Kingdom** faced capacity shortages. To avoid delays, quite a number of shipping lines opted for the transshipment of UK flows in mainland European ports (mainly Rhine-Scheldt Delta and Le Havre) instead of calling at UK ports directly. Later, shipping lines opted for more direct mainline calls as new capacity became available (e.g. London Gateway).

The larger **stand-alone gateways** in Europe have lost market share for various reasons. For example, despite its proximity to the economic centers along the Rhône corridor and Southern France, Marseille suffered from labor disputes and its rather remote location vis-à-vis the main shipping route (high diversion distance).

Transshipment hubs in the Mediterranean have substantially increased their role in the container market. After a steep increase of the market share from 4.5% in 1989 to 14% ten years later, their market position further evolved to reach 14.8% in 2019. Piraeus, Algeciras, Gioia Tauro and Marsaxlokk (Malta) remain the most important pure transshipment hubs on the European shores of the Med. Still, they are facing increased competition from hubs in Africa (Tanger Med in particular, but also to a lesser extent the Egyptian hubs of Port Said, Alexandria and Damietta) and Turkish ports.

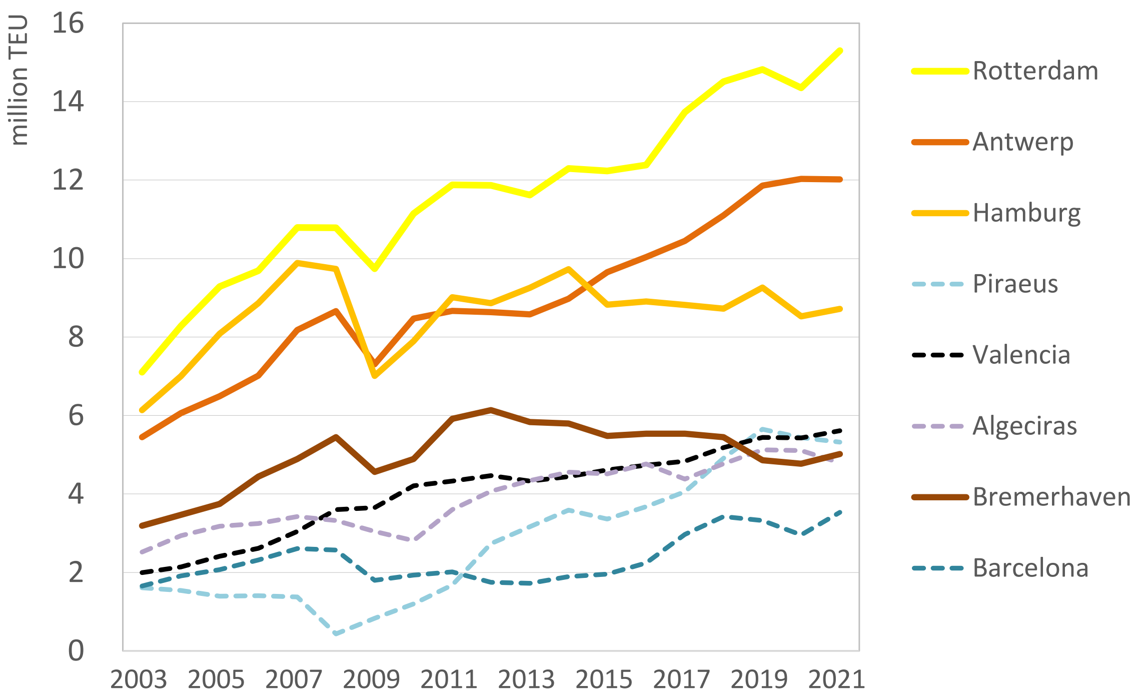
Table 5.1. The top 15 container ports in the European Union in 2021 (in 1000 TEU) and growth H1 2022

Rank 2021	Rank 2020	Rank 2007	Port	Container traffic 2021 in 1000 TEU	Growth H1 2022	Growth 2020-2021	Growth 2019-2021	Growth 2007-2021
1	1	1	Rotterdam (NL)	15,300	-4.4%	7.8%	3.2%	41.8%
2	2	3	Antwerp-Bruges (BE) (*)	14,225	-6.2%	2.8%	5.1%	39.5%
3	3	2	Hamburg (DE)	8,715	0.9%	2.2%	-5.9%	-11.9%
4	5	8	Valencia (ES)	5,614	-6.2%	3.4%	3.2%	84.5%
5	4	17	Piraeus (EL) (**)	5,317	-14.7%	-2.2%	-5.9%	**287.3%**
6	7	4	Bremerhaven (DE)	5,019	-9.7%	5.2%	3.3%	2.6%
7	6	6	Algeciras (ES)	4,797	1.4%	-6.1%	-6.4%	40.3%
8	9	10	Barcelona (ES)	3,531	0.8%	19.4%	6.2%	35.3%
9	8	7	Gioia Tauro (IT)	3,147	15.3%	-1.5%	24.7%	-8.7%
10	10	9	Le Havre/Rouen (FR) (+)	3,070	0.1%	25.6%	10.2%	9.1%
11	11	12	Marsaxlokk (MT)	2,970	N/A	21.7%	9.2%	56.3%
12	12	14	Genoa (IT)	2,558	-1.7%	8.7%	-2.2%	37.9%
13	13	11	Gdansk (PL)	2,118	2.4%	10.1%	2.2%	**2085.8%**
14	15	62	Sines (PT) (++)	1,824	-5.4%	13.2%	28.2%	**1116.0%**
15	17	19	Marseille (FR)	1,480	5.0%	12.3%	1.7%	47.6%
			TOP 15	**79,685**		**7.1%**	**0.8%**	**29.6%**
			TOP 3	**38,240**		**9.5%**	**6.4%**	**32.5%**

(*) Port of Antwerp merged with Zeebrugge port authority to form Port of Antwerp-Bruges in late April 2022.
(**) TEU volume growth in H1 2022 excludes Pier 1
(+) Maritime container volumes of HAROPA (Le Havre/Rouen/Paris)
(++) Figure for first five months of 2022
Note: ranking before 2020 includes UK ports (pre-BREXIT) + Antwerp and Zeebrugge were ranked separately

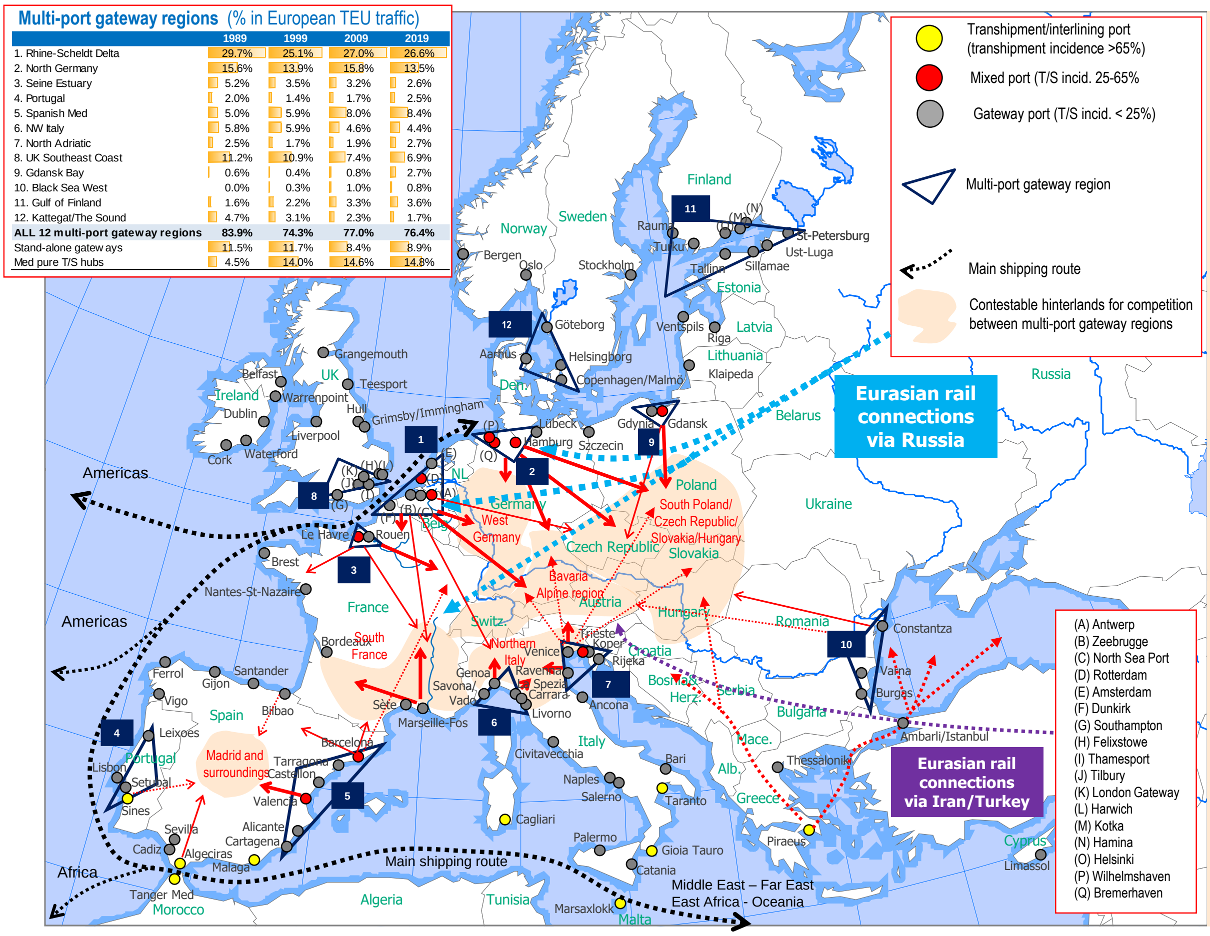
Source: own compilation based on traffic data respective port authorities

Figure 5.1. Container throughput of the largest North European and South European ports (in TEU)



Source: own compilation based on port authority statistics

Figure 5.2. The European container port system and main contestable hinterlands



Multi-port gateway regions (% in European TEU traffic)

	1989	1999	2009	2019
1. Rhine-Scheldt Delta	29.7%	25.1%	27.0%	26.6%
2. North Germany	15.6%	13.9%	15.8%	13.5%
3. Seine Estuary	5.2%	3.5%	3.2%	2.6%
4. Portugal	2.0%	1.4%	1.7%	2.5%
5. Spanish Med	5.0%	5.9%	8.0%	8.4%
6. NW Italy	5.8%	5.9%	4.6%	4.4%
7. North Adriatic	2.5%	1.7%	1.9%	2.7%
8. UK Southeast Coast	11.2%	10.9%	7.4%	6.9%
9. Gdansk Bay	0.6%	0.4%	0.8%	2.7%
10. Black Sea West	0.0%	0.3%	1.0%	0.8%
11. Gulf of Finland	1.6%	2.2%	3.3%	3.6%
12. Kattegat/The Sound	4.7%	3.1%	2.3%	1.7%
ALL 12 multi-port gateway regions	**83.9%**	**74.3%**	**77.0%**	**76.4%**
Stand-alone gateways	11.5%	11.7%	8.4%	8.9%
Med pure T/S hubs	4.5%	14.0%	14.6%	14.8%

Source: own compilation

5.1.2. The North-South balance in perspective

The dominance of ports in the Rhine-Scheldt Delta and Germany in Europe is very apparent when looking at throughput statistics (see earlier). This observation fuels a decades-old debate on what some observers call the 'unhealthy' balance between North and South. There is the widely held belief that in recent years Mediterranean container terminals have made such sweeping improvements as to be able to recover sea-going traffic from the terminals of the Northern Range. However, this discussion needs to be placed in the right context.

First of all, the term 'recover' is inappropriate. To speak of recovery implies that traffic has been unduly diverted from the Mediterranean to the North, thus skewing a pre-existing hypothetical situation of proper traffic distribution. But there is no proper distribution. It is no longer possible to map out the territorial catchment area of a terminal, in that the criteria of definition based on geographical distance, the equivalence of overland transport costs, or other similar factors have been abandoned. Through the services it offers and its ability to fit into a logistical network, the terminal is itself capable of contributing to establishing the confines of its own catchment area, which cannot therefore be determined, and which are in any case flexible.

Secondly, the growth in the Mediterranean can be largely attributed to the emergence of transshipment hubs such as Piraeus, Algeciras, Gioia Tauro, Marsaxlokk and Sines. Also some initial gateway ports with a focus on import/export cargo for the hinterland have been successful in attracting large sea-sea transshipment flows. Valencia and Barcelona in Spain are notable examples of such mixed gateway/transshipment ports. Sea-sea transshipment traffic has also increased in North Europe, but the Hamburg-Le Havre range does not feature any pure transshipment hubs (see also colored dots in Figure 5.2).

Third, several Mediterranean terminals do not in fact constitute a potential gateway to the core of the European hinterland (also known as the "blue banana" area). This is for example the case for terminals in Greece or southern Italy.

Nevertheless, it is clear that competition exists between a number of Mediterranean ports and those of the Northern Range, in that they constitute two different systems through which ocean-going traffic can reach the economic and industrial heartland of Europe. In order to assess the results of such competition, we would have to compare ocean-going traffic through the Northern ports with similar traffic through the Mediterranean ports. In order to examine the North-South balance, it therefore seems appropriate to consider only gateway cargo (import/export flows to the hinterland) of the North and South European ports which are in a good position to serve the European core hinterland. To empirically test whether any imbalances can be observed in existing and historical traffic distribution patterns, we apply the following methodology:

- First, we identified two customized container port ranges, i.e. the **Le Havre-Hamburg range (LH-H range)** and the **Valencia-Rijeka range (V-R range).** The LH-H range is a much-cited port group spread along the coastline from northern France to north Germany. While some researchers, policy makers and practitioners have proposed alternative port groupings for northwestern Europe (e.g. the LH-H range plus the ports along the southeast coast of the UK or the Le Havre-Gdansk range), the LH-H range remains a relevant port system when focusing on gateway/hinterland cargo flows to the core hinterlands of the EU. The V-R range includes all ports along the Med coastline between Valencia and Rijeka. Pure transshipment hubs in the Med are not considered as they do not in fact constitute a potential gateway to the core hinterlands of Europe, and participate only in a marginal way in hinterland competition. Therefore, in order to make a valid comparison, it seems appropriate to consider the coastal terminals of the north-western Mediterranean and north Adriatic grouped in the V-R range.

- For each of the ports in the two ranges, we collected container gateway traffic data in TEU (i.e. import and export containers to/from the hinterland). The sea-sea transshipment volumes of the ports were excluded. Transshipped containers only transit through the terminal and eventually will end up in another European (or non-European) port. This implies that a container that is transshipped in a European port before reaching the final port of discharge will appear three times in Europe's container port statistics: two times in the transshipment hub (in/out) and one time in the port of destination. The inclusion of T/S flows is therefore not relevant when analyzing the relative importance of port ranges in serving the European hinterland.

- Next, we measured the geo-economic significance of the immediate and somewhat more distance hinterland regions of the two ranges considered. To do so, EU data on GDP was collected using NUTS-3 level statistics of Eurostat. In view of detecting evolutionary patterns, the dataset includes four years of observation, i.e. 1996, 2006, 2016 and 2019. The analysis of the geo-economic significance of the ranges was operationalized by considering a 300km and a 600km inland reach of the ports considered. In other words, the orange and green shaded areas in Figure 5.3 represent the area covered by the respective port ranges when reaching respectively 300 km and 600 km into the core hinterlands of the European mainland. The distances are Euclidean distances as the crow flies. Overseas regions which can only be reached by seagoing vessel (e.g. the UK/Ireland vis-à-vis the LH-H range) were not considered.

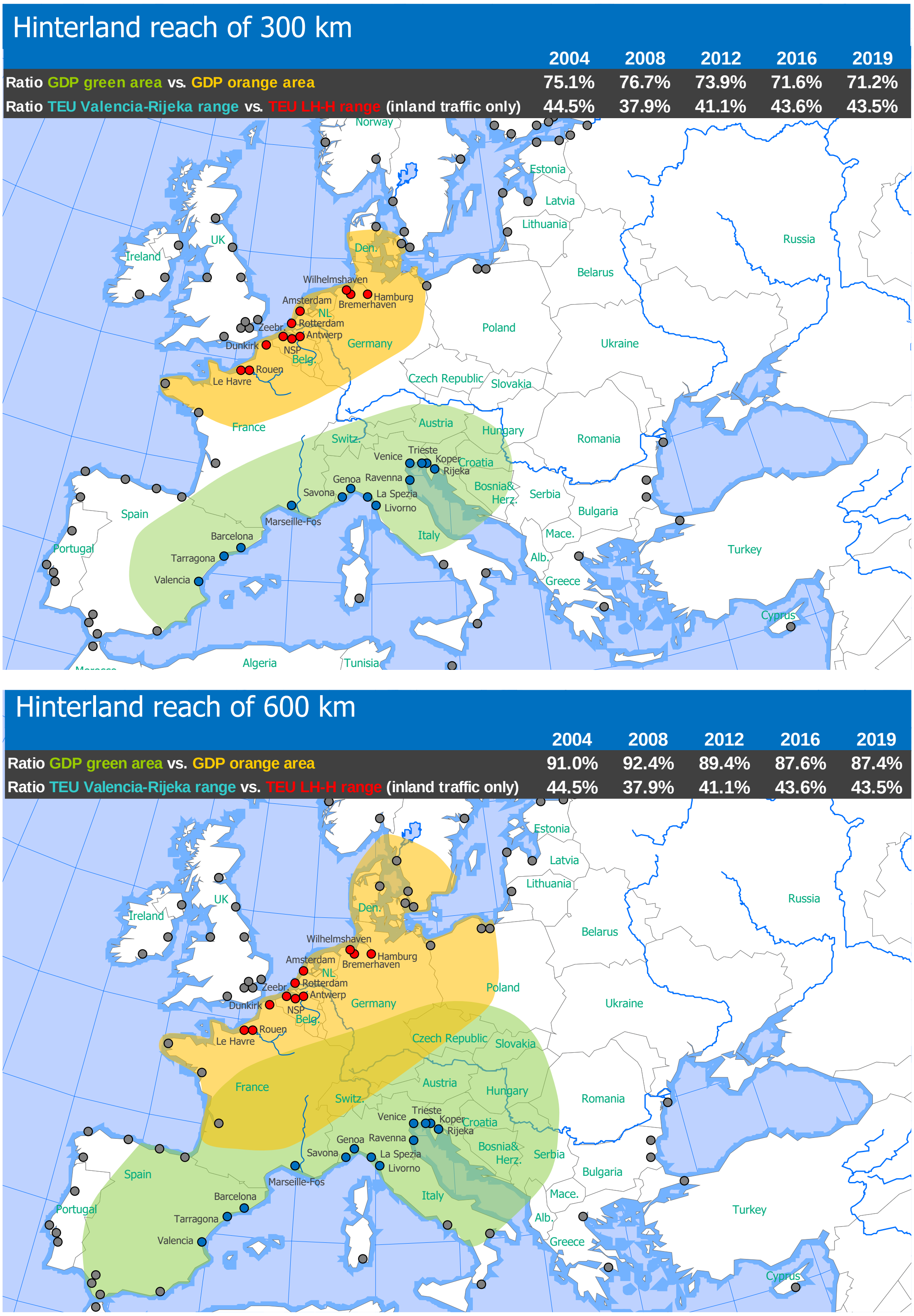
- Finally, we apply several ratios which compare the 'weight' of the V-R range to the LH-H range, i.e. the GDP of the green area (V-R range) over the GDP of the orange area (LH-H range); and the hinterland TEU of the V-R range over the hinterland TEU of the LH-H range.

The results demonstrate that there is a traffic imbalance despite an increasing participation degree of mainland Med ports in international shipping networks. When considering a 300km inland range the total GDP of the green area amounts to only 71% of the total GDP of the orange area (figures 2019), while the green area is much larger in surface. This demonstrates that economic activity is much more concentrated near the northern range compared to the southern range. While the GDP difference of the two areas is less than 30%, the volumes handled by the respective container port ranges is much larger: the hinterland flows handled in the V-R range are only 43% of the total hinterland volume handled by the LH-H range (figures 2019). In case of a 600km hinterland coverage, the GDP difference between the two shaded areas amounts to about 13%, while the gap in hinterland volumes is much larger. Thus, in relative terms, the LH-H range is handling a lot more cargo than what could be expected based on the economic activity in its direct hinterland (300 to 600km inland reach).

Since 2004, the GDP gap between the two shaded areas has increased, making the economic significance of the direct hinterland of the HL-H range ports even more important in relative terms compared to the southern range. However, the relative gap in hinterland container flows has remained fairly stable, thus indicating the V-R range has consolidated its market position in inland traffic despite a weaker GDP balance of the south vs. the north.

The *cargo routing choices of shippers and shipping lines* depend on a lot of factors such as costs (port, inland transport, sea voyage, feeder/shortsea), time (at sea, in port and to the hinterland), efficiency, inland connectivity of ports of call, frequency, reliability, infrastructure and equipment availability, cargo balance (import/export) and ease of business. Quite a few port choice models have been developed and tested in the past. For example, the contestable economic potential of the hinterland from Hamburg and from its possible emerging competitors was determined by using simple travel time matrices for different transport modes in Biermann and Wedemeier (2016). The world container model in Tavasszy et al. (2011) models the movement of containers on a global scale. Veldman and Buckmann (2003) and Veldman et al. (2005) applied a container port competition model based on logit analysis to the LH-H range ports. Also Zondag et al. (2010) built a container port competition model based on generalized cost for North West Europe. More recently, Mueller et al. (2020) developed a model which includes 31 European mainland container ports, 231 NUTS-2 regions in Europe and three hinterland transport modes (road, rail and barge) as well as deep-sea and feeder shipping, to analyse port choice. All these models show that the outcomes are very sensitive to changes in input variables, such as costs, time variables or frequency/reliability.

Figure 5.3. The relative shares of iso-distance zones (300 km and 600 km) for the Hamburg-Le Havre range and the Valencia-Rijeka range



Source: own calculations on the basis of GDP statistics of Eurostat (Nuts 3- level) and traffic figures provided by the respective port authorities

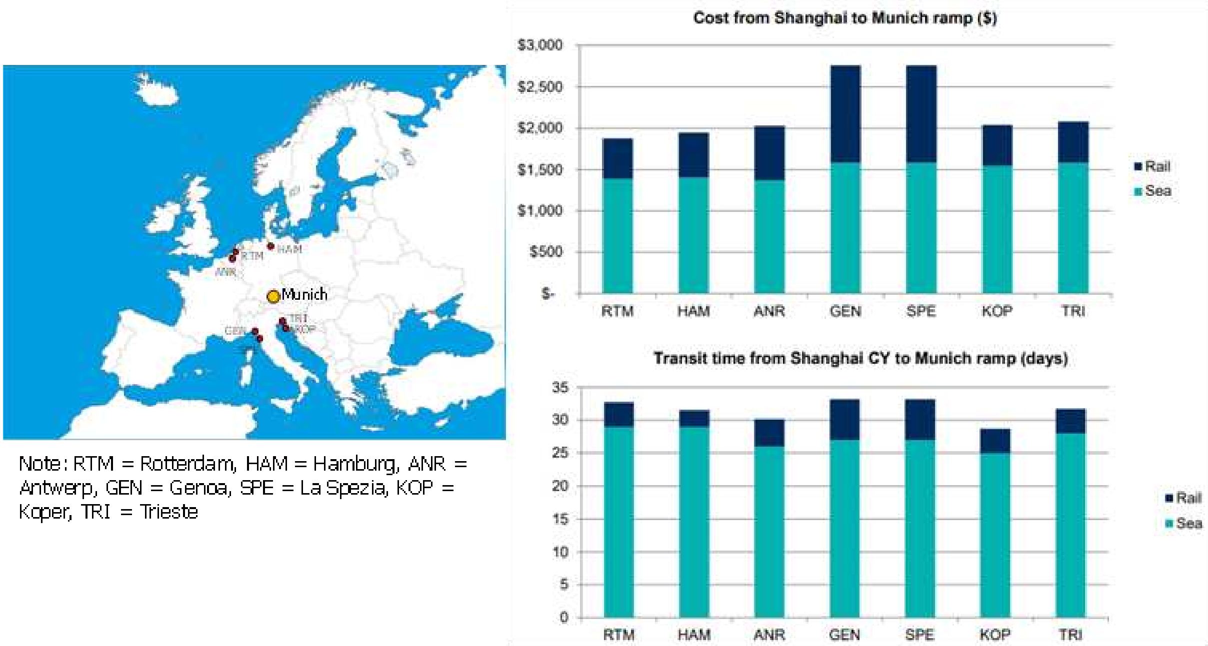
Table 5.2. Comparison of monetary costs to serve Padan Plain in north Italy, port of La Spezia vs. Antwerp/Rotterdam

Origin Far East	Via La Spezia per TEU	Via Antwerp/Rotterdam per TEU	Via La Spezia per FEU	Via Antwerp/Rotterdam per FEU
Deep sea transport	822	795	1643	1589
THC port	170	183	170	183
THC rail terminal	33	35	33	35
Cost of rail connection (traditional MTOs)	405	905	540	1130
Total cost (traditional MTOs)	**1429**	**1918**	**2386**	**2937**

Origin North America	Via La Spezia per TEU	Via Antwerp/Rotterdam per TEU	Via La Spezia per FEU	Via Antwerp/Rotterdam per FEU
Deep sea transport	900	746	1058	869
THC port	170	183	170	183
THC rail terminal	33	35	33	35
Cost of rail connection (traditional MTOs)	405	905	540	1130
Total cost (traditional MTOs)	**1508**	**1869**	**1801**	**2217**

Source: own compilation based on findings of Lupi et al. (2021)

Figure 5.4. Routing options to serve Munich based on cost and fastest transit times on the Shanghai-Europe route - results relate to the period 2015-2016



Note: RTM = Rotterdam, HAM = Hamburg, ANR = Antwerp, GEN = Genoa, SPE = La Spezia, KOP = Koper, TRI = Trieste

Source: own compilation based on Drewry (2016a)

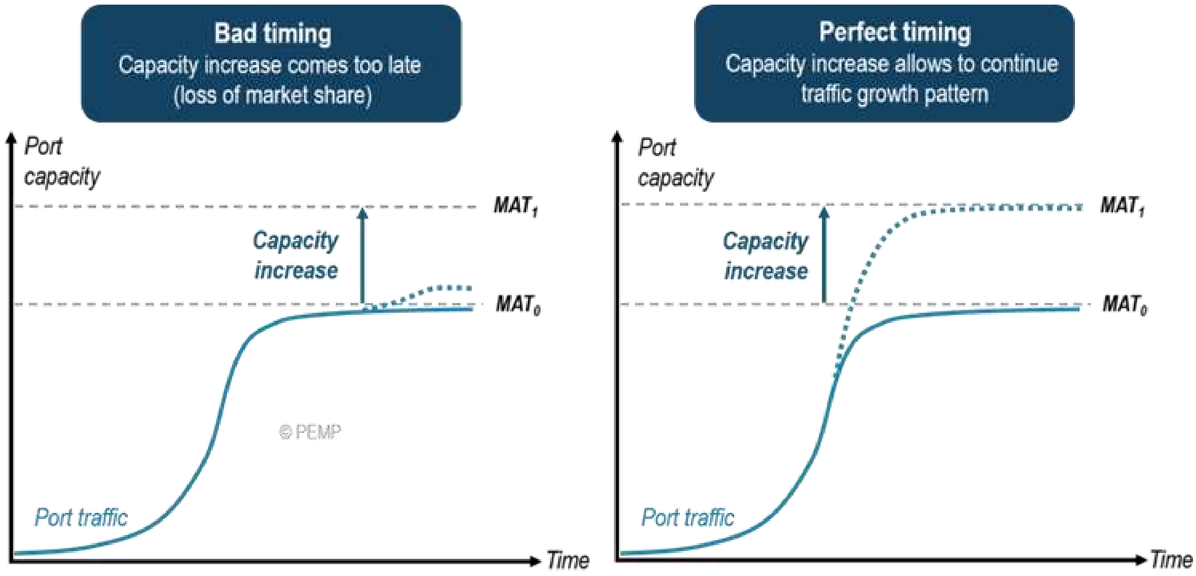
There are a number of studies specifically focusing on ports competing for certain hinterland regions, but their findings are general very dependent on the underlining data such as the freight rates of the moment. For example, Lupi et al. (2021) focus on the position of Italian and north European ports in serving the Padan Plain in northern Italy. The authors estimate the number of TEUs according to scheduled rail connections between northern range ports and Italian intermodal centres/freight village. They also analyze transport costs and travel times in order to determine the advantage of unloading containers coming from the Far East or North America and destination in the Padan Plain through northern range ports instead of Italian ports (see an excerpt of the findings in Table 5.2).

However, their input data relate to the situation in early 2020, so prior to the sharp rise in container freight rates on the Asia-Europe trade which started in the Summer of 2020. Another example can be found in Drewry (2016a) focusing on inter-port competition for serving the Bavarian hinterland and Munich in particular (Figure 5.4). Also here, the results are very much linked to freight rates and other costs and the schedule reliability in liner shipping during the period of analysis, i.e. the period 2015-2016 when freight rates were historically low.

5.1.3. Factors and developments affecting the future North-South balance

A number of key factors and developments are expected to influence the competitiveness of routing options into the European hinterland, and thus in the North-South cargo balance, with an impact on costs, transit times and inland connectivity.

Figure 5.5. The Timing of Port Capacity Extensions



Source: Notteboom et al. (2022), adapted from Winkelmans and Notteboom (2002)

First, the timely supply of sufficient **container terminal capacity and human resources** will have a major impact on the market position of individual container ports, certainly when faced with a market environment characterized by port congestion and tight labor supply. In economics, a production function defines the output as a function of inputs/production factors labor (human resources), capital, land and entrepreneurship. The (un)availability of land and labor poses some of the greatest challenges to a number of European ports, combined with the complex and lengthy decision-making and permitting procedures surrounding major port expansion projects. A late realization of a port expansion project can lead to a weaker market position (left part of Figure 5.5) as port customers will start looking for alternative routing options when faced with capacity shortages and poor outlooks with regard to the remediation of these shortages in the short to medium term.

Since the early 2000s, some major port expansion projects have been realized in the Rhine-Scheldt Delta and more capacity is planned:

- *Rotterdam*: Major feats include the opening of APM T MV2 and Rotterdam World Gateway in 2014 as part of the Maasvlakte 2 development with a further capacity expansion of APM T MV2 being considered[2]. The latter would involve an expansion with a quay length of more than 2.5 km and a surface area of 180 hectares, good for an estimated 4 million moves per year. The Rotterdam Port Authority announced that the construction of a total of approximately two kilometers of new quays along the Amaliahaven at Maasvlakte 2 must be completed by the end of 2024. Also the Euromax terminal operated by ECT still has room for further expansion. In September 2022, it was announced that Hutchison Ports and Terminal Investment Limited (TIL/MSC) will jointly redevelop the entire northside of the Maasvlakte 1 peninsula in order to realize a terminal of some 6 to 7 million TEU. The first section of the terminal should be operational by 2027;

- *Antwerp-Bruges*: Major feats include the opening of Deurganckdock in 2005, the move and expansion of MPET (MSC/PSA) from the right bank to the Deurganckdock in 2016 and the ongoing capacity expansion of Antwerp Gateway through additional quay cranes and the implementation of automated stacking cranes (ASCs) on the yard. Also the Europe Terminal on the right bank operated by PSA is undergoing a major upgrade with an extension of the quay walls and the installation of ASCs which should bring total capacity to 2.4 million TEU in the medium term. The development of about 7 million TEU of additional container capacity is still in a planning phase as part of the ECA project, among which new capacity is planned along a new one-sided dock on the left bank. There is a high sense of urgency towards its realization given the current elevated terminal capacity utilization in the port, which has already resulted in traffic shifts to other ports. In the Zeebrugge port area, the sale of the APM Terminals terminal in the outer port to Cosco Shipping Ports has given prospects for further capacity increases in the future. In January 2022, Cosco Shipping Ports extended the concession of its terminal in Zeebrugge by 15 years until 2055. Plans are also being made to significantly increase the terminal's capacity to 2 million TEU through optimization within the existing port area (note that the terminal handled 930,000 TEU in 2021);
- The other ports in the Rhine-Scheldt Delta do not feature any large-scale container terminals. Instead, they mainly focus on barge and rail connectivity to the deepsea terminals in Antwerp-Bruges and Rotterdam. Small and medium-sized container terminals can be found in these ports, such as the specialized cooling and freezing terminal of Kloosterboer in Flushing (North Sea Port) with a storage capacity of 5,600 TEU including 800 reefer plugs.

South European ports are planning and investing in port and terminal expansion projects on a massive scale. Remarkable is the ease and speed with which some of these projects are being planned and realized. Some examples:

- In early 2022, *Valencia (Spain)* has received a favorable report by Puertos del Estado on the construction project for a container terminal expansion in the port's northern area. The new container terminal will involve an investment of close to 1.4 billion euro and will have a capacity of 5 million TEU per year. The new terminal will be operated by TIL/MSC and is expected to be fully operational in 2030. Valencia is already one of the largest ports in the Med handling 5.6 million TEU in 2021;
- *Rijeka (Croatia)*: In November 2021, the project for a new container terminal in Rijeka became a reality with the signature of a concession agreement for Rijeka Gateway – a new state-of-the-art facility to be developed and jointly operated by APM Terminals and ENNA as joint venture partners (APM Terminals 51%, ENNA 49%). The first phase is expected to be completed in 2025. After the completion of Phase 2, both phases together will have a projected throughput of 1,055,000 TEU. Rijeka port handled 356,068 TEU in 2021;

[2] In September 2022, APM T announced that a final decision on the doubling of the capacity at its terminal in the Ameliahaven is postponed to the end of 2022.

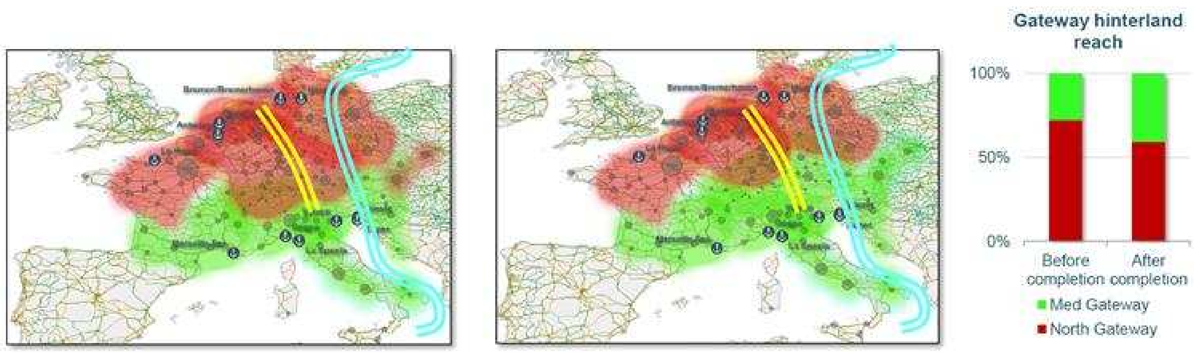
- *Koper (Slovenia)*: An extension project is underway to extend the quay and add additional stacking area. In a couple of years, the terminal capacity is expected to reach 1.5 million TEU. Koper handled just under 1 million TEU in 2021;
- *Sines (Portugal)*: The first stage of Phase III of the Sines Container Terminal was inaugurated in 2022. When the Phase III expansion plan will be fully completed by 2028, the terminal will have doubled its annual handling capacity to 4.1 million TEU. The fast-growing port handled 1.8 million TEU in 2021 (see Table 5.1 earlier);
- *Vado Ligure (Italy)*: In December 2019, APM Terminals opened a new container terminal in Vado Ligure, on the Italian Riviera, which is capable of handling 900,000 TEU. APMT has a 50.1% share in the Vado Gateway, while Cosco Shipping Ports has a 40% share and Qingdao Port International has a 9.9% share. The project can be associated with the Belt and Road Initiative (BRI) initiated by China;
- *Piraeus (Greece):* Cosco-controlled Piraeus Port Authority (PPA) plans to build a fourth container terminal at the port as part of a 800 million euro investment master plan. The fourth container terminal would expand the port's current container capacity from 7 million to 10 million TEU. However, Greece's Port Planning and Development Committee has rejected the plan, giving the reason that the conditions for a new container terminal are not mature at the moment. The port of Piraeus is one of the key maritime nodes in China's Belt and Road Initiative (BRI).

Such large terminal infrastructure projects also increase the need for **skilled and cost-efficient dock workers and a flexible workforce** that can cope with the volatility in terminal activity caused by the variability in ship arrival patterns, seasonality in the container market and operational challenges caused by human, economic and natural disruptions. Finding and training dock workers has become a challenge in many ports around Europe due to current labor shortages and the associated war for talent. Still, each port or port region comes with its own challenges with respect to the workforce at the container terminals, in the logistics centers in the port area and in the field of hinterland transportation (truckers, train drivers, etc.). For example, the Zeebrugge port area is facing shortages in dock labor. In the first half of 2022, there was a shortage of dock workers for a total of 8,129 shifts equivalent to about 120 days of shortages. The port area currently employs about 2,000 recognized dock workers and is aiming for a net growth in dock workers of 350 people in 2022, partly through an intensive campaign. Between mid-2021 and mid-2022 some 190 new dock workers were recognized. Also other ports of the Rhine-Scheldt Delta are stepping up their efforts to secure enough dock workers after having faced some dock labor shortages in 2021. For example, employers organization CEPA and training center OCHA in Antwerp have increased their targets when it comes to training candidate dockers: between 2022 and 2024 the aim is to train 576 candidate dockers for general work ('algemeen werk') as well as 450 straddle carrier drivers through training on a round-the-clock basis.

Second, **sustainability considerations** will increasingly have an impact on inter-port competition and the hinterland reach of European ports. Van Hassel et al. (2016) examined environmental policy impacts on competition between the European container ports in the LH-H range on the one hand and the Mediterranean ports on the other, by considering two scenarios: the internalization of external costs on the European hinterland and the establishment of a Sulphur Emission Control Area (SECA) in the North Sea region. Their calculations show that the effects of either policy option would not significantly impact on the theoretical captive hinterland of both port ranges. Still, we expect that CO_2 taxes and high bunkering costs can favor shorter routes and affect modal choice in hinterland transport. The energy transition will also affect the cost base of the different transport modes.

Third, **corridor formation (particularly by rail)** will have a major influence on future cargo routing decisions and competition between north and south European ports. European legislation requires sea and inland ports to be linked to the rail network. For seaports, the connection of TEN-T ports to the TEN-T rail network is mandated by Regulation (EU) 1315/2013, Article 41(2), which sets out that seaports shall be connected with the railway, road and, where possible, inland waterway transport infrastructure of the trans-European transport network by 31 December 2030. While the Commission identified that all seaports of the Core and Comprehensive Network are already connected to the TEN-T rail network, major improvements remain necessary to ensure efficient and sustainable rail transport into the hinterland. In 2017, Ocean Shipping Consultants and Royal Haskoning estimated how the completion of some TEN-T corridors (Figure 5.6) and the lowering of logistics costs in south European gateway ports could improve the hinterland position of the Med ports. In principle, a number of mainland Mediterranean ports offer transit time advantages over the north European ports for accommodating cargo flows between Asia/Middle East and large parts of Southern and Central Europe. Gateway ports in the west Med have gained a much better connectivity in the global shipping networks than before, which gives these ports the opportunity to benefit from a higher critical mass and the economies linked to larger vessels. But so far, they seem to have difficulties in substantially extending their hinterland reach north through rail services.

Figure 5.6. High level cost-based hinterland calculation before (left) and after (right) the completion of the Rhine-Alpine and Scandinavia-Med TEN-T corridors



Source: OSC (2017)

While Spanish ports (except for Barcelona) always faced a major technical challenge in setting up rail shuttles to France (i.e. the difference in rail gauge), the North-South paradox for North Italian cargo is mainly linked to a weaker intermodal organizational performance for intra-Italian rail products. Moreover, a smaller critical rail volume makes that frequent rail services are hard to maintain and sometimes disappear soon after introduction. While France and Spain are mainly involved in North–South trade, Italy could also represent a gateway for trades with Eastern Europe. However, north Italian ports at present collect only a very small portion of the merchandise of the area extending from Bavaria to Hungary. Also, significant flows of Italian cargo do not sail from Italian ports but from ports in the Rhine-Scheldt Delta and Germany.

There is improvement though:

- Several joint initiatives are underway with the objective of improving the position of the Med ports. West Med ports' strategies include a range of logistics platforms both in seaports and in strategic inland locations (e.g. the tm-concept of the Barcelona port authority). To attract Asian trade distribution to the region, some ports have joined their marketing efforts under the umbrella of Medports. Infrastructural efforts are combined with marketing initiatives for Med ports to become gateway to Europe for specific good flows. For example, Marseille, Venice and Koper are among the Med ports trying to develop logistics chains for perishable goods from the regions around the Mediterranean Sea to Northern and Central Europe, thereby leveraging on short inland transit times by rail.

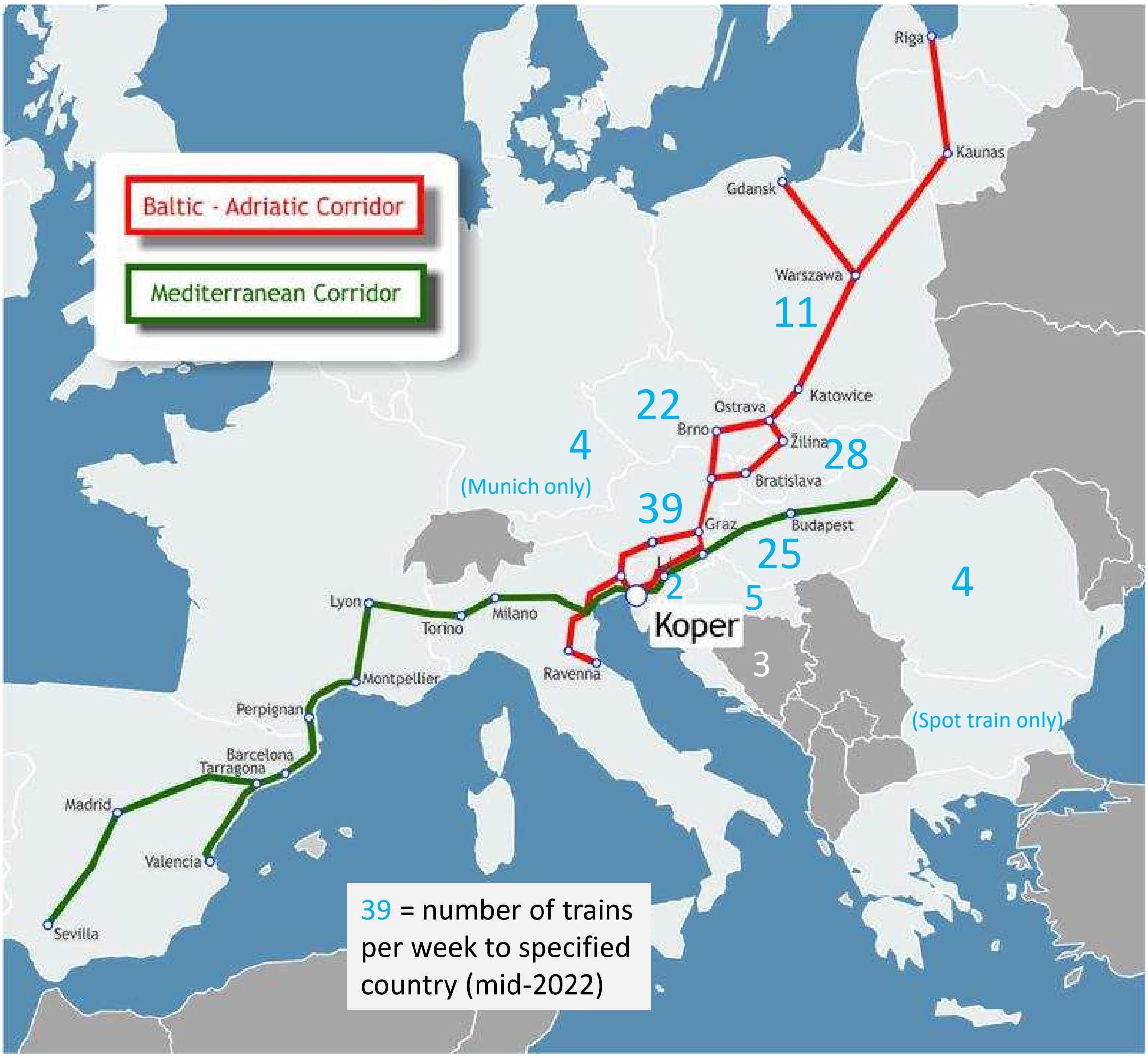
- Next to south-north corridors (mainly rail) included in TEN-T program, there are also ideas about the development of a reticular and polycentric railway axis reaching from the southern part of Spain all the ways to the core economic regions in the Benelux and Germany and further north to Stockholm (i.e. the FERRMED axis).

- In the Spanish supply chain, 5.4% of goods entering or leaving the country's ports is done by rail and 94.6% by truck. At present, the railway network in Spain is not very competitive, deficient and distant from the productive system. However, over the last few years, Spanish ports have made great strides in railway investment. Out of the 475 million euro of investment for basic infrastructures of the port authorities until 2025, 100 million euro are destined to different railway aspects such as internal lines of the ports, connections with the general interest railway network or improvement of the performance of the railway network that affects ports. For example, only 7.3% of goods moved through the port of Valencia move by rail (data Valenciaport). The port wants to boost the rail links with Portugal and France through dry ports and the promotion of corridors such as Canfranc on the Spanish-French border. The port has since committed 240 million euro to improving its rail access and infrastructure such as for the electrification of tracks, the remodeling of the railway network in the port, and the adaptation of the network to the European rail gauge. Important for gateway cargo is that the planned new container terminal (see earlier) will be combined with investments in a railway terminal equipped with six 1,000-metre-long tracks with the capacity to move 305,000 TEU per year by rail;

- North-Adriatic ports such Koper are gaining ground to serve the Alpine region and central and eastern Europe, partly by relying on an extensive and dense network of rail services (Figure 5.7). Figure 5.8 demonstrates that Koper has already established strong market shares on inland flows to countries like Hungary, Slovakia and Austria;

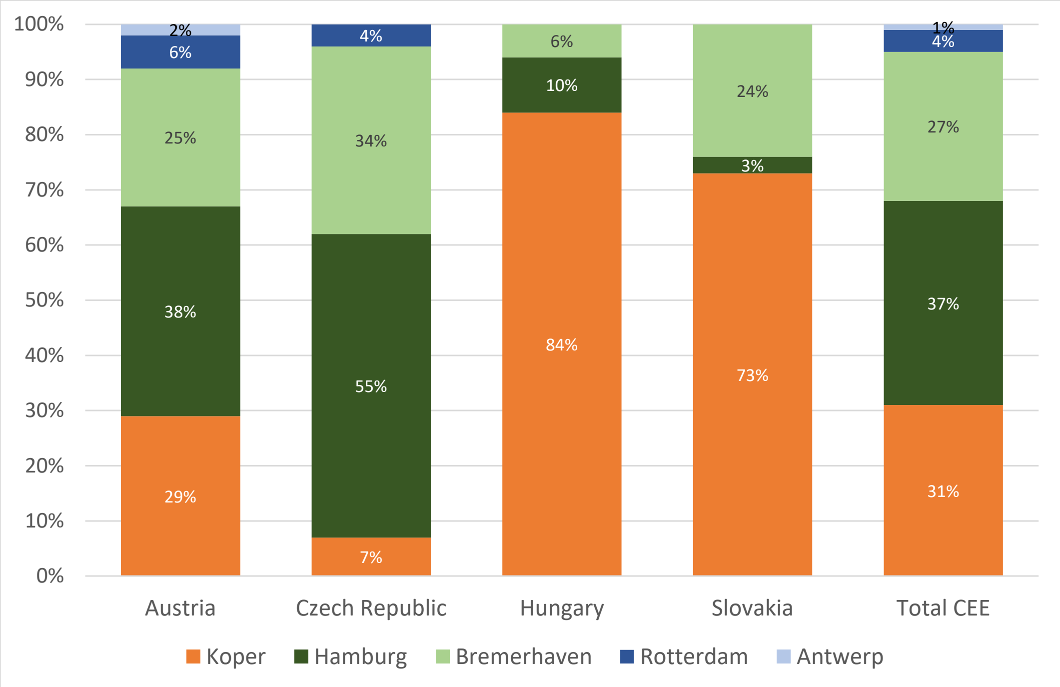
- About five years ago, Italian ports along the northwest coast have established a multi-regional coordinating body (Cabina di Regia) among the provinces of Liguria, Lombardia and Piemonte focused on the joint development of infrastructures and logistics integration (e.g. lobbying actions towards central government for funding and project approval, technical supervision and coordination of physically adjacent projects, etc.). Liguria is a member of the EGTC Rhine-Alpine. At national and regional level, incentives for rail transport (from/to port terminals) have been established since late 2017 (for example, the Ecobonus). The focus is also on the implementation of a new rail service concept involving longer trains (750m instead of 440-500m), a larger hinterland service range (up to 400km instead of 180km), a stronger focus on cross-border rail connections instead of only domestic services, higher service frequencies and commercial speed, and lower costs per TEU-km. Ongoing rail infrastructure investments are aimed at improving the rail connectivity of Ligurian ports. For example, works on the Terzo Valico dei Giovi (Third Pass) are advancing well. Works have commenced in 2013 and the Pass should be operative in 2025 for a total estimated cost of over 6 billion euro. Once fully completed, the Pass will connect the port of Genoa with the Po Valley and the rest of Northern Italy and thus Europe by being integrated into the Rhine-Alpine Corridor. The project involves the construction of a 53km railway line (37 of which are in tunnels) between Genoa in Liguria and Tortona in Piemonte. On the commercial side, quite a few new Alpine and trans-Alpine rail services have been introduced in recent years, such as the Southern Express train, which directly links the PSA Genova Pra' terminal to Basel, with a further extension to Wolfurt, an industrial area in the Voralberg region in Austria. The Western Ligurian Sea Port Authority which includes the ports of Genoa and Savona-Vado Ligure reported a rail traffic of some 216,000 TEU in the first half of 2022 or about 10% more than in H1 2021. In H1 2022, close to 17% of the total gateway containers was transported by rail. In 2021, rail accounted for 15.7% handled in/out of the ports. In 2019 this figure amounted to 13.4% (figures Ports of Genoa website). Rail is thus becoming increasingly important in the ports' hinterland connectivity.

Figure 5.7. Koper's inland rail network - number of train services per week in mid-2022 and main EU corridors.



Source: own compilation based on data of Port of Luka-Koper

Figure 5.8. Market share of Koper and a number of LH-H range ports in ocean TEU in key CEE countries, figures for 2016 based on hinterland TEU



Source: own compilation based on data ISL

All these initiatives are taken in a market environment where northern range ports are also very active in intensifying their intermodal networks, mainly to inland service areas in France, Germany, the Alpine region and to some extent also to East and Central Europe. One of the main obstacles to Med ports is that the hinterland volumes are still a lot smaller than in the Rhine-Scheldt Delta, which implies that a vast network of frequent intermodal services out of these ports typically is harder to develop and maintain. The concentration of cargo flows largely explains why the range and diversity of the intermodal service offer of large Delta ports is still far bigger and more established than in their Mediterranean counterparts. As it is highly unlikely this gap is going to be bridged in the foreseeable future, the presence of northern ports in south European container markets remains a market-driven reality.

Fourth, the spatial configuration of **distribution networks** in Europe has an impact on cargo routing decisions and the balance between north and south European ports (see proposition 2.3 for a more detailed discussion in European distribution trends). At the moment, North West Europe still offers the best access to the EU core markets and infrastructure. The majority of European Distribution Centers (EDCs) is still opting for a location in the Benelux region, northern France and western parts of Germany. The location of all these EDCs brings additional overseas containerized volumes to be handled by the Rhine-Scheldt Delta ports, Le Havre and German ports, although part of the products will be distributed to markets in southern Europe. Thus, a concentration of EDCs in the direct hinterland of the Rhine-Scheldt Delta ports partly causes the observed cargo imbalance between the LH-H range and the V-R range. However, more and more regions are vying for EDCs. Efficient long-distance corridors to south and east Europe can have a downside to the Rhine-Scheldt Delta as a well-established EDC region: they make it easier for logistics service providers to move distribution facilities inland closer to the customer base without having to sacrifice a good accessibility to the maritime gateways.

Finally, there exists a tension between **cargo concentration and cargo dispersion** in the European container port system. While the European container port scene is becoming more diverse in terms of number of ports involved, a lot of cargo is still concentrated in a limited number of ports (see earlier). The container handling market remains more concentrated than other cargo handling segments in the European port system, as there are strong market-related incentives for cargo concentration in the container sector. Out-of-pocket costs alone are not sufficient to understand the current routing of containerized goods in Europe. Intermodal bundling effects, connectivity effects and aggregated service quality effects at specific gateway ports make that a 'natural' gateway for a certain hinterland region is not necessarily the port closest to that hinterland region. The combination of the above effects also makes that environmental impacts per TEU-km generated by cargo passing through large gateways can end up lower compared to ports which are not able to benefit from the same connectivity and bundling effects. As such, the present cargo distribution patterns in Europe are a reflection of complex interactions between actors and factors related to infrastructure, transport services and the logistics organization of supply chains.

5.1.4. Structured summary on proposition 2.1

Proposition 2.1 "The rise of Mediterranean seaports will only lead to a limited maritime cargo shift from north to south."

Overall evaluation: Accept conditionally

Arguments & observations in support of the proposition	Arguments & observations going against the proposition
1. The container cargo imbalance between LH-H range and V-R range has hardly changed over the past two decades. 2. The strong growth in the Med has mainly been driven by the growth in sea-sea transshipment, and far less by the rise of gateway cargo (import/export). 3. The present cargo distribution patterns in Europe are a reflection of complex interactions between actors and factors related to infrastructure, transport services and the logistics organization of supply chains. 4. There is a big difference in maritime connectivity, terminal capacities and the scale of hinterland flows between the northern range and most of the Med ports. A vast network of frequent intermodal services out of Med ports typically is harder to develop and maintain. 5. Local or immediate hinterlands remain the backbone of ports' cargo bases (see later the discussion under proposition 2.3). Most of the shared contestable hinterlands between north and south European ports are located in the more distant hinterland. 6. North-Adriatic and Greek ports have a strong focus on serving the CEE hinterlands. The Rhine-Scheldt Delta has a modest market position in these regions. 7. European Distribution Centers (EDCs) are still opting for a location in the Benelux region, northern France and western parts of Germany, thereby capturing associated overseas container flows.	1. A number of Med ports are developing large new container terminals, thereby narrowing the scale differences with the large north European ports. 2. Any future labor shortages (dock works) can hamper the development of north European ports. 3. Med ports are increasingly focusing on rail to reach hinterland regions, partly targeting cargo-generating areas in South Germany, the Alpine region and southeastern/south France. These regions thus increasingly become contestable hinterlands for north and south European port ranges. 4. Efficient long-distance corridors from the Delta to south and east Europe make it easier for logistics service providers to move distribution facilities further inland. This creates opportunities for Med ports to act as gateways for these flows.

5.2. Proposition 2.2

Proposition 2.2. The battle for the European hinterland will increasingly be shaped by the role of rail, barge transport and shortsea/coastal shipping as part of ports' modal split.

5.2.1. The local/immediate hinterland as the backbone of port volumes

A large part of the volumes in dry and liquid bulk products is relatively captive to the discharging port region since the customers are typically located in the port region or in vicinity of the port (steel plants, power plants, oil refineries, chemical companies, etc.). The gateway function for major dry and liquid bulks of the Rhine-Scheldt Delta ports mainly involves one traffic direction (incoming seaborne cargo), a limited number of market players and a few nodes, i.e. the port and a limited number of destinations in the hinterland. Changes in the traffic position of the Delta ports as a whole in dry bulk and liquid bulk are therefore to a large extent linked to (1) economic cycles - demand, (2) terminal and inland transport supply in the Delta, also taking into account the environmental space such as the carbon footprint profile; (3) energy policies and energy transition in the Benelux and Germany and (4) location decisions of major steel and chemical companies for which competition plays at a global scale.

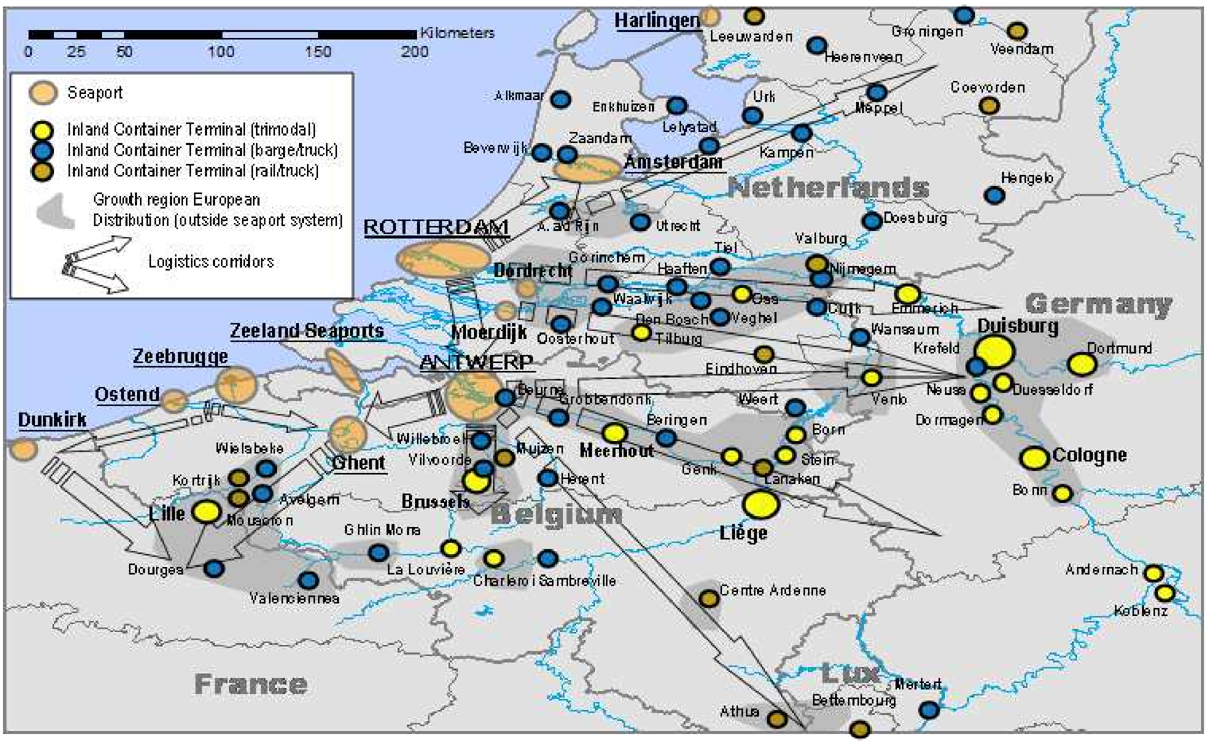
For containerized cargo, the hinterland profile involves numerous origins and destinations dispersed over a vast hinterland (and thus more competitors), a large number of economic players and two traffic directions. Therefore, the captive nature of container cargo for Rhine-Scheldt Delta ports is much smaller than for bulk cargo. Also, container flows are partly entwined with re-export and EDC activities in the region (see proposition 2.3 in the next section).

The local or immediate hinterland of the Rhine-Scheldt Delta ports remains very important. Even large European gateways such as Antwerp-Bruges and Rotterdam have a high proportion of container flows that is generated by the port city and its immediate surroundings. About 40% of containers leaving or arriving at Antwerp by truck are coming from or going to markets within a radius of 50km of the port. The most significant distance class for Rotterdam is the 150-200km radius. This is directly related to the port's role as a cargo generating location linked to the strong manufacturing and distribution base of the immediate hinterland (think of Venlo). The high share of rather local traffic is partly linked to the role of the low countries in EDCs and re-exporting activities. The ports' surrounding regions are home to a large number of EDCs. A large portion of the containers flows leaving the Delta ports is destined for EDCs or other logistics centers in the immediate hinterland. Containers arriving in these EDCs are typically stripped and after some value-adding manipulations the cargo is reconsolidated to reach the final destinations - even in the more distant hinterland – mostly by truck in a conventional non-containerized form. While road haulage has always played a major role in reaching the core hinterland regions, intermodal transport has slowly but surely acquired a strategic role as well. Rotterdam, the Antwerp port area, Amsterdam and the Ghent port area heavily rely on barges to reach water-linked hinterland regions. The Zeebrugge port area has developed a strong orientation on rail shuttles. Here, a strategic role is played by the many inland terminals and associated logistics zones that have been developed over the past three decades along major hinterland corridors.

5.2.2. The growing importance of inland ports and logistics zones

Since the early 1990s, the dynamics in logistics networks have created the right conditions for a large-scale development of inland ports throughout Europe with a strong concentration of such nodes in the Benelux, Northern France and the western part of Germany (Figure 5.9). The functions presented by inland logistics centers is wide ranging from simple cargo consolidation to advanced logistics services. Many inland locations with multimodal access have become broader logistics zones. Not only have they assumed a significant number of traditional cargo handling functions and services, but they also attracted many related services, a.o. distribution centers, shipping agents, trucking companies, forwarders, container-repair facilities and packing firms. The concept of logistics zones in the hinterland is now well-advanced in Europe: e.g. 'platformes logistiques' in France, the Güterverkehrszentren (GVZ) in Germany, Interporti in Italy, Freight Villages in the UK and the Zonas de Actividades Logisticas (ZAL) in Spain. Logistics zones are usually created within the framework of regional development policies as joint initiatives by firms, intermodal operators, national, regional and or local authorities, and or the Chambers of Commerce and Industry. Quite a few of these logistics zones are competing with seaports for what the location of European distribution facilities and value added logistics (VAL) are concerned. Shortage of industrial premises, high land prices, congestion problems, the inland location of the European markets and severe environmental restrictions are some of the well-known arguments for companies not to locate in a seaport.

Figure 5.9. Logistics polarization and logistics zones in the Rhine-Scheldt Delta



Source: updated from Notteboom (2010)

Rail and barge corridor development enhances the location of logistics sites in inland ports and along the axes between seaports and inland ports. Some of the inland ports such as Liège and Brussels are capable of accommodating shortsea and sea-river services. The interaction between seaports and inland locations leads to the development of a large logistics pool consisting of several logistics zones. This trend towards geographical concentration of distribution platforms often occurs spontaneously as the result of a slow, market-driven process. But also national, regional and/or local authorities try to direct this process by means of offering financial incentives. With respect to the Rhine-Scheldt Delta, there are now large concentrations of logistics sites in and around the inland port of Liège, along the Rotterdam-Germany axis, along the Geel-Hasselt-Genk axis and the Antwerp-Brussels axis, and in the Kortrijk/Lille border region. Apart from the Liège area, also other parts in Wallonia are becoming logistics hotspots, next to large concentrations of inland terminals along the lower and middle Rhine, and Northern France (Valenciennes and Lille). The existing geographical concentration of logistics sites has stimulated the development of inland terminals in these areas.

Logistics sites in the immediate hinterland typically value the flexibility a multi-port gateway system offers in terms of available routing options for import and export cargo. In a logistics world confronted with mounting reliability and capacity issues, routing flexibility is one of the keystones for the logistics attractiveness of a region. For example, the logistics attractiveness of large parts of Belgium and the Netherlands for EDCs is partly due to the reality of having several large and efficient gateways at their disposal.

In the future, a further integration of intermodal transport and supply chain management will undoubtedly lead to new value-added services in inland locations. This will enhance the provision of logistics services at key transfer points and the organization of distribution patterns around such nodes. The availability of fast, efficient and reliable intermodal connections between the gateway ports and the inland terminals is one of the most important prerequisites for the further logistical development of logistics zones in the hinterland.

5.2.3. Competitiveness in the more distant hinterlands

The Rhine-Scheldt Delta ports are strategically located in relation to the area of the European Union with the highest concentration of main economic centers, i.e. the so-called ‘blue banana’ reaching from the southern part of the United Kingdom over the Benelux, central and eastern France to northern Italy. The ‘blue banana’ is the core hinterland of the Rhine-Scheldt Delta ports but competition for cargo to this blue banana is fierce. Next to competition among Delta ports themselves, these ports also compete heavily with Le Havre for French cargo and with Bremerhaven, Wilhelmshaven and Hamburg for traffic to/from Germany, the Alpine region, northern Italy and Central and Eastern Europe. Major hinterland overlap regions characterized by intense port rivalry are the Rhine-axis (the German Ruhr Area in particular), northern France, northern Italy and the east-west corridors from the Benelux ports to the hinterland.

As was demonstrated under proposition 2.1, an increasing number of ports (try to) gain direct hinterland access to the ‘blue banana’ area. This development has broadened container port competition and altered spatial hierarchy, in the sense that the Rhine-Scheldt Delta ports are expected to face moderate levels of competition from container ports in other European port ranges (Baltic, Adriatic and Med) particularly for cargo related to South Germany, the Alpine Region, northern Italy, and southern and southeastern France. These contestable hinterlands are increasingly being served not only by the ports of one gateway region, but by several multi-port gateway regions.

Textbox 2.1. Rail development in Hamburg and Polish ports

Polish ports (Gdansk in particular) are developing a network of inland rail services to reach the domestic and foreign hinterland markets. Rail presently has a 33% in the modal split of container inland traffic of the port of Gdansk and is mainly focused on reaching the Polish hinterland. However, the future aim is to reach a 50% rail share by further developing links to CEE countries such as the Czech Republic and Slovakia. The most important intermodal transport routes from the seaports of Gdansk and Gdynia are those leading to Brzeg Dolny or Warsaw, and via the border crossings with Germany and Belarus. The main intermodal train routes from the port of Gdansk in 2021 - accounting for more than 70% of all routes from that port - were to Brzeg Dolny, Gądki, Kąty Wrocławskie, Kutno, Łódź, Poznań, Radomsko, Sławków and Warsaw. As for connections from the port of Gdynia, they were mainly to Ciechanów, Gądek, Kutno, Łódź, Nowe Skalmierzyce, Poznań, Radomsko, Rypin, Warsaw and Terespol Pomorski, with these connections accounting for approximately 61% of all connections made from the port in 2021. In 2021 there were 43 intermodal terminals operating in Poland with a total storage area of 228,528 TEU and a declared annual throughput of more than 9.6 million TEU. Also, the connections with China as part of the Eurasian rail links is high on the agenda. In November 2019, the first regular rail service connecting Xi'an (China) and Gdansk CT was launched. In 2021, 5279 international intermodal trains traversing the border into Germany were routed through the Rzepin - Oderbruecke crossing, and 914 were routed through the Węgliniec - Horka crossing. On the eastern frontier with Belarus, 5066 intermodal trains passed through the Brest Severnyy - Małaszewicze Centralne/Południowe border crossing and 4333 passed through the Kobylany – Park Bug crossing point.

Figure 5.10. Destinations for intermodal services out of the port of Hamburg

Source: Port of Hamburg website

The **port of Hamburg** was a pioneer in developing regular rail services to CEE countries shortly after the fall of the Iron Curtain in the early 1990s. Hamburg is Europe's largest railway port for containerized cargo. Of the 5.4 million TEU hinterland traffic of Hamburg in 2021, an elevated 51.5% was transported by rail compared to 46.1% by truck and 2.4% by inland barge. The rail share in the other German ports is 46% in Bremerhaven and 33% in JadeWeser Port (Wilhelmshaven). The main European hinterland regions served are located in Germany, the Alpine region, northern Italy and CEE countries with also services to France and Spain. HHLA is a major player in Hamburg operating a dense rail network connecting their own port terminals in Hamburg, Trieste, Odessa and Tallinn to the West European and CEE hinterlands and towards Asia. HHLA's daughter Metrans owns 5 hubs and 12 hinterland terminals as well as more than 3,200 light-weighted railway wagons and 128 state-of-art locomotives.

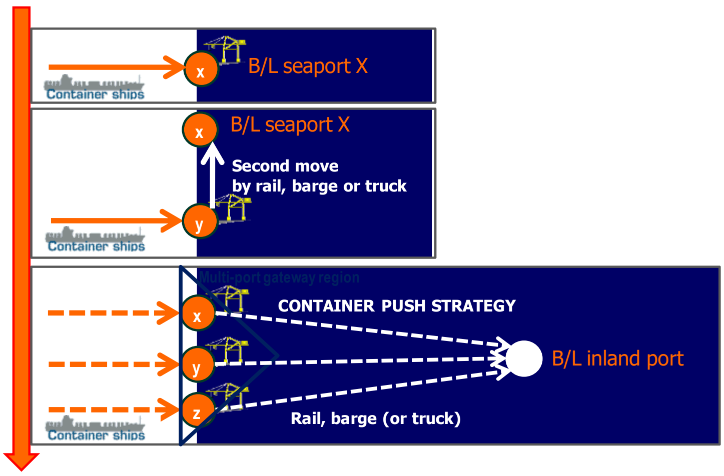
A port with a strong local cargo base will sooner or later be tempted to increase the inland penetration of its intermodal offer so as to increase its capture area. From that moment on the existing dense network of direct shuttles to nearby destinations might be complemented by indirect inland services to more distant destinations built around one or more inland hubs. Extensive cargo concentration on a few trunk lines opens possibilities to economies of scale in inland shuttles (through the deployment of longer trains or larger inland barges) but even more likely to higher frequencies. Containers for the more distant hinterland benefit from a port's strong local cargo base as local containers often provide the critical mass for allowing frequent deep sea liner services. The CEE countries are part of the distant hinterland of the Delta ports. It was demonstrated earlier that the container market position of Rotterdam and Antwerp-Bruges in CEE is very modest. Achieving a stronger position in these hinterlands implies entering into more aggressive head-on-head competition with Hamburg, Polish ports (Textbox 2.1), Adriatic ports and Greek ports mainly relying on rail traffic or a combination of barge traffic to the Rhine basin followed by a rail leg.

5.2.4. The hinterland focus of market players

Many market players have come to understand that landside operations are key to a successful integration along the supply chain. As a result, competition between ports and across the logistics sector looks set to intensify. As ports and logistics firms battle to protect and gain market share, the race to find cost savings and efficiency gains will become even more pronounced.

Shipping lines are keen on developing carrier haulage volumes. In order to streamline the inland distribution system, shipping lines and alliances between them seek to increase the percentage of carrier haulage on the European continent. Contrary to the Rotterdam-Antwerp inter-port market where barge container transport is 'dominated' by the deep sea shipping lines in the framework of second moves (carrier haulage), the inland market is still dominated by large shippers (merchant haulage). A number of larger shipping lines such as Maersk Line and MSC are developing hub-concepts in the hinterland of the key ports in their networks. Inland terminals and rail and barge services are combined to push import containers from the ocean terminal to an inland location, from where final delivery to the receiver will be initiated at a later stage. This "push" strategy (see Figure 5.11) is initiated by the shipping line, yet prioritized based on the required delivery date. Export containers are pushed from an inland location to the ocean terminal, initiated by the shipping line, yet prioritized based on available inland transport capacity and the ETA of the mother vessel.

Figure 5.11. The evolving role of shipping lines in the hinterland: towards a 'push' strategy

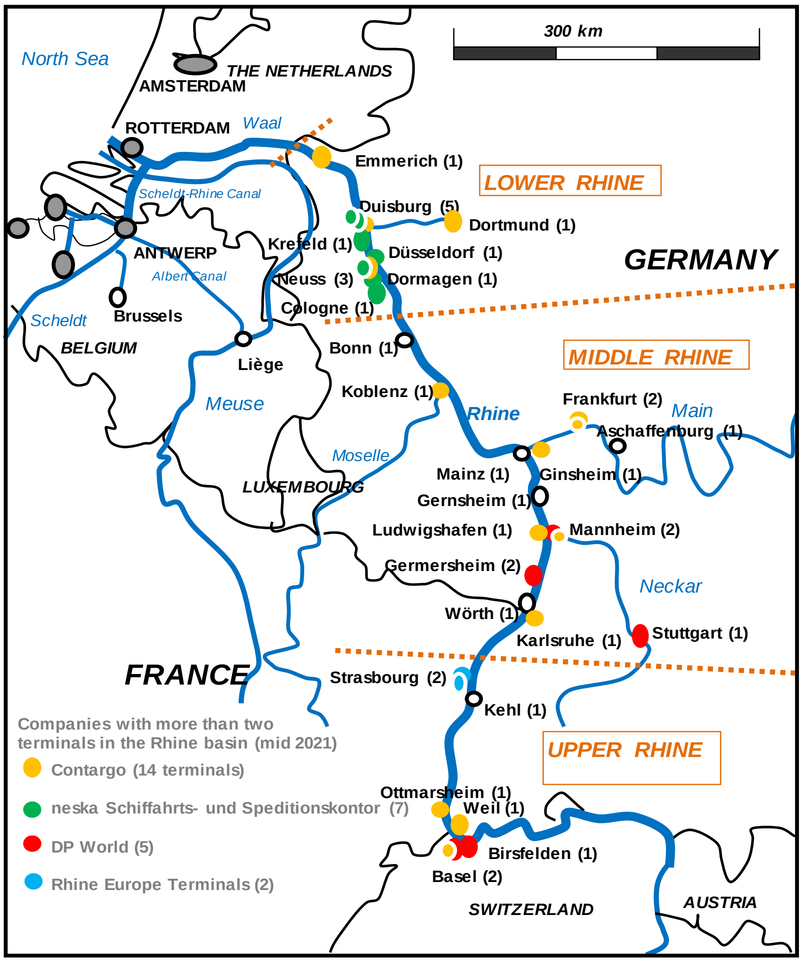


Source: Notteboom (2013)

Textbox 2.2. Extended gates and terminal operator haulage

Inland terminals can be incorporated as 'extended gates' to seaport terminals and as such can help to reduce container dwell times on seaport terminals. Container terminal operator ECT in Rotterdam (part of Hutchison Ports) follows an active strategy of acquiring key inland terminals acting as extended gates to its deep sea terminals. Through 'European Gateway Services', ECT offers shipping lines, forwarders, transport companies and shippers a variety of services to facilitate the optimal flow of containers between the deep-sea terminals in Rotterdam and the direct European hinterland. ECT bundles cargo, which allows for highly frequent inland barge and rail connections to various logistics hotspots in the European hinterland. The inland network includes a.o. the TCT Venlo rail and barge terminals (the Netherlands), DeCeTe terminal in Duisburg (Germany), TCT Belgium in Willebroek (Belgium), ACT in Amsterdam, MCT in Moerdijk, AVCT in Avelgem (Belgium) and LCT in Liège (Belgium). ECT is not the only deep sea terminal operator developing an active extended gate policy. The door-to-door philosophy of other companies such as APM Terminals, DP world, PSA and Eurogate has transformed these terminal operators into logistics organizations and or organizers/operators of inland services. While extended gate solutions are being offered by terminal operators, the terminals themselves are not necessarily owned by these terminal operators. The ownership structure of inland barge terminals on the Rhine shows that logistics groups such as Contargo (Rhenus) and neska logistics dominate the scene (Figure 5.12). Only few deep-sea terminal operators such as DP World (upper and middle Rhine) and Hutchison Ports (DeCeTe in Duisburg) have a presence along the Rhine.

Figure 5.12. Ownership of terminals on the Rhine (situation mid-2022)



Note: Duisburg (5) implies there are five barge container terminals in Duisburg

Source: Notteboom and Neyens (2017) and updates from Notteboom et al. (2020)

Some *terminal operators* in Europe are also increasing their influence throughout supply chains by engaging into inland transport. They seem to do so mainly by incorporating inland terminals as 'extended gates' to seaport terminals (see Textbox 2.2) and by introducing an integrated terminal operator haulage concept for the customers. The advantages of the extended gate system are substantial: customers can have their containers available in close proximity to their customer base, while the deep sea terminal operator faces less pressure on the deep sea terminals due to shorter dwell times and can guarantee a better planning and utilization of rail and barge shuttles. However, the success of both extended gates and terminal operator haulage largely depends on the transparency of the goods and information flows. Unfortunately, terminal operators often lack information on the onward inland transport segment for containers that are discharged at the terminal. A close coordination with shipping lines, forwarders and shippers is needed to maximize the possibilities for the development of integrated bundling concepts to the hinterland.

5.2.5. Modal shift to rail and barge

There is a clear ambition of policy makers and ports to decarbonize transport to achieve the climate goals. Electrification and the use of non-fossil fuels (such as bio-based and synthetic fuels including hydrogen, see proposition 5.1) have their role to play in this transition process. The focus is also on realizing a modal shift or co-modal setting where inland waterway transport, rail transport and shortsea shipping play a more important role. Quite a few ports have set modal split ambitions, particularly in hinterland container transport. Rail and barge transport especially have potential on corridors and in regions where sufficient volumes are present. This allows for highly frequent transport by rail and barge. The Delta and its immediate to distant hinterland in principle qualifies as such a region. Still, Table 5.3. demonstrates that the ports of Rotterdam and Antwerp have a long way to go, particularly when it comes to the rail share. Container transport by rail has seen a spectacular development in German ports and Zeebrugge, while other both small and large ports are implementing strategies to significantly increase the market share of rail in the modal split after years of stagnation or relative decline.

Already in the 1990s, European and national policy makers showed a strong urge to almost 'force' a modal shift, backed by the liberalization (or at least the start of it) of the barge and rail markets, new pricing tools and extensive subsidy and supporting programs (e.g. PACT). The market players reacted only moderately to the incentives in this 'policy push' phase, even at the peak of the modal shift hype. As a result, the modal split trends remained almost unchanged. Flanders provides a good example. The Mobility Report 2022 of MORA (Mobiliteitsraad) in Flanders explicitly states that the support to rail and barge transport has not resulted in fundamental changes in the modal split. For the period 2019-2024, the modal shift is a prominent objective of the Flemish government that must be achieved through an investment policy in transport infrastructure and Flemish co-financing of rail investments. The Flemish Resilience 2020 recovery plan (4.3 billion euro) provides for additional investments for infrastructure of which 172 million euro is provided for the modal shift. But the MORA sees no clarity about the objectives of the modal shift, nor a clear interpretation of a concrete approach and measures. According to the forecast of the Planning Bureau, the share of road transport in the modal split will still be 77% in 2040. Rail and inland shipping stagnate at around 11 to 12%. This means that there will be almost no change in the modal split between 2019 and 2040. In the seaports the picture is more nuanced. In the overall modal split of the port of Antwerp, road transport has a share of 34% overall, compared to 7% for rail and 44% for inland shipping. In Ghent this is respectively 27%, 9% and

54% and in Zeebrugge 72%, 18% and 0.3%. Estuary shipping in Zeebrugge accounts for 6.6% of the modal split.

Table 5.3. Current state-of-affairs and ambitions for the modal split in hinterland container transport in large seaports in Northern-Western Europe (MS = modal shift)

Port		Total container volume (in TEU)	Container hinterland volume (% of total)	Modal split % container hinterland transport		
				Road	Rail	Barge
Rotterdam	2017	13,734,334	65.5%	56.2%	10.4%	33.4%
	Target 2035			Max. 35%	Min.20%	Min. 45%
	Necessary MS			*-21.2%*	*+9.6%*	*+11.6%*
Antwerp	2017	10,450,900	66%	55.1%	6.9%	38.0%
	Target 2030			Max. 43%	Min. 15%	Min. 42%
	Necessary MS			*-12.1%*	*+8.1%*	*+4%*
Hamburg	2017	8,815,469	59.8%	55.0%	42.6%	2.4%
	Target 2035			Max. 53.4%	Min. 42.5%	Min. 4%
	Necessary MS			*-1.6%*	*N/A*	*+1.6%*

Source: Langenus et al. (2022) based on OSC, Drewry, Dynamar, ISL, Port of Antwerp and Port of Hamburg.

The last decade has brought a more bottom-up approach mirroring a clear market-driven interest from the users and suppliers of intermodal services (market pull) and more initiatives aimed at a better coordination. A number of issues are critical in achieving a further modal shift.

First, **not one single kind of party is leading in finding and implementing a transport solution involving rail and/or barge**. Shipping lines, terminal operators, inland terminals, inland transport operators, 3PL companies, shippers and public authorities all have their role to play in the development of solutions. The Rhine-Scheldt Delta ports often employ strategies to increase the modal share of rail and barge on their own initiative. As most port authorities assume both public and economic responsibilities, they actively address societal challenges beyond the port area. Creating synergies beyond the port perimeter and across market players is particularly relevant in the context of hinterland connections. Coordination and cooperation is needed to form an integrated intermodal service that complies with the requirements imposed by the supply chains that pass through the port. Van Der Horst and De Langen (2008) made a detailed analysis of the coordination problems in hinterland chains of seaports and arrangements to resolve these problems. They distinguish four main categories of arrangements to improve coordination: the introduction of incentives (e.g. a bonus or penalty), the creation of an inter-firm alliance (e.g. through the introduction of standards for quality and service or a joint capacity pool), changing the scope of the organization (e.g. through vertical integration or the introduction of a chain manager) and collective action (e.g. through the governance by a port authority or a concerted action by a branch association). The dynamics in contemporary port-hinterland relationships is thus not taking place in a vacuum, but is articulated by the joint strategic and operational decisions of the actors involved. This need for coordination is also rooted in the belief that the private interests of individual companies will not lead to the creation of efficient and extensive pan-European intermodal networks. Companies cannot be expected to be the promoters of an intermodal network system that leads to higher efficiency at the macro-level rather than the level of the firm. The call for cooperation and coordination is materializing against the backdrop of large scale consolidation and vertical integration in the logistics industry, also affecting the control of hinterland transport chains (see further in the discussion on proposition 3.1). Each of the actors involved approaches hinterland issues from their respective viewpoints and objectives. Logistics service providers and transport operators all have their specific operational and commercial reasons to get involved in the shaping of hinterland networks. Notwithstanding potential objective struggles and varying levels of logistics integration, they have some shared interests when it comes to hinterland issues. First of all, logistics service providers, shipping lines, terminal operators and transport operators are facing major challenging in the cost structure (e.g. pricing systems, fuel costs), sustainability and the reliability and synchronization of inland transport services. Secondly, all these market players expect government regulation and liberalization to support their efforts to create efficient hinterland transport networks.

Second, the success of rail and barge strongly depends on developing efficient **cargo bundling solutions** and **last-mile connections**. Smaller ports and new terminals often find themselves confronted with a vicious circle in the organization of rail and barge transportation, which complicates a further modal shift and could impede the development of new multimodal corridors. Cargo bundling is one of the key driving forces of container service network dynamics. The advantages of complex bundling are higher load factors and/or the use of larger transport units in terms of TEU capacity and/or higher frequencies and/or more destinations served. The main disadvantages of complex bundling networks are the need for extra container handling at intermediate terminals (higher transit time, increased risk of damage), longer transport distances and a higher dependency on service quality. These elements incur additional costs which could counterbalance the cost advantages linked to higher load factors or the use of larger unit capacities. Complex bundling networks strongly rely on the speed and cost-effectiveness of the transfers at intermediate terminals. Appropriate handling equipment needs to be in place, which is financially justified only where there is sufficient traffic. One way to guarantee higher volumes is by providing a broader range of services and modes and by mixing port-hinterland traffic with intra-European traffic. Another way is by directing cargo of different ports to one and the same inland hub. The duplication of hub terminals each operated by other market players is only feasible in places with sufficient cargo volumes. Pre- and endhaul costs typically are very significant in intermodal transport, thereby putting pressure on, for example, last mile solutions by truck or the connections between the private rail sidings on the quay side and the national rail network. The formation of barge and rail shuttles in large seaports often requires the **grouping of containers within the port area**. Two alternative systems exist in this respect:

- the vehicle (i.e. barge or train combination) calls at various deep sea container terminals in order to fill the available capacity,
- all containers bound for a specific inland shuttle are brought to one or two central transshipment points through a network of separate intra-port services by truck, barge or rail.

In the first option, barges and trains consume time while collecting hinterland cargo. The use of one or two central loading/discharging points in the port area dramatically reduces port time for barges and train combinations, but incurs extra costs related to the operation of inter-terminal container transfers and extra container handlings. The desired configuration is highly dependent on the spatial lay out of the port area (cf. inter-terminal distances), operational characteristics of terminals, berths and transport equipment and the decision of who will have to bear the costs of inter-terminal transfers (shipping line, terminal operator or any other party). Both Antwerp-Bruges and Rotterdam have worked out approaches to deal with intra-port bundling of containers. For example, **barge hubs** in the port of Rotterdam have dedicated barge services with 'fixed windows' at the deepsea terminals and sail between Waal-Eemhaven, Botlek and the Maasvlakte. The Port of Rotterdam Authority is also planning for the construction of a **Container Exchange Route (CER)** which would connect all terminals on Maasvlakte 1 and 2. It is unclear whether CER will be based on autonomous vehicles or manned transport given uncertainty on the operational and financial risks for the complete container exchange implementation. In Antwerp-Bruges, **Railport** - a joint initiative of the Port of Antwerp-Bruges, the Maatschappij Linkerscheldeoever (MLSO) and the umbrella federations Essencia Vlaanderen and VOKA-Alfaport - coordinates all rail activities at the port areas and develops projects with various partners. These are intended to strengthen railway transport within the port and links with other European hubs. The ambitions for Antwerp are clear: to double the share of rail transport in the port platform in the coming years. To achieve this, Railport, together with Infrabel, puts the railway vision into practice and, as a neutral party, offers advice and solutions to the various parties active in the rail landscape.

Third, while rail has been liberalized in Europe, there is still a **persisting national approach on rail**. European rail logistics remain highly complex. The slow progress on implementation of ERTMS to improve the technical interoperability impedes the smooth functioning of the railway market and the efficient cargo flow by rail from ports to their European hinterland or catchment area. Not only technical issues, such as differences in traction energy, train length, train controlling systems, rolling stock, operational rules and train crew certification need to be addressed, but cross-border cooperation needs to be strengthened in other dimensions, as well. Infrastructure managers should even more exchange cross-border information, to facilitate seamless rail operations. The creation of RailNetEurope was a major step forward to improve coordination among national and regional rail infrastructure managers. Still, rail operators continue to face issues when launching new rail services. In many cases, rail products remain relatively expensive and finding the necessary critical mass is not an easy task, certainly when facing a fragmented cargo base controlled by many forwarders.

Fourth, especially for distances below 300 km, freight shipments coming in or out of the Rhine-Scheldt Delta ports by rail or barge are an important means to reduce congestion and can play an essential role in urban freight logistics. The seamless connection to **inland terminals and logistics zones** is crucial to the success of **short and medium-distance rail and barge services**, so reducing delays and waiting times in port areas is a key action field. This requires among others more efficient intra-port bundling schemes and the provision of enough dedicated infrastructure (e.g. operating berths and waiting berths for barges, rail sidings and rail hubs). Improving the Delta's market position in **more distant hinterlands** requires a targeted commercial rail strategy jointly developed by all relevant parties. A 'carpet bombing' approach to distant hinterland regions is not appropriate. Instead, the focus should be a creating 'islands' of cargo capture in well-chosen hinterland regions through viable and competitive rail services.

5.2.6. Structured summary on proposition 2.2

Proposition 2.2. "The battle for the European hinterland will increasingly be shaped by the role of rail, barge transport and shortsea/coastal shipping as part of ports' modal split."

Overall evaluation: Accept, conditionally

Arguments & observations in support of the proposition	Arguments & observations going against the proposition
1. Local or immediate hinterlands remain the backbone of ports' cargo base: strong progress has been made in the use of rail and barges on distances below 300 km with an essential role played by inland terminals and logistics zone development. 2. The scale of hinterland flows in the RSD port region facilitates the development of a vast network of frequent intermodal services. 3. Improving the Delta's market position in more distant hinterlands requires a targeted commercial rail strategy jointly developed by all relevant parties to create 'islands' of cargo capture in well-chosen hinterland regions. 4. Quite a few market players such as 3PLs, forwarders, shipping lines and terminal operators have rolled out hinterland strategies involving a strong focus on rail and barge.	1. Modal split ambitions of the RSD ports are high, but mostly there still is a long way to go, especially for the rail share. 2. European rail logistics remain highly complex. In many cases, rail products remain relatively expensive and finding the necessary critical mass is not an easy task, certainly when facing a fragmented cargo base controlled by many forwarders. 3. Delays and waiting times in port areas are a key action field requiring more efficient intra-port bundling schemes and the provision of enough dedicated infrastructure.

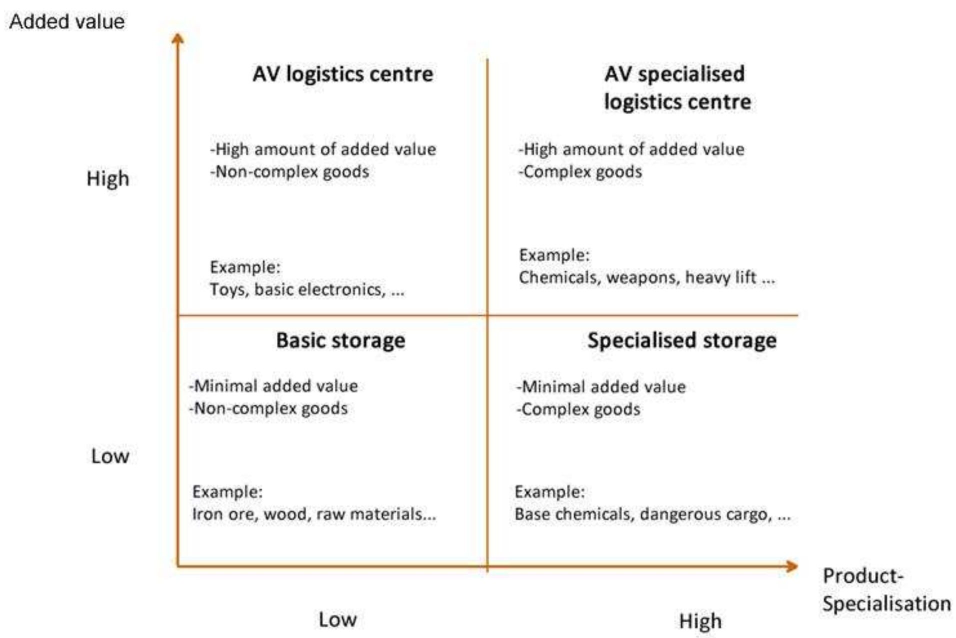
5.3. Proposition 2.3

Proposition 2.3. Centralized European distribution with XXL warehouses and liquid bulk storage hubs is the dominant model for the future favoring the competitive position of the Rhine-Scheldt Delta ports

5.3.1. Trends in European distribution structures

It is possible to distinguish certain types of warehousing depending on their distance to the customer and the degree of specialization required by the product (Figure 5.13). Depending on the specialization degree and customer distance four types of warehousing can be identified, ranging from the basic storage facilities like grain silos and simple sheds for storing wood to specialized logistics/distribution centers with a high amount of added value activities.

Figure 5.13. Warehousing typology diagram

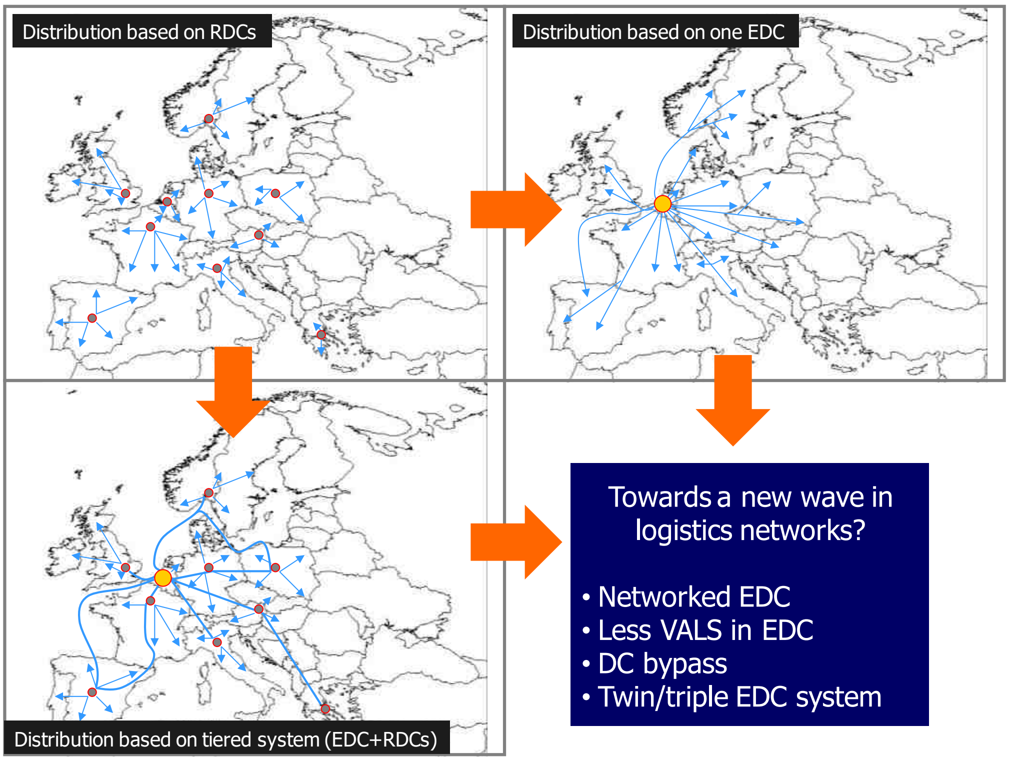


Note: AV = added value

Since the RSD port region is close to the final consumer markets and the majority of production facilities in high tech or specialized products, the types of warehouses primarily found in Northwest Europe are quite complex. Most activities take place in the upper right quadrant, thus specialized logistics/distribution centers. Before 1993, most companies set up a distribution structure based on a network of distribution centers in major countries in which they were present. Since cross-border transactions have increased drastically after the creation of the European Internal Market in 1993 and the fall of the Iron Curtain, most companies consolidated their national distribution centers to European distribution centers (EDC) covering all of Europe. When it comes to overseas goods not all companies have the same distribution structure. It stands to reason that not all goods can be handled and distributed in the same manner. Companies can opt for delivery without the use of a distribution center, distributing through an EDC, distribution through a group of NDCs (National Distribution

Centers) or RDCs (Regional Distribution Centers) or a tiered structure with one EDC and several supporting NDCs/RDCs (Figure 5.14). The choice is mainly influenced by the type of product and the frequency of delivery. In the fresh food industry for example, EDCs are not common because the type of product (perishables) dictates a local distribution structure. In the pharmaceuticals industry, EDCs are common but RDCs or local distribution centers are not present, because the pharmaceutical products are often manufactured in one central plant and delivery times are not very critical (hospitals often have own inventories). However, in the high tech spare parts industry, all of the distribution center functions can be present because spare parts need to be delivered within a few hours and high tech spare parts are usually expensive (which would require centralized distribution).

Figure 5.14. Trends in the configuration of logistics networks in Europe



Contemporary logistics networks are thus characterized by a few main developments (Figure 5.14). First, the evolution from EDC to a networked EDC reducing labor requirements but demanding higher skills. A certain degree of decentralization takes place where EDCs are combined with lower tier RDCs, cross docks and rapid fulfilment centers in order to offer the best results in terms of a high service level, frequency and cost control. When multiple products are delivered by the same company, a hybrid distribution structure is an option allowing the slower goods to pass through the EDC and the faster goods with a shorter life cycle through RDCs.

Second, less value added services (VALS) are performed at the central distribution centers as these are decentralized or moved to low cost production facilities or even overseas to the source. Third, the EDC can be bypassed altogether by cross docking, merge in transit or adequate consolidation at the supplier transport hub. Fourth, a shift in location takes place caused by market dynamics (distribution follows demand) and logistics trends (a shift from push to pull logistics). This can lead to a decoupling of one EDC serving the whole European market to two or even three EDCs of similar status spread over Europe (twin or triple EDCs). Fifth, specific sectors require EDCs for their supply chain like basic processing industries (chemicals, food, etc..), sectors with a low logistics cost (pharmaceutical, medical) and Asian

SMEs with new emerging global brands from China. The fifth trend does not offset the others. Existing EDCs will be transformed to networked EDCs.

The future distribution system configuration obviously has an impact on the cargo routing patterns in Europe. EU enlargement up to now has not had a huge impact on the location of EDCs in the blue banana as this zone still offers the best access to the EU's core markets and infrastructure. However, road congestion, increasing labor costs and scarcity of land may encourage companies to search for alternative distribution structures. High potential candidates for RDC location are northern Germany and Finland for northern access, Hungary and Austria for central access, northern Italy and the north Adriatic region for southern access and the Czech Republic and Poland for eastern access.

Land and maritime corridors might prove to be crucial to support the further development of efficient European distribution network configurations. However, efficient long-distance corridors can also have a downside to well established EDC regions such as Belgium and the Netherlands: they make it easier for logistics service providers to move distribution facilities inland closer to the customer base without having to sacrifice a good accessibility to the maritime gateways.

5.3.2. Preferred locations for EDCs

Some locations are more EDC preferable than others. At present, the center of gravity for EDCs is located in a region comprising Belgium, the south and eastern parts of the Netherlands, northern France (Lille/Valenciennes) and parts of western Germany (mainly the Ruhr area). According to the statistics of the Holland International Distribution Council (HIDC), 57% of all EDCs serving American companies and 56% of those serving Asian companies are located in the Netherlands, concentration levels far higher than in the other EU countries in the ranking, namely Belgium and Germany.

Cushman & Wakefield publishes European distribution reports to compare European top-regions for logistics, based on macro-economic factors with an impact on distribution and logistics. The reports traditionally give a ranking of countries in and around the so called "Blue Banana" area, and now has expanded to other regions. The 2019 report of Cushman & Wakefield identifies the important new transportation corridors which will emerge between now and 2030 to support the evolution of the European logistics industry (Cushman & Wakefield, 2019). The logistics 'Blue Banana', which is Europe's primary distribution corridor from the Benelux countries to northern Italy, has transformed into multiple corridors in response to EU expansion and new motorway and rail additions. These logistics corridors are set to evolve further due to factors including increasing freight volumes, transport costs, labor shortages, road congestion, e-commerce, multimodal connectivity and transport networks. In addition, political issues including the UK's departure from the European Union also have an impact. Cushman & Wakefield identifies eight primary logistics corridors likely to define European logistics in 2025 or 2030 (Figure 5.15):

- The **original blue banana** which imply the channeling of international trade into Europe primarily via the Benelux ports, through the German Rhineland to northern Italy. The growing importance of Mediterranean ports is likely to extend the blue banana to include north Italian ports (see proposition 2.1);
- **UK corridor** (post-Brexit) as a result of UK supply chains increasingly being domestically focused;
- **Irish corridor** heavily relying on the short-sea shipping route between the ports of Cork and Dublin in Ireland and the port of Antwerp-Bruges with some spill-overs to North Sea Port and Rotterdam;

- **Iberian corridor** in Spain and Portugal fed by manufacturing activities (such as in the automotive industry) and growing import flows from Asia, and supported by rail developments (see proposition 2.1).
- **Central Europe corridor** supported by TEN-T motorway and rail developments This corridor could eventually extend to northern Italy and thus connect to the original blue banana via Bologna and Milan.
- **North Sea corridor** connecting the port of Hamburg with Copenhagen and Malmo through completion of Rodby-Puttgarden tunnel.
- **Black Sea corridor** – A future distribution corridor that will be connected to the Central Europe 'banana' once TEN-T Rhine-Danube rail and motorway network's branch connecting Budapest with the Black Sea is completed. As a result, Romanian markets such as Bucharest are expected to play a crucial role.
- **Baltic corridor** – The Baltic's growing importance as a manufacturing location will partly depend on the construction of TEN-T motorway road and rail networks that will connect this region with Finland, Poland, the Czech Republic and Germany.

Figure 5.15. Future logistics corridors in Europe

Source: Cushman & Wakefield (2019)

The emergence of new logistics corridors implies that the center of gravity in European distribution is expected to slowly shift east to southeast due to the rise of Central and Eastern Europe, implying Belgium and the Netherlands will face increasing competition in attracting EDCs. In the shorter term, Wallonia in Belgium, Luxembourg and many German logistics hubs have already gained in importance as good locations for EDC activity. This geographical shift is facilitated by strongly developed rail and barge corridors emanating from the west ports Rotterdam, Antwerp-Bruges and North Sea Port and the north German gateways of Hamburg, Bremerhaven and Wilhelmshaven. Port competition has become fiercer as all these ports, and ports in Northern Italy, the North Adriatic and Poland vie to serve these new logistics regions.

5.3.3. The rise of XXL warehouses

Under the influence of e-commerce and online retail, XXL warehouses are increasingly being built. These are warehouses with a floor area of at least 40,000 m². The number of XXL warehouses in Belgium and the Netherlands is growing explosively. The scale of activity reflects widespread recognition by investors of the structural shift by supply chain managers and retailers towards larger schemes. In addition to logistics service providers or Third party logistics operators (3PLs), many shippers also choose for XXL warehouses. Among them are many e-commerce companies, which handle the mostly small orders collect in plastic containers or directly in shipping boxes. The transport then takes place with long conveyors, which connect the different zones with each other and with the packaging and forwarding department to connect. Some of the Dutch examples include Zalando in Bleiswijk (140,000 square meters), Bol.com in Waalwijk, VidaXL in Venlo, Primark in Roosendaal, and Inditex in Lelystad.

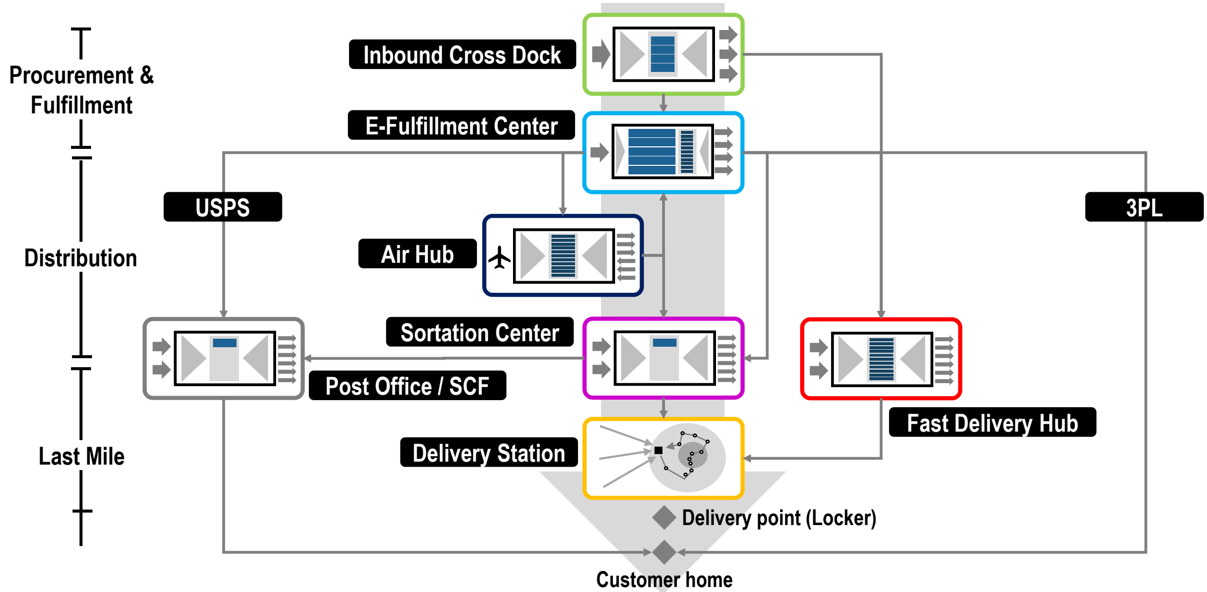
A range of factors is driving the remodeling of logistics networks, such as a growth in the number of product lines and order complexity, customer demand for quicker delivery times, and the need for flexibility to cope with demand volatility. These are particularly relevant for supply chains that support growth in online retailing. These drivers have pushed take-up of XXL warehouses. The growth in demand for XXL warehouses thus arises from supply chain reconfiguration and the consolidation of operations into fewer, larger centralized hubs. These hubs supply a large hinterland area more cost-effectively than might be possible from traditional networks.

XXL warehouses offer several advantages. Two important factors that determine the size of a warehouse are inventory costs and transport costs. Concentrating the stock in one facility requires less stock than with a network with two, three or even more stock points. The inventory costs are therefore lower with an XXL warehouse. When it comes to transport costs, it is less clear which is better in terms of number of stock points. With one central stock point, the distances to customers, and therefore the costs of transport, are higher than with a network with several stock points. On the other hand, less transport is required for stocking one warehouse than for two or three warehouses. Another argument for an XXL warehouse is the overhead costs. With one warehouse, only one organization is needed to control the operation and management of the building. In addition, investments in automation systems are more easily earned back with one warehouse.

However, XXL warehouses also bring some challenges. Extra measures are needed to organize the internal logistics operations efficiently. Because of the longer driving and walking distances, there is a risk that the productivity of the employees in the warehouse will decrease. Also, when choosing an XXL warehouse, it is important to think carefully about its design by dividing an XXL warehouse into several areas or zones. By having the incoming and outgoing flows of goods run through the docks near those zones, driving distances remain limited. An additional advantage is that these different operations often have different peak moments. This offers the logistics service provider the opportunity to deploy its employees more efficiently. If it is quiet in one zone, those employees can be moved to a busier zone. This requires a sophisticated planning system for the use of the loading docks and accurate forecasts. Another disadvantage of an XXL warehouse are the risks such as startup issues, fire risk, disruptions by strikes, mechanical or digital failures, etc. Furthermore, an XXL warehouse requires a large upfront investment which can only give a good ROI if anticipated cargo volumes are realized.

Despite the growth of XXL warehouses, the market has not moved towards omnichannel warehouses in which all activities take place under one roof. Instead, the market has evolved towards different types of warehouses, as illustrated by the e-commerce activities of Amazon in the US (Figure 5.16). E-commerce leads to the development of more cross docking sites close to large population groups in order to act quickly. The XXL warehouses have been developed where a lot of workers and space are available. Online trade therefore had a positive impact on the development of logistics real estate.

Figure 5.16. The E-Commerce Supply Chain of Amazon in the US



Note: Amazon uses three distribution channels. A sectional center facility (SCF) is a processing and distribution center (P&DC) of the United States Postal Service (USPS) that serves a designated geographical area defined by one or more three-digit ZIP Code prefixes. A sectional center facility routes mail between local post offices and to and from network distribution centers (NDCs), which form the backbone of the network.

Source: Rodrigue (2020)

5.3.4. The role of the Rhine-Scheldt Delta ports in European distribution networks

The rise of EDCs and XXL warehouses is particularly visible in the hinterland with vast developments that have taken place along waterway/rail/road corridors connecting ports and the markets as well as in inland ports and inland logistics platforms.

However, not all EDC activities are drawn inland. Major seaports, such as Antwerp-Bruges, remain the prime location for large-scale distribution facilities for commodities such as oil products, cacao, coffee and tobacco (cf. impact of traders), for forest products and steel, for new and second-hand cars and for bulky goods linked to the local (chemical) industry. The Rhine-Scheldt Delta ports have actively stimulated logistics polarization in their port areas by enhancing more flexible labor conditions, smooth customs formalities, and powerful information systems. Service providers at the ports provide value-added activities for all types of goods, tailored to the customer. In addition to unloading and loading goods, many port companies offer other services including freight forwarding, customs administration, transport, etc. Logistics activities can take place at the terminal, in a logistics park where several logistics activities are concentrated, or, in the case of industrial subcontracting, on the site of an industrial company. While there is a clear tendency in the container sector to move away from the terminal, an expansion of logistics on the terminals can be witnessed in other cargo categories. A non-exhaustive list of logistics activities that typically opt for a location in a port includes (Notteboom et al., 2022):

- Logistics activities involving large volumes of bulk cargoes, suitable for inland navigation and rail.
- Logistics activities directly related to companies that have a production site in the port area.
- Logistics activities related to cargo needing flexible storage to create a buffer (products subject to seasonality or irregular supply).
- Logistics activities with a high dependency on short sea shipping.

Moreover, ports are competitive areas for distribution centers in a multiple import structure and as consolidation centers for export cargo. Quite a few XXL warehouses can be found in the Delta ports. Some examples:

- The Dudok Group develops a new distribution center of 50,000 m^2 at Distripark Maasvlakte in Rotterdam. Other operators of large distribution facilities at Distripark Maasvlakte include Nippon Express, Kloosterboer and Broekman Logistics. Distripark Botlek is home to smaller warehousing facilities.
- Katoen Natie has developed a vast logistics platform on the left bank of the River Scheldt under the name Loghidden City, next to many other facilities they operate in Antwerp-Bruges, Amsterdam and North Sea Port. The Loghidden City logistics platform in Antwerp has a covered storage capacity of 1 million m^2 and a future expansion possibility of more than 200,000 m^2. The total workforce consists of more than 3,000 employees. Other companies operating large-scale covered distribution facilities for consumer products and/or commodities include Tabaknatie (tobacco), Molenbergnatie (mainly coffee, cocoa and agro-commodities), BNFW/Sea-Invest (fruit and food logistics), Zuidnatie (wide range of breakbulk, container and soft commodities), Euroports, Nova Natie (project cargo, machines, steel, wood and soft commodities), Wijngaardnatie (metals, project cargo, chemicals and food), etc.[3]. The port of Antwerp-Bruges offers more than 7 million m^2 of covered warehousing and distribution space.
- The existing warehouses in North Sea Port currently cover an area of 1 million m^2 with room available for various new projects and investments in storage and distribution. The warehousing and logistics activities include raw materials, consumer goods and semi-finished products. One of the latest realizations is the Ghent Logistic Campus of Heylen Warehouses with a covered warehousing space of 150,000 m^2. AGP eGlass, a producer of hightech glass for the automotive industry, will rent about 70.000 m^2 of the total surface.
- The port of Amsterdam is one of the leading ports in the handling of cocoa. Cargill and OLAM have developed large warehouses for the handling and storage of this commodity. Other logistics operators in the port area include Neele-Vat, Steinweg, DSV, etc.

[3] The notion of 'natie' or guild goes back many centuries and is unique to the cargo handling and warehousing business in the port of Antwerp. A ship was discharged in the harbor by captain and crew, assisted by locally recruited stevedores. Once the crane brought the goods on quay, they were received and stored by the guild. The guild worked on commission for the buyer of the goods. Only few of the companies with 'natie' in their name are still organized as true guilds. Also, over the years they have integrated stevedoring in their portfolio of activities.

The decision to locate a distribution center inside the port implies advantages and disadvantages. According to Ferrari et al. (2006) and Monios et al. (2016), the most cited advantages can be summarized as follows:

- Good integration and cooperation between terminal operations and distribution center activities;
- Possibility to re-export from the port to other markets;
- Reduce traffic congestion and pollution for local inhabitants when operating distribution activities inside the port area.

Still, the development of distribution centers and XXL warehouses in port areas often comes with some specific points of attention:

- These facilities require large plots of land on prime port sites with excellent connectivity to the large container terminals and the hinterland. However, many RSD ports are facing land availability challenges while at the same time they need land for realizing projects in the field of energy transition and the circular economy. This combination can render it more difficult to meet the high demand for warehousing and distribution sites in the port, thereby pushing some of these activities to inland locations.
- Some investors might be somewhat discouraged by the land management regime in port areas. Port real estate tends to be priced differently. Very often, the logistics service provider cannot buy the land as most ports are landlords whereby the port authority gives the port site as a concession to the private port or warehouse operator for a specific term.
- Manufacturers might have less flexibility because of the constraint to call the port where the distribution center is located, giving fewer routing options. A distribution center located at an intermediate location along a hinterland corridor typically has more options and benefits more from inter-port competition.
- In a few cases, logistics service providers might decide not to locate a distribution center in a port partly because of the complexity and/or cost of the dock labor system. This can involve a lack of experience with the existing social dialog patterns in that port, such as labor unions.
- In some cases, the port is located far away from the final destination of goods and thus offers a locational disadvantage.

5.3.5. Dynamics in liquid bulk distribution and storage

Thousands of terminal operators are active in the global commercial tank storage industry. The biggest players are found in China with Sinopec (tank storage capacity of 44.1 million m^3 spread over 51 terminals), CNPC (25.7 million m^3 and 24 terminals) and PetroChina (19.8 million m^3, 34 terminals); the US with Kinder Morgan (21.7 million m^3, 96 terminals), Buckeye (18.1 million m^3, 114 terminals), Marathon (16.7 million m^3, 99 terminals), Enterprise (13.2 million m^3, 55 terminals) and Magellan (13.1 million m^3, 93 terminals); and in Europe with Vopak (33.1 million m^3, 69 terminals) and Oiltanking (17.6 million m^3 and 73 terminals)[4]. Vopak has locations in more than 20 countries with the largest concentration of terminals in the Netherlands. With a combined total capacity of 223 million m^3, the top 10 players cover around 21% of the total capacity globally. However, there is enough room for other tank terminal players to operate a sustainable business in specific regions, countries or ports. Europe is one of the regions with the largest concentration of terminals, i.e. 1,125 terminals. Figure

[4] Data 2019 based on Insight Global (data TankTerminals.com)

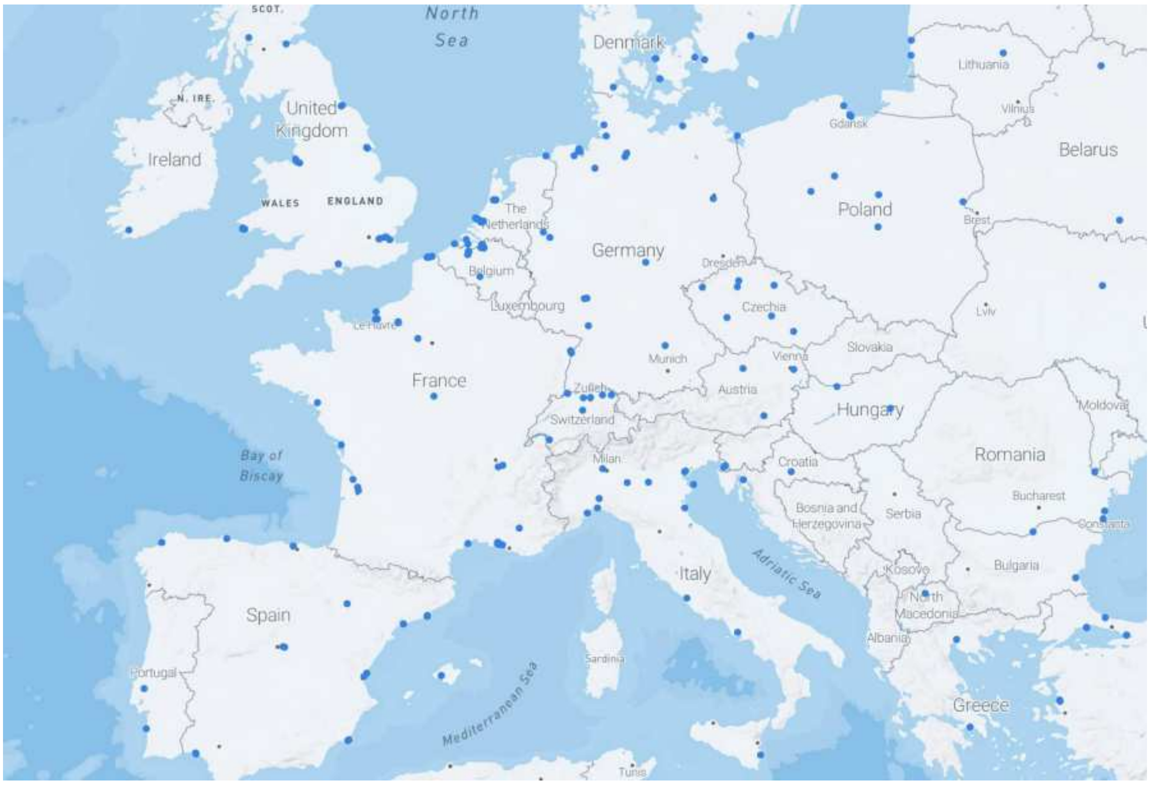
5.17 provides an overview of the distribution of the largest terminal facilities with a capacity of more than 250,000 m^3.

The Rhine-Scheldt Delta ports are home to a large number of tank terminals. The largest facilities per port are listed in Table 5.5. These large terminals combined offer a tank storage capacity of 41.5 million m^3 or an estimated 4% of the world total. Tank terminals typically support a combination of functions with each function having its own commercial specifics (Insights Global, 2020):

- *Logistical and hub functions* (make/break bulk, distribution and intermodality, integration with industrial complex in the port area, buffer stock);
- *Trading platform* (physical arbitrage, blending, contango storage, optionality). Inventories are needed at various locations in the supply chain to balance variations in supply and demand. At times of oversupply, tank terminal capacity is needed to store the excess product and to stimulate players to hold on to such inventories. Such periods of oversupply and contango (i.e. when futures price of a commodity is higher than the spot price) can last several years, therefore requiring a considerable amount of spare tank capacity.
- *Strategic storage:* Strategic storage requirements are dependent on oil product and chemical consumption levels. If consumption in a certain region is declining, less inventory is needed to balance variations in supply and demand and less is needed for security of supply reasons.

The specializations of the terminals in the Rhine-Scheldt Delta greatly differ. Some terminals are focused on only one type of product (for example LNG or crude oil) while other terminal operators offer tank storage services to a wide range of petroleum products, chemicals, vegetable oils and biofuels.

Figure 5.17. Tank terminals in Europe with a capacity of more than 250,000 m^3



Source: based on database Tankterminals.com

Table 5.5. Tank terminals in the Rhine-Scheldt Delta with a capacity of more than 250,000 m^3

Tank terminal	City/port	No. of tanks	Total capacity (in m3)	Berths	LNG	LPG / NGL	Crude oil	Chemical	Biofuel	Vegetable oil	Petroleum products	Other
ROTTERDAM												
Euro Tank Terminal (ETT)	Europoort (Rotterdam)	42	1,389,000	13				x	x		x	x
Evos Rotterdam	Europoort (Rotterdam)	20	256,500	4				x	x			
Gate Terminal	Maasvlakte (Rotterdam)	3	540,000	3	x							
HES Botlek Tank Terminal (HBTT)	Botlek (Rotterdam)	56	510,000	6				x	x	x	x	
Koole Tankstorage Minerals	Pernis (Rotterdam)	103	1,100,000	19				x	x	x	x	x
Koole Tankstorage Pernis	Botlek (Rotterdam)	340	675,000	10					x	x		
Koole Terminal Botlek	Botlek (Rotterdam)	270	1,622,000	14			x	x	x	x	x	x
Maasvlakte Oil Terminal (MOT)	Maasvlakte (Rotterdam)	39	4,500,000	2			x					
MET	Europoort (Rotterdam)	21	1,600,000	3			x					
Rubis Terminal	Botlek (Rotterdam)	59	252,710	5				x	x			
Shell Europoort Terminal	Europoort (Rotterdam)	43	2,150,000	5			x		x		x	
Stargate Oil Terminal	Europoort (Rotterdam)	83	1,288,000	8		x	x		x		x	
TEAM Terminal	Europoort (Rotterdam)	33	2,754,900	3			x					
Vopak Terminal Botlek	Botlek (Rotterdam)	196	900,264	17				x	x	x	x	
Vopak Terminal Europoort	Europoort (Rotterdam)	99	3,926,249	21			x				x	
Vopak Terminal Laurenshaven	Botlek (Rotterdam)	15	923,818	3							x	
Vopak Terminal TTR	Botlek (Rotterdam)	89	326,066	4				x	x			x
Vopak Terminal Vlaardingen	Vlaardingen (Rotterdam)	293	554,396	10				x	x	x		x
ANTWERP-BRUGES												
ADPO Group	Kallo (Antwerp)	266	400,000	6				x				x
Antwerp Terminal and Processing Company (ATPC)	Antwerp	116	965,000	9		x	x	x			x	
Gunvor Petroleum Antwerp	Antwerp	74	982,000	7		x		x	x		x	
LBC Antwerp	Antwerp	170	275,000	8				x	x	x	x	x
Noord Natie Terminals	Antwerp	254	430,400	13				x	x	x		x
Oiltanking Antwerp Gas Terminal	Beveren (Antwerp)	15	288,531	7		x						
Oiltanking Stolthaven	Antwerp	192	1,330,600	19		x		x			x	x
Sea-Tank Antwerp	Antwerp	42	1,029,873	20					x		x	x
Vesta Terminal Antwerp	Antwerp	40	785,000	6		x		x	x		x	
Vopak Terminal Eurotank	Antwerp	173	280,650	5				x			x	
Fluxys Belgium	Zeebrugge	9	566,000	2	x							
AMSTERDAM												
Eurotank Amsterdam (ETA)	Amsterdam	173	1,262,000	11				x	x		x	
Evos Amsterdam East	Amsterdam	86	1,614,545	18					x		x	x
Evos Amsterdam West	Amsterdam	41	1,216,180	13							x	
Exolum Amsterdam	Amsterdam	45	613,861	6					x		x	
GPS Amsterdam	Amsterdam	17	282,500	3					x		x	x
Zenith Energy Amsterdam	Amsterdam	75	1,100,228	11		x			x		x	
NORTH SEA PORT												
Evos Ghent	Ghent (North Sea Port)	68	1,007,237	6				x	x	x	x	x
Evos Terneuzen	Hoek (North Sea Port)	40	511,187	6				x	x		x	x
GTS Kluizendok Tankterminal	Ghent (North Sea Port)	12	405,000	12					x		x	x
Max Terminals	Ghent (North Sea Port)	6	300,000	12					x		x	
Sea-Tank Terminal	Ghent (North Sea Port)	176	320,000	5				x	x	x		x
Vesta Terminal Flushing	Ritthem (North Sea Port)	9	288,000	1					x		x	
Total			**41,522,695**									

Source: own compilation based on database Tankterminals.com (status September 2022)

Figure 5.18. The gas infrastructure map for northern Europe

Source: excerpt from the Gas Infrastructure Europe (GIE) LNG Map (April 2022)

5.3.6. Factors affecting the concentration/dispersion of liquid bulk storage facilities

Several factors and developments will have an impact on the future spatial concentration patterns in tank terminal facilities.

Diversity in product markets: Each of these product markets has its own dynamics, also in terms of the concentration of cargo flows. For example, LNG handling and storage is spatially highly concentrated in Europe (see Figure 5.18 for an overview of northern Europe), while there are 1,270 terminals handling petroleum products in Europe[5]. Each product market is very dependent on the future volatility in market circumstances. Trade flows in a specific liquid bulk product depend on global and regional demand including regional imbalances, and the production capacity situation in the market. Market dynamics are also very much influenced by commodity prices, the capacity of the vessel fleet (crude carriers, parcel tankers, chemical tankers and gas carriers) per vessel size class, the changes in product grades and regional inventory levels. A terminal that functions excellent in certain high value segments can ask premium storage rates and will find enough demand to rent out its tank capacity. However, an abrupt change in the market situation alters clients' requirements and shift profit potential. Given the existing diversity and volatility in the wide range of liquid bulk product markets, it is not possible to draft a general future direction for tank terminals.

[5] According the Tankterminals.com database there are 70 LNG terminals in Europe (both seaports and inland locations). For other liquid bulk this figure amounts to 160 terminals handling crude oil, 330 terminals for chemicals, 399 for biofuels, 161 for vegetable oils and 1,270 terminals handling petroleum products.

The **location choice of large tank terminals** is very much driven by the proximity to suppliers and consumers of products, the availability of large-sale transport solutions to the hinterland (pipeline network, rail and inland shipping) and the access to deep water port infrastructure for receiving tankers. In particular, large petrochemical and chemical ecosystems in port areas help to bind tank storage facilities. A high maritime connectivity supports hub-and-spoke systems in liquid bulk distribution. The RSD ports score very high on all the above location factors.

The commodity trade landscape has changed extensively over the past decades. After WW2 large trading companies, which used to dominate primary commodity trade throughout the 20th century, have undergone vast structural changes. They have dropped in numbers and are not nearly as huge as they used to be. Also the size of the assets and diversified sales of the more hardened survivors have increased prodigiously. At the same time a parallel shift was the mutation of largely single-line commodity traders into multi-commodity traders spanning the entire spectrum of commodities that enter world trade. Today growing global profit pools, rising profiles of industry leaders and lower entry barriers have attracted a large number of players to the commodity trading market. The traditional picture of the landscape with a small number of professional traders and the abundance of customers is under pressure with an increased number of actors acquiring trading skills. Quite a few traders have vertically integrated their activities and became asset-based, even controlling key storage facilities and assets (for example Glencore or Trafigura). At the same time, producers are setting up their own trading units while many financial institutions are into the physical commodity trading today. The volatility in the commodity trade is affecting ports as they are key buffers in commodity supply chains and places where speculative stocks are held. Market uncertainty or low commodity prices can lead to high inventories in centralized locations such as seaports, and generally increase the spatial concentration of flows in a limited number of terminal facilities. As such, the (speculative) decisions of traders increasingly affect the cargo handling, storage and distribution function of seaports, and favor the use of large terminal facilities in diversified port clusters such as the Rhine-Scheldt Delta.

The **energy transition** will boost the need for large-scale tank storage facilities in ports specialized in biofuels, liquid ammonia (so-called ‘liquid organic hydrogen carriers’ in general) and methanol (see proposition 5.1 for a detailed discussion on hydrogen).

The **war in Ukraine** has resulted in a stronger focus on gas imports by ship and non-Russian piped gas. LNG import facilities in ports play a key role in securing gas supplies for Europe. For example, Fluxys in Zeebrugge is experiencing its busiest year ever. In July 2022, the terminal sent a record amount of 12.4 TWh on the grid. The number of ship operations (loading, unloading and transshipment) at the Fluxys LNG terminal in Zeebrugge amounted to 183 in the first seven months of 2022 or already above the record number of 181 in 2021. In June 2022 alone 40 ships were handled at the terminal facility.

5.3.7. Structured summary on proposition 2.3

Proposition 2.3. "Centralized European distribution with XXL warehouses and liquid bulk storage hubs is the dominant model for the future favoring the competitive position of the Rhine-Scheldt Delta ports"

Overall evaluation: Accept

Arguments & observations in support of the proposition	Arguments & observations going against the proposition
1. The growth of XXL warehouses is driven by e-commerce and the remodeling of logistics networks, such as a growth in the number of product lines and order complexity, customer demand for quicker delivery times, and the need for flexibility to cope with demand volatility. 2. The rise of EDCs and XXL warehouses is particularly visible along waterway/rail/road corridors connecting the RSD ports and the European markets as well as in inland ports and inland logistics platforms. 3. The main RSD seaports remain prime locations for large-scale distribution facilities for commodities, for forest products and steel, for new and second-hand cars and for bulky goods linked to the local (chemical) industry. 4. The RSD ports combined represent one of the largest concentrations of tank terminals in the world. The large terminals combined offer a tank storage capacity of 41.5 million m^3 or an estimated 4% of the world total. 5. The RSD ports are good locations for large tank terminals given the proximity to suppliers and consumers of products, the availability of large-sale transport solutions to the hinterland, the access to deep sea port infrastructure and a high maritime connectivity supports hub-and-spoke systems in liquid bulk distribution. 6. Market uncertainty can lead to high inventories in centralized locations such as seaports, and generally favor the use of large terminal facilities in diversified port clusters such as the Rhine-Scheldt Delta. 7. The energy transition will boost the need for large-scale tank storage facilities in ports specialized in biofuels, liquid ammonia (so-called 'liquid organic hydrogen carriers' in general) and methanol.	1. Despite the growth of XXL warehouses, the market has not moved towards omnichannel warehouses in which all activities take place under one roof. 2. The emergence of new logistics corridors implies that the center of gravity in European distribution is expected to slowly shift east to southeast due to the rise of Central and Eastern Europe, implying Belgium and the Netherlands will face increasing competition in attracting EDCs. 3. Attracting EDCs and XXL warehouses to ports is challenging due to land availability issues, existing land management regimes in port areas and, in a few cases, the complexity and/or cost of the dock labor system. 4. The tank terminal market shows a large diversity. Each of the product markets has its own dynamics, also in terms of the concentration of cargo flows.

6. Theme 3: Ports and the organization of (maritime) supply chains

6.1. Proposition 3.1

Proposition 3.1. Vertical integration in (maritime) supply chains will increase further, resulting in increased competition for the orchestration of these chains.

6.1.1. Logistic integration as a general trend

The logistics industry is subject to integration forms, aiming to improve its scale, scope, and market reach. Functional integration involves horizontal consolidation and vertical integration strategies. Vertical integration is commonly understood as a single organization who owns and controls one or more links in their supply chain. A distinction can be made between partial or full (i.e., the entire supply chain is fully managed by one company) vertical ownership integration. Partial integration can be subdivided into tapered integration (i.e., a portion of the supply chain is managed by the company, the other portion is outsourced), quasi-integration (i.e., the company does not own 100% of the integrated business units – e.g. franchises, joint venture), and contracts (i.e., no internal integration, but contract concerning responsibilities). Vertical integration creates a logistics market consisting of a wide variety of service providers ranging from megacarriers to local niche operators. Not only does the geographic coverage of the players differ (from global to local), but major differences can also be observed in focus (generalist versus specialist), the service offering (from single service to one-stop-shop), and asset-orientation (asset-based versus non-asset-based).

Globalization and outsourcing open new windows of opportunities for shipping lines, forwarders, terminal operators and logistics operators. Manufacturers are looking for global logistics packages rather than just basic shipping or forwarding. Global logistics is the name of the game. Most actors in the supply chains have responded by providing new value-added services in an integrated package, through a vertical integration along the supply chain. Competition between logistics service providers is no longer focused only on services to the cargo flows: advanced services in the management of information flows are increasingly key to gaining a competitive advantage in the market. These advanced services are more and more aimed at offering total pipeline/supply chain visibility to customers in terms of reliability performance through advanced tracking and tracing, environmental impact measurement (e.g. carbon footprint calculator), security risks and related event management.

Many market players have also come to understand that landside operations are key to a successful integration along the supply chain. As a result, competition between ports and across the logistics sector looks set to intensify. As ports and logistics firms battle to protect and gain market share, the race to find cost savings and efficiency gains will become even more pronounced.

6.1.2. Logistics integration strategies in the pre-COVID-19 era

In the ten pre-COVID-19 years following the 2008-2009 financial crisis, a lot of companies reconsidered their integration strategies and tended to focus more on their core activities. For example, the low or even negative operating margins in liner shipping forced many carriers to divest in other than maritime activities in order to generate liquidity for carrier survival.

Still, a number of carriers tried to develop logistics integration strategies. For example, in September 2016, A.P. Møller-Mærsk announced a major restructuring initiative that marked the start of a transition from a diversified conglomerate in shipping and energy to a global logistics integrator focusing exclusively on its container line, terminals and forwarding businesses. With this strategy, the company wants to focus on new product offerings, digitalized services and individualized customer solutions. Maersk's strategy resides on three pillars: (1) End-to-end digitally enabled transport and logistics services by integrating land-based logistics and ocean business; (2) Financial and operational synergies between the ocean business and terminals business for lower cost, productivity and asset utilization; (3) Build competitive advantage through technology and new digital platforms, which enable integrated offerings, standardization and automation. The ultimate goal is to enable and facilitate global supply chains through a lean transparent global conglomerate with each business unit operating on arm's-length principles. This clearly points to a stronger focus on logistics integration by better combining and coordinating the activities of its various sister companies.

Another development pre-corona was that a number of larger shipping lines such as Maersk Line and MSC were developing hub-concepts in the hinterland of the key ports in their networks. Inland terminals and rail and barge services are combined to push import containers from the ocean terminal to an inland location, from where final delivery to the receiver will be initiated at a later stage. Export containers are pushed from an inland location to the ocean terminal, initiated by the shipping line, yet prioritized based on available inland transport capacity and the estimated time of arrival (ETA) of the mother vessel.

A number of global container shipping lines are thus keen on developing carrier haulage volumes. The deployment of larger vessels, the formation of strategic alliances (see later in this report) and the waves of M&A have resulted in lower costs at sea, shifting the cost burden of shipping lines to the landside. Therefore, a number of shipping lines extend their scope beyond terminal operations to include inland transport and logistics. In order to streamline the inland distribution system, shipping lines and alliances between them seek to increase the percentage of carrier haulage on the European continent. Contrary to the Rotterdam-Antwerp inter-port market where barge container transport is 'dominated' by the deep sea shipping lines in the framework of second moves, the inland market is still dominated by large shippers (merchant haulage). The 2008-2009 financial crisis initially made merchant haulage even stronger as some shipping lines and terminal operators reduced their commitments in inland transport by focusing more on their core activity (i.e. maritime transport when considering shipping lines). Some terminal operators in Europe also increased their influence throughout supply chains by engaging into inland transport. They seem to do so mainly by incorporating inland terminals as 'extended gates' to seaport terminals and by introducing an integrated terminal operator haulage concept for the customers.

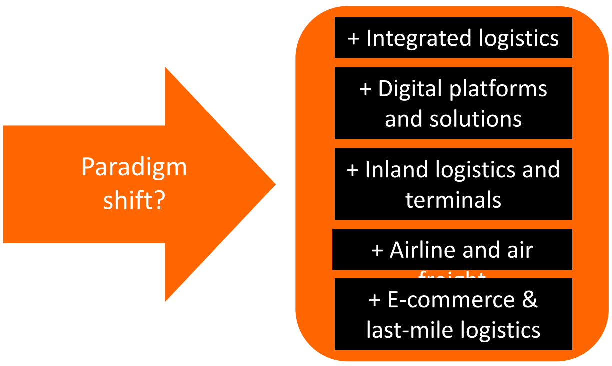
6.1.3. Logistics integration strategies since 2020

COVID-19 has accelerated the logistics integration strategies of some major container carriers. High freight rates have resulted in a record profitability in container shipping and deep pockets of carriers. The average operating margins in container shipping sharply increased from 2.6% in Q1 2020 to more than 55% in the second half of 2021 and in Q1 2022. In comparison, these margins fluctuated between +5% and -11% in the period 2011-2019 (figures Alphaliner). Helped by historically high operating margins, a number of carriers, such as Maersk Line, CMA CGM or MSC, have embarked on a take-over spree in the air freight business, e-commerce and last-mile logistics, digital platforms and forwarding activities (Figures 6.1 and 6.2). Examples include the take-over by Maersk of Senator International (air freight forwarding) and e-commerce firms HUUB (fashion industry), B2C Europe Holding, Visible SCM (US) and Pilot Freight Services; or the take-over by CMA-CGM of Ingram Micro's Commerce & Lifecycle Services (CLS) in November 2021 to boost its e-commerce expertise and the preliminary agreement to acquire a 51% stake in the Colis Privé Group (e-commerce services & last-mile logistics, February 2022). However, not all carriers are walking the path of logistics integration. For example, there is currently no indication from ONE, Evergreen or Hapag-Lloyd of a large investment ramp-up in logistics companies. Hapag-Lloyd, Evergreen, and ONE have not followed competitors' strategic forays into logistics, container terminals, or air freight business (Shipping Watch, 2021). This can be partly explained by the presence of a logistics company in the shareholding of these carriers (e.g., the Kühne family as one of the main shareholders of Hapag-Lloyd while also being active in global 3PL company Kühne & Nagel) or by the fact that these carriers belong to larger conglomerates somewhat already active in the logistics sector (e.g. the Japanese NYK group as active shareholder of carrier ONE while also having its own logistics division Yusen Logistics).

Figure 6.1. Logistics integration by container shipping lines

- Past: Waves in logistics integration (invest vs. divest) but with continued interest in terminals
- Present: COVID-19 and deep pockets support transition from carrier to logistics integrator, although large differences among carriers remain

Company	Shipping activity	Terminal activity
AP Moller	Maersk Line	APM Terminals
China Cosco Group	COSCO and OOCL	COSCO Shipping Ports
NYK Group	Ocean Network Express-ONE (together with MOL and K-Line)	
MSC	MSC	Terminal Investment Limited (TiL) (*)
CMA CGM	CMA CGM	Terminal Link (51%) en CMA Terminals (100%) (**)



(*) Fully owned by MSC till 2013, stake brought to 60% in May 2019. Other shareholders are Global Infrastructure Partners (GIP) and GIC Private Limited, a Singaporean Sovereign Wealth Fund; (**) Terminals controlled by CMA Terminals were transferred to Terminal Link in late 2019

Source: own compilation

Figure 6.2. Recent logistics integration moves by CMA-CGM, Maersk and MSC

MAERSK

Transformation from a diversified conglomerate to a focused and integrated global logistics company

- Jan 2021: Damco's Air and LCL integrated into the Maersk brand.
- Investments in e-commerce business, e.g. HUUB (fashion industry); B2C Europe Holding (NL); Visible SCM (US); Pilot Freight Services (US, Feb 2022)
- Nov 2021: take-over Senator International (air freight forwarding) + new plane orders
- Digital platforms such as Tradelens (with IBM), Traxens, supply chain platform NeoNav (cf. Unilever deal), etc..
- Planned investments in storage facilities

MSC

Moving beyond ad hoc opportunity grasping?

- Logistics company Medlog including subsidiaries such as intermodal operator Medway
- 2019: Increase in shareholding of TiL
- Dec 2021: USD 6.43 billion offer for take-over of Bolloré Africa Logistics (20,800 employees + 16 container terminal concessions, including in Ivory Coast, Ghana, Nigeria and Gabon + three rail concessions in the region).
- Jan 2022: take-over of Brazilian company Log-In Logistica
- Jan 2022: MSC and Lufthansa joint bid to take a controlling stake in ITA Airways (successor of Alitalia). Sept 2022: bid unsuccessful.
- Sept 2022: announcement of start MSC Air Cargo in early 2023

CMA CGM

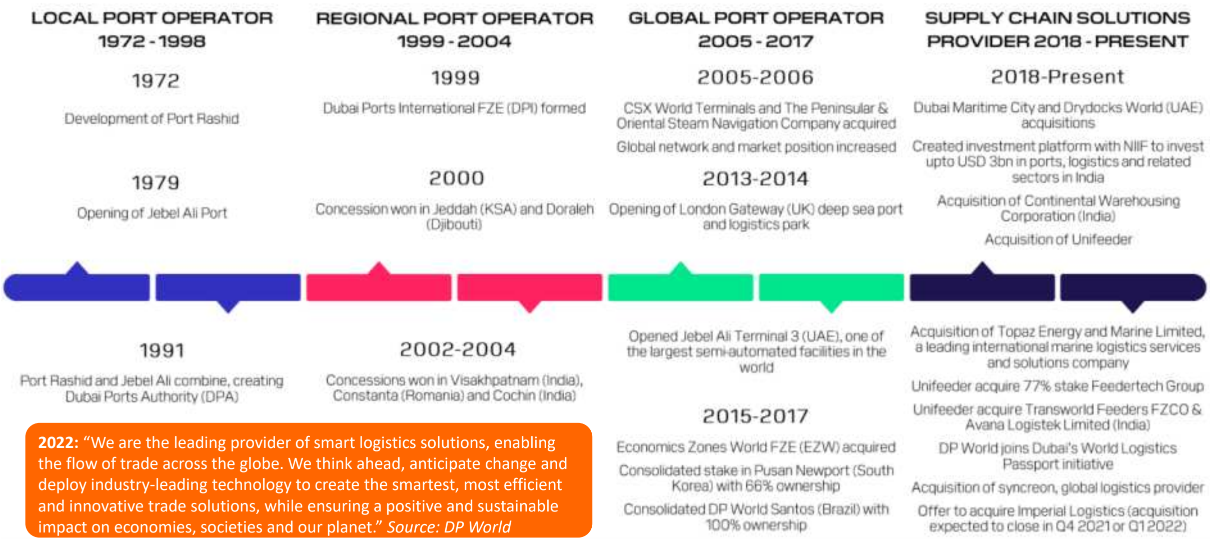
The CEVA Logistics game changer

- CMA CGM intermodal services (CC Log through partners)
- Early 2019: controlling stake in CEVA Logistics; March 2019: Share in CEVA Logistics from 50.6% to 89%
- CMA CGM reduced terminal assets to support Ceva Logistics acquisition (CMA Terminals => Terminal Link)
- Sept 2020: 30% stake in French airline company Groupe Dubreuil Aero
- Nov 2021: Order of 4 air freighters for CMA CGM Air Cargo
- Dec 2021: Majority stake in Ingram Micro's Commerce & Lifecycle Services (CLS) of US to boost e-commerce expertise
- Feb 2022: preliminary agreement to acquire a 51% stake in the Colis Privé Group (e-commerce services & last-mile logistics)

Source: own compilation

This apparent expansion of a number of carriers' business activities from the ocean liner market to global logistics services, supported by an increased focus on digital transformation, adds to an emerging new market environment in which also large retailers, e-commerce firms (Amazon, Alibaba) and even terminal operators (e.g. the take-over of Syncreon and Imperial Logistics by DP World or the take-over of BDP International by PSA) are eyeing a much great involvement in global supply chain management. For example, Figure 6.3 illustrates the transformation of DP World from a local port operator to a supply chain solutions provider. Note that DP World's mission statement does not even refer to the terminal operating business.

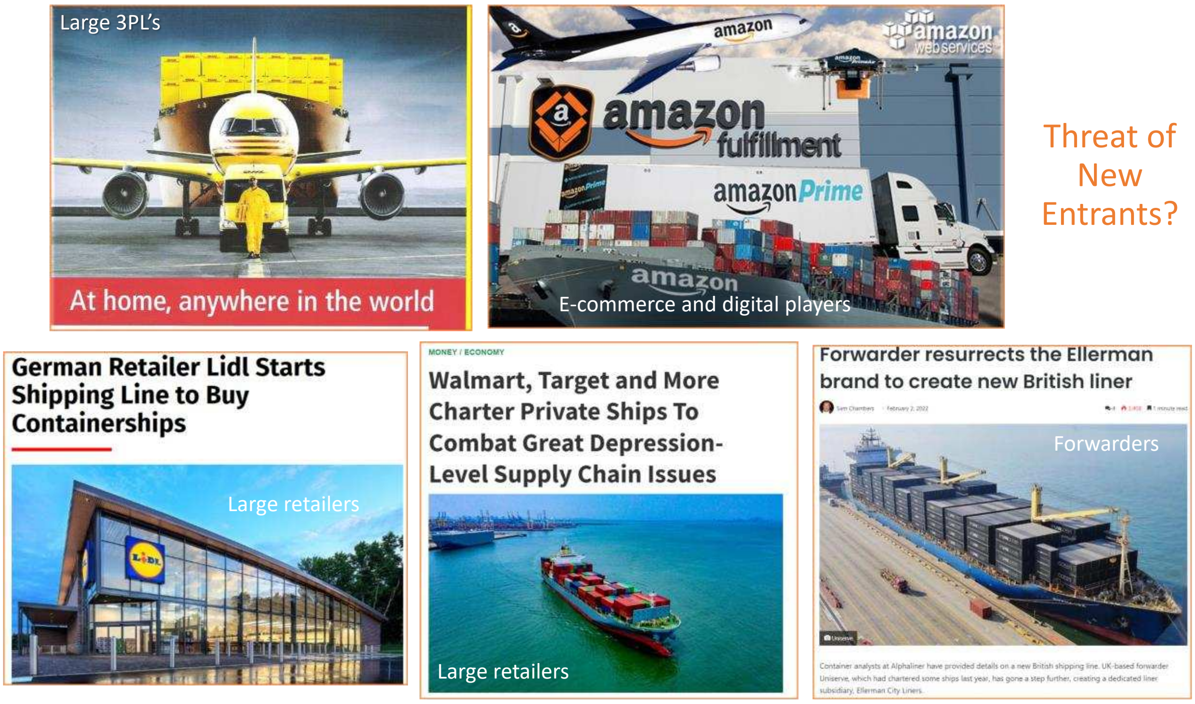
Figure 6.3. The transformation of DP World from local port operator to a supply chain solutions provider



2022: "We are the leading provider of smart logistics solutions, enabling the flow of trade across the globe. We think ahead, anticipate change and deploy industry-leading technology to create the smartest, most efficient and innovative trade solutions, while ensuring a positive and sustainable impact on economies, societies and our planet." *Source: DP World*

Source: DP World Investor Presentation, March 2022, page 6

Figure 6.4. New entrants in container shipping?



Source: own compilation based on selected news coverage in online specialized magazines.

The level of consolidation in liner shipping (i.e. the top 10 shipping lines control 91.5% of the total fleet capacity and all belong to an alliance) combined with very high freight rates in the period late 2020 to 2022 give new entrants, such as large e-commerce players and logistics service providers, incentives to consider a direct involvement in container shipping. In other words, while some carriers are vertically integrating in view of offering global logistics solutions, other market players (might) enter the container shipping business although on a small and rather fragmented scale for now (Figure 6.4). For example, faced with the challenge of keeping stores stocked amid a global supply chain crisis, e-commerce giants such as Amazon as well as large retailers like Walmart and Costco went so far as to charter their own container ships, typically calling at smaller container ports.

Some shipping lines have used their financial position also to place massive vessel orders and expand their portfolios by acquiring regional niche carriers. The stronger financial position of carriers in principle should also support the green shipping agenda. Carriers are anticipating carbon taxation and new fuel types.

In summary, the level of functional integration is increasing rapidly although not all companies are adopting such a strategy. Many distribution functions which used to be separated are now controlled by a single entity or are coordinated between parties. Mergers and acquisitions have permitted the emergence of large logistics operators that control many segments of the supply chain and meet the requirements of many shippers to have a single contact point on a regional or even global level (the 'one-stop shop'). Technology is playing a particular role in this process namely in terms of IT (control of the process) and intermodal integration (control of the flows). As a result, competition between ports and across the logistics sector looks set to intensify. As ports and logistics firms battle to protect and gain market share, the race to find cost savings and efficiency gains, and to achieve sustainable and resilient supply chain solutions will become even more pronounced.

The vertical integration trend has several impacts on the Rhine-Scheldt Delta ports. It leads to larger port users with strong bargaining power throughout the supply chains. Different forms of co-makerships and partnerships with these market players are needed to address issues affecting the performance of the port-related chains in terms of efficiency, sustainability and resilience. It also implies that ports have to think along with the port users and have more than ever to go for a less port-centric supply chain focus while doing so. Logistics integration also comes with higher demands for digital transformation solutions that go beyond individual ports. Finally, the needs and challenges of companies that cannot or do not want to opt for logistics integration should not be ignored.

6.1.4. Drivers of logistics integration

Various drivers are pushing companies to opt for vertical integration in the supply chain:

- Vertical integration allows a company to **access more information and data** and better coordinate activities along the supply chain. Closer collaboration between the different stages of the supply chain can provide creative solutions to a variety of challenges, which will further improve efficiency;
- The acquisition of a particular upstream or downstream company is often accompanied by the acquisition of its **valuable know-how and information about customers** (in case of downstream integration). This expertise provides a deep understanding of what customers value, how to bring such value to the market, and how value can be created in the future.
- Vertical integration allows to meet major customers demand for **one-window integrated just-in-time and efficient all-inclusive door-to-door service** at a predetermined price;
- **Spillover effects** on efficiency can be achieved by allowing one division to benefit from the investments of the next division;
- Vertical integration may entail a **decrease in transaction costs**. These transaction costs typically include efforts to search for, negotiate, execute, adjust and monitor market contracts;
- The ocean business is characterized by an increasing level of 'commoditization' of container services leaving little room for differentiation between carriers when only focusing on liner services. Commoditization occurs as carriers offer increasingly homogenous liner shipping services to price-sensitive customers who incur relatively low costs in changing suppliers (Reimann et al, 2010; Maloni et al, 2016). Vertical integration provides shipping lines with a **path towards focused differentiation** combined with a high degree of specialization and increasing market power for the provision of certain services;
- Vertical integration can help to **create market entry barriers**. This may discourage others from entering the market. Establishing a competitive vertical integration requires significant sunk investments in assets and know how, superior technological innovation, economies of scale and strong customer relationship, which might not be readily available to most market entrants.

6.1.5. Limits to and market implications of logistics integration

Vertical integration comes with specific risks and limitations:

- The decision to vertically integrate rests on the **trade-off between cost and control**. Companies may lose cost efficiency by vertically integrating logistics activities, in exchange for an increase in control of the supply chain.
- A **lack of trust** among the integrated activities can lead to an increase in uncertainty, a decrease of commitment and cooperation among partners, and a reluctance to share information and

knowledge in a sensitive environment. Spatial dispersion and cultural differences can have a negative impact on mutual trust and commitment. Thus, vertical integration may end up **increasing the transaction costs** (such as screening and determining the cultural fit of both companies, post-acquisition efforts, combining the know-how into new business units, and so on), rather than decreasing them.

- Vertical integration **can turn out negative** when there is a lack of resources, and when management and the governance structure is not built for huge investments, or when they do not have the time and knowledge to do so.
- Logistics integration strategies can lead to a **cannibalization of part of the customer base**. Some carriers are entering in direct competition with freight forwarders, thereby compromising the close relationships with these ocean business clients. In this regard, recent years have brought an increasing number of incidents. For example, European freight forwarders association CLECAT reacted strongly to new tariff structures of Maersk Line/Hamburg Süd, claiming that these practices are sidelining freight forwarders and would make it very difficult to find space for their cargo unless forwarders venture into the less favorable spot market. They also complain about carriers approaching the very customers of the forwarders whose business they are rejecting (CLECAT press release, 16 December 2021). Vertical integration might also deteriorate the relationships with the different alliance members and investors.
- By entering into new business activities, a company will automatically **face new rivals** in the market who may have more (local) expertise than the vertically integrated company and offer more tailored services to the customer.
- Vertical integration requires significant sunk investments in assets, know-how and technological innovation. **The long-term return on investment** may pose a barrier to vertical integration.
- The **lack of proper information systems** can form a barrier to vertical integration. In order for a company to facilitate the coordination integration, a high degree of knowledge transfer between the different supply stages is required.
- Depending on the transaction scale and the impact on existing markets, take-overs or mergers in the context of vertical integration might face scrutiny by **regulatory (competition) authorities**. These entities might impose conditions on the approval of a merger or acquisition. This might prevent the vertically integrated company to reap the full anticipated benefits of the integration move.

6.1.6. Structured summary on proposition 3.1

Proposition 3.1. "Vertical integration in (maritime) supply chains will increase further, resulting in increased competition for the orchestration of these chains."

Overall evaluation: Accept

Arguments & observations in support of the proposition	Arguments & observations going against the proposition
1. Logistics integration is happening. Different types of (large) market players are moving in that direction. 2. The focus on the 'one-stop-shop' idea intensifies competition in the logistics market, and makes it more difficult to classify or tag companies as carrier, forwarder, retailer, etc. 3. There are strong market incentives and pressures to opt for logistics integration. 4. The emerging new market environment is enabled by an increased focus on digital transformation (software). It also comes with higher demands for digital transformation solutions that go beyond individual ports. 5. The vertical integration trend confronts RSD ports with large port users with strong bargaining power throughout the supply chains. Different forms of co-makerships and partnerships with these market players are needed to address issues affecting the performance of the port-related chains in terms of efficiency, sustainability and resilience.	1. High-profile logistics integration moves receive lots of media coverage, and somewhat hide that many companies are sticking to their core business. The needs and challenges of companies that cannot or do not want to opt for logistics integration should not be ignored. 2. Logistics integration does not eliminate the need for smaller and medium-sized specialized niche players 3. The recent moves towards logistics integration are visible, but it remains to be seen whether the outcomes will be favorable, also considering possible changes in the market environment (e.g. lower profitability) and the challenges brought by integrating acquired activities. Moves towards a certain level of disintegration cannot be excluded. 4. Regulatory authorities are expected to set boundaries when logistics integrators become dominant and (might) abuse their market power. 5. Logistics integration strategies can lead to a cannibalization of part of the customer base.

6.2. Proposition 3.2

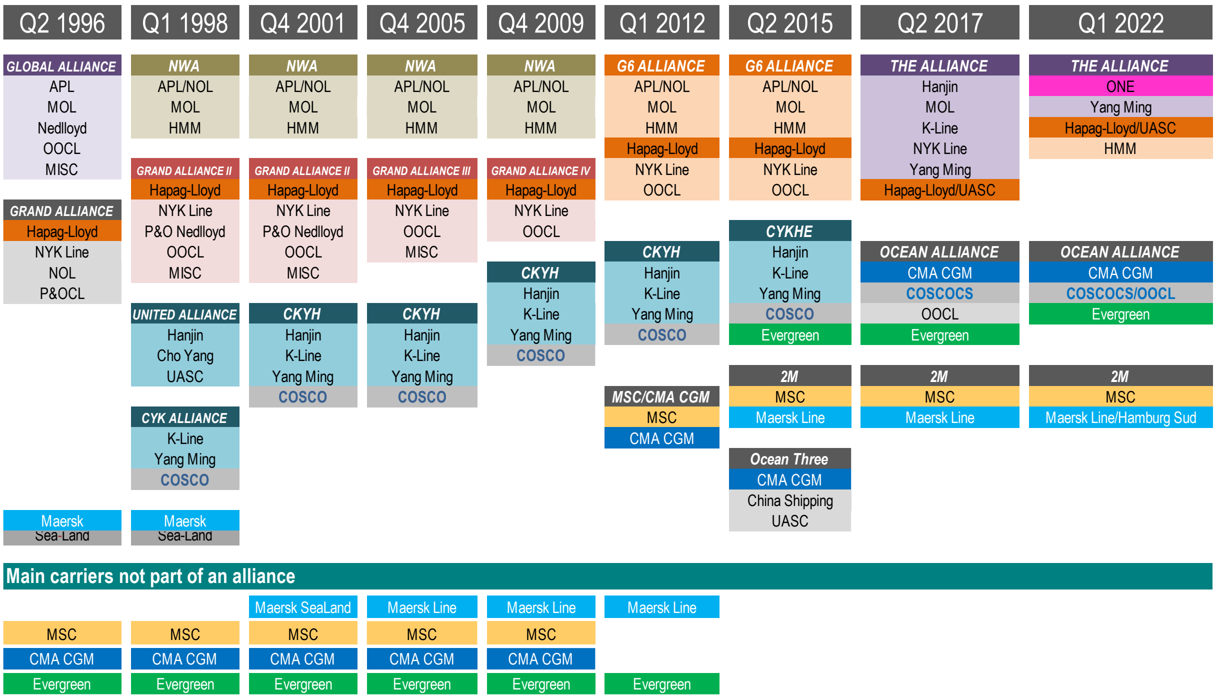
Proposition 3.2. The era of alliances between container shipping companies is gradually coming to an end.

6.2.1. The origins and history of alliances in liner shipping

A vessel sharing agreement (VSA) involves a limited number of shipping companies agreeing to operate a liner service along a specified route using a specified number of vessels. A vessel sharing agreement is usually dedicated to a particular trade route with terms and conditions specific to that route. In contrast, an alliance is a large-scale VSA involving joint fleet capacity management and liner service offerings on the main east-west trade routes. The members of an alliance are not allowed to jointly set freight rates. Alliances are about capacity management, not price-fixing.

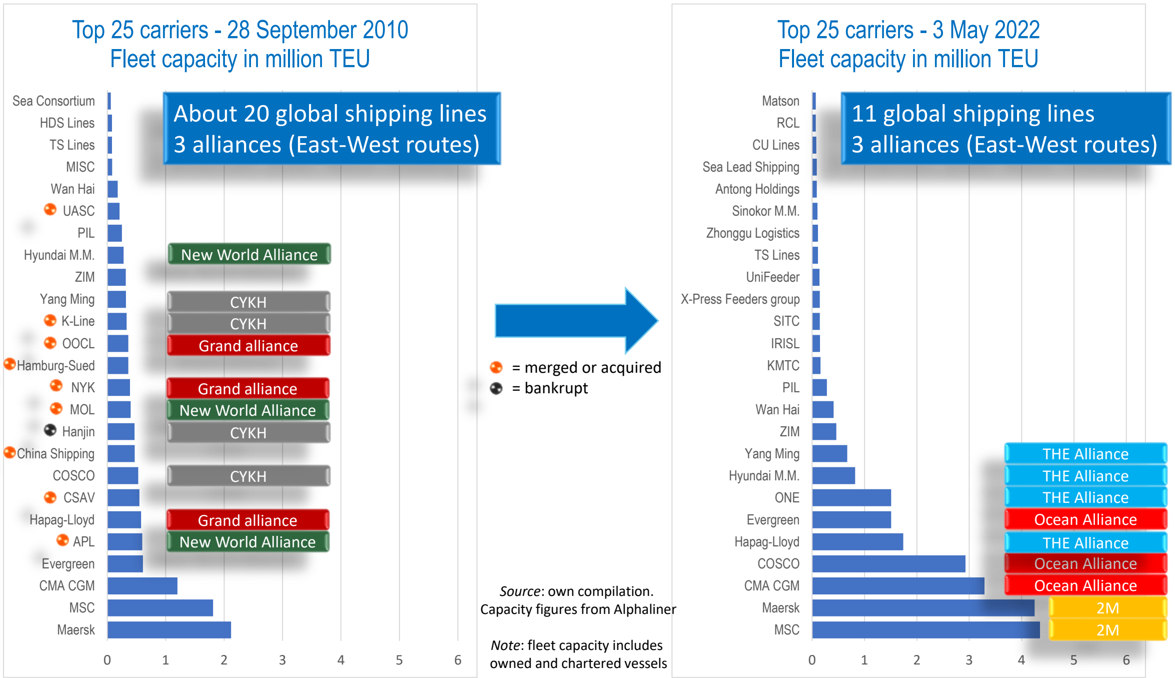
The first strategic alliances among shipping lines date back to the mid-1990s, which coincided with the introduction of the first vessels above 6,000 TEU on the Europe-Far East trade route (Figure 6.5). In 1997, about 70% of the services on the main East-West trades were supplied by the four main strategic alliances. As of 2020, three alliances are operational in the market: 2M, Ocean Alliance, and THE Alliance. This represented an evolution from just five years earlier when four alliances were still active: 2M, Ocean Three, CKYHE, and G6. Alliance partnerships evolved due to mergers and acquisitions (see Figure 6.6) and the market exit of liner shipping companies, such as the bankruptcy of South Korean carrier Hanjin in 2016.

Figure 6.5. Dynamics in alliances in container shipping



Source: updated from Notteboom et al. (2017)

Figure 6.6. The impact of the 2014-2017 M&A wave in container shipping on the top 25 carriers and the associated strategic alliances – a comparison between September 2010 and May 2022



Source: own compilation based on carrier fleet data of Alphaliner

Initially, many of the largest carriers did not opt for alliance membership. These firms reached a sufficient scale to benefit from the same economies of scale and scope that strategic alliances offer. Maersk Line, MSC, CMA CGM, and Evergreen, were notable examples. In comparison, the remaining two top-six carriers (i.e. COSCO and Hapag-Lloyd) have always opted for alliance membership despite the scale of their activities. Several shipping lines, such as Evergreen, initially did not participate in alliances due to commercial independence and flexibility. However, in more recent years, even the largest shipping companies have resorted to joining alliances as a competitive strategy and to increase margins. The case of Evergreen demonstrates that even outsiders have had to pursue alliance membership.

6.2.2. Evaluating the future of alliances

In order to evaluate whether alliances have a future, we first discuss the advantages and disadvantages of alliance membership from a carrier perspective. As summarized in Figure 6.7 (box at the top right), there are many incentives for alliance formation, such as achieving a critical mass in the scale of operation, exploring new markets, enhancing global reach, improving fleet deployment, and spreading risks associated with investments in large container vessels. Strategic alliances provide their members with easy access to more loops or services with relatively low-cost implications and allow them to share terminals to cooperate in many areas at sea and ashore, thereby achieving cost savings.

Despite these advantages of alliance membership, alliance members engage increasingly in vessel sharing agreements with outside carriers. As such, individual shipping lines show an increased level of pragmatism when setting up partnerships with other carriers on specific trade routes. The three alliances in existence (2M, THE Alliance, and Ocean Alliance) play a key role in capacity management on the main East-West routes. Still, their dominance on specific trade route is somewhat eroding. For example, Alphaliner calculated that the market share of the three alliances on the trans-Pacific trade declined from 82.2% in April 2021 to 67.7% in April 2022. Thus, the 9 members of the three alliances are not the only shipping lines providing container services between Asia and the US. Matson, ZIM, Wan Hai Lines, BAL Container Line, China United Lines, Jin Jiang Shipping, Sea Lead, SM Line, Swire, Transfar Shipping, Pasha and VASI Shipping are also active on this trade route.

There are also some drawbacks associated with alliance membership. Carriers lose some operational independence when joining an alliance, which can result in lengthy and difficult negotiations among members when designing joint liner services and selecting ports of call. Such discussions can become even more difficult when alliance members have invested in own container terminals or when they are rolling out far-reaching vertical integration strategies along supply chains. In these cases, the choices made within the alliance structure might not necessarily align with the strategic interests of the vertically-integrated carrier. As such, alliances imply a certain loss of strategic and operational independence.

Another observation is that alliances typically play a strong role in company survival during depressed market conditions. The scale and risk spreading offered by the alliance structure enables members to keep costs low. However, the added value of alliances might be less obvious during good times. As mentioned earlier, the average operating margins in container shipping sharply increased since the start of pandemic to more than 55% in the second half of 2021 and in H1 2022. High operating margins might reduce the urge to seek partnership with other carriers, as company survival is no longer at stake.

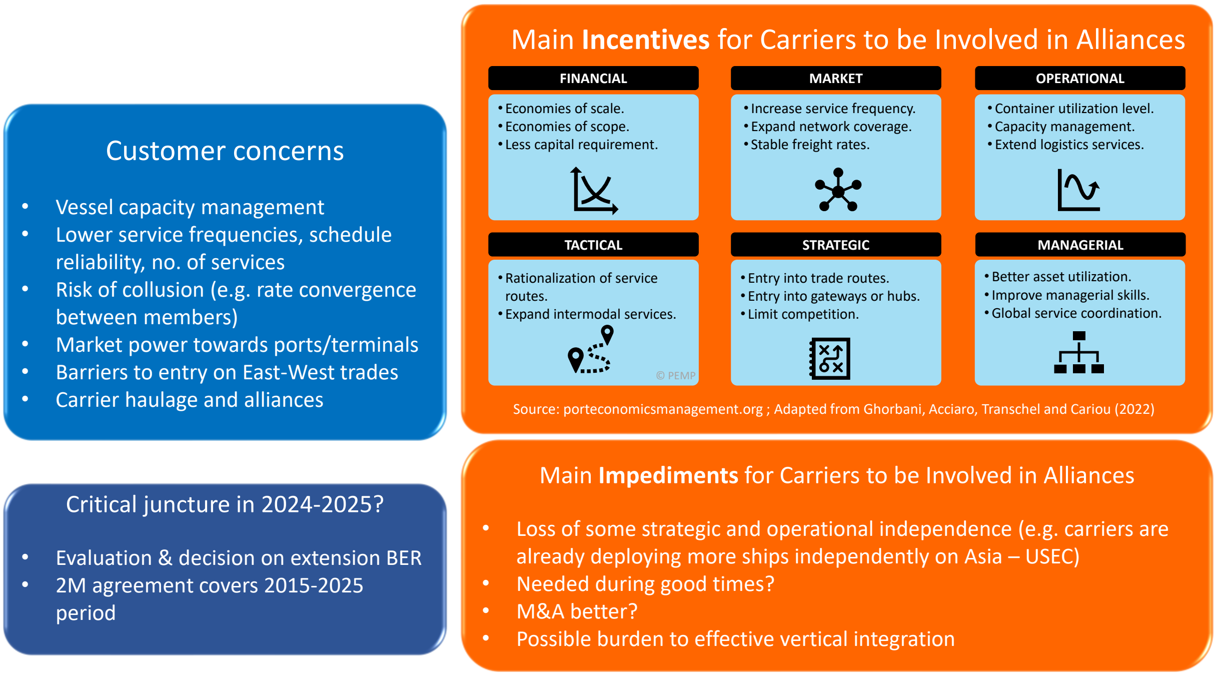
Alliances have been under increasing legal scrutiny. In 2009, the EU adopted a Consortia Block Exemption Regulation (BER, Commission Regulation (EC) No 906/2009), allowing shipping companies to operate joint liner shipping services. This regulation was prolonged in 2014 by five years and was due to expire on 25 April 2020. After a lengthy and heated public consultation launched in September 2018, the EU decided in late 2019 to prolong the regulation for another four years till 25 April 2024. For example, during the consultation period, a report of ITF-OECD (2018) openly attacked alliances by explicitly stating that:

- There is a link between alliances and overcapacity;
- Alliances have contributed to lower service frequencies, fewer direct port-to-port connections, declining schedule reliability and longer waiting times;
- Alliances contribute to concentration of port networks and bigger cargo shifts from one port to another;
- Alliances and alliance carriers frequently exert strong pressure for publicly funded infrastructure upgrades to be undertaken to support the use of megaships;
- Alliances represent barriers to entry on East-West trades and could function as vehicles for collusion between carriers;
- Alliances give very considerable bargaining power to carriers in regard to ports and terminals.

ITF-OECD therefore recommended the European Union to adopt a presumption toward repeal of shipping-specific block exemptions from competition law. They also argued that if the block exemption would be extended, its scope should be limited, in particular by introducing a provision to consult maritime transport stakeholders and by excluding joint purchasing by alliances.

During the BER consultation round, the defenders of alliances, such as the World Shipping Council, voiced concerns about the reliability of data used by analysts who are against alliances. They are not convinced that customer satisfaction will improve if alliances would disappear, stating that alliances have facilitated investments in bigger ships, allowing to drive costs and freight rates down. Furthermore, they argue that the decrease in connectivity (in terms of number of weekly services) on some trade lanes is the result of the need to deploy larger vessels, not because of the existence of alliances. There is no proven causal link between schedule reliability and alliance formation.

Figure 6.7. Factors affecting the future of alliances



Source: own compilation

The discussion on the future of alliances has intensified since late 2020 due to major changes in market conditions: COVID-19 and the supply chain crisis went hand in hand with capacity shortages and record profits for shipping lines. This has brought some consternation among the customer base, branch organization and public authorities. Still, at present, there are no signs that the EU would take action against alliances. However, late 2023 will form another critical juncture as the EU will then have to decide on whether or not the Consortia Block Exemption Regulation (BER) will be prolonged again and, if so, under which conditions alliances might operate from April 2024 onward. Note that around the same time, the 2M agreement between Maersk and MSC will expire prompting a discussion on a possible prolongation. This poses another critical moment for the future of alliances.

In a joint press release of 22 July 2022, ten trade organizations, representing the owners and forwarders of cargo, port terminal operators and other parts of the supply chain dependent on container shipping, urged the European Commission to start an immediate review of European Union's Consortia Block Exemption Regulation for the container shipping industry. They argue that the Regulation exempts container shipping lines from many of the checks and balances of EU competition law and permits them to exchange commercially-sensitive information to manage the number and size of ships deployed and the frequency and timing of sailings on trade routes around the world. They argue that the ability of the shipping industry to generate profits totaling USD 186 billion in 2021, at the expense of the rest of the supply chain, demonstrates that the benefits of the exemption are not being shared fairly between the lines and the rest of the economy. The Regulation's review will allow all interested parties to submit evidence and arguments as to how the Commission should act to ensure the deep-sea container shipping market operates in a way that is fair and transparent to all parties in the maritime supply chain.

The supply chain crisis in the US, which was particularly felt in the ports of Long Beach and Los Angeles, incited US President Biden to take aim at the shipping's exemption from competition law during his State of the Union in early March 2022. He announced his administration will target regulations that allow carriers to collaborate on vessel sharing and other elements in the supply chain (Savvides, 2022). However, the strong stance of President Biden against carriers and alliances is completely at odds with the results of an investigation by the Federal Maritime Commission (FMC). After two years of thorough market research, FMC determined that there is a lot of competition on the trans-Pacific and that the rates have only exploded because there was more cargo than ship capacity. Furthermore, the Chair of the FMC has made several statements in favor of alliances: "I would not undo alliances: that would lead to more consolidation" and "Alliances are the worst things you can imagine, except all the alternatives" (Savvides, 2022). The idea that alternative arrangements might be worse than alliances, is a much-stated notion in regulatory circles. In May 2022, a new Ocean Shipping Reform Act was passed addressing many of the grievances of users and services suppliers to the container shipping lines.

In a recent communication, the global forwarders' association FIATA calls for a rethinking of regulatory antitrust exemptions and vessel sharing agreements in support of shipping lines to ensure they remain fit for their intended purpose. FIATA considers that a more appropriate regulatory response would be to grant permissions to shipping lines, rather than exemptions, to deviate from antitrust law in certain prescribed situations. This would retain the regulatory intent, whilst allowing for certain criteria to be developed for such benefits to ensure they are not misused (FIATA, 2022).

There are some implications for the Rhine-Scheldt Delta port system. Alliances are beneficial to larger container ports and terminals. So any changes to alliances as we know it, can have strong disruptive effects on the market position of individual container ports. More in particular, any restrictions on alliance formation and changes in alliance compositions can come with major impacts on liner service schedules and choices in terms of port of calls. Alliances can play off one port against another. Having one or more members of an alliance as co-owner of a (dedicated) terminal helps to increase loyalty (see the results in Notteboom et al., 2017). It becomes apparent that these alliances do not put all eggs in the same basket (so not only one hub port of choice). For example, the announcement in early September 2022 of the plan to create a 6 to 7 million TEU terminal in Rotterdam to be operated by TIL/MSC and Hutchison Ports and other recent TIL/MSC investments in Le Havre demonstrate that the North European hub status of Antwerp (MPET terminal) does not imply exclusivity in terms of terminal investments, particularly given the current capacity constraints of MPET.

6.2.3. Structured summary on proposition 3.2

Proposition 3.2. “The era of alliances between container shipping companies is gradually coming to an end.”	
Overall evaluation: Accept (if we talk about alliances in their present form)	
Arguments & observations in support of the proposition	**Arguments & observations going against the proposition**
1. The dominance of alliances is eroding on a number of trade routes. 2. Alliance membership becomes more difficult to reconcile with vertical integration strategies of carriers. 3. Alliances have less value to carriers during ‘good times’. 4. Increasing regulatory scrutiny and bold statements against alliances by key political figures and organizations. 5. Customer concerns about alliances are mounting fast.	1. Despite increased regulatory scrutiny, alliances still enjoy regulatory antitrust exemptions (for now). 2. Alliances continue to bring large operational, strategic, managerial, financial and market-related benefits to its members. 3. Alternatives to alliances might be worse than alliances. So, future alterations of the alliance concept are more likely than abolishment. 4. Any changes to alliances as we know it, can have strong disruptive effects on the market position of individual container ports in the RSD.

6.3. Proposition 3.3

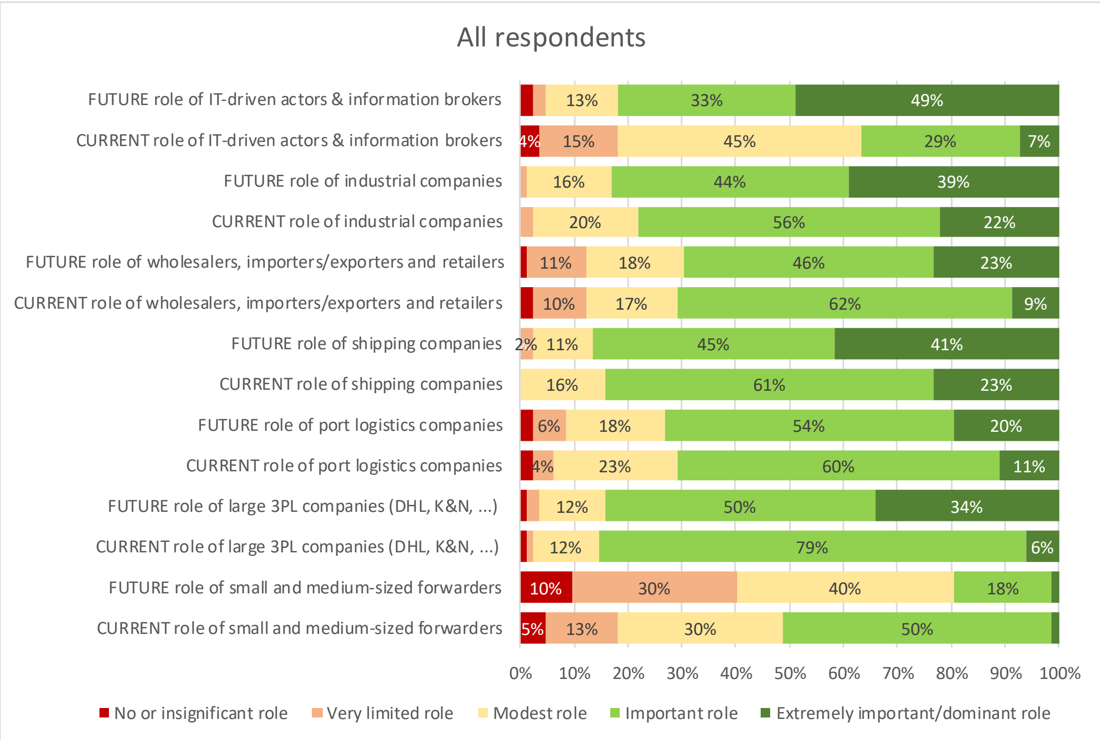
Proposition 3.3. Small and medium-sized freight forwarders without a strong digital backbone will struggle to survive.

6.3.1. Future power relations between market players active in port-related supply chains

The survey of the 2017 ING report (Notteboom and Neyens, 2017) contained questions on the expected changes in the power relations between market players active in port-related supply chains. For this purpose, we distinguished seven market player groups:

- Small and medium-sized forwarding companies (including customs agents);
- Large third-party logistics service providers (3PL) such as DHL, Kuehne & Nagel, Geodis, etc.;
- Port logistics companies which includes logistics companies with a strong focus on and origins in seaports (e.g. Stukwerkers, Zuidnatie, Molenbergnatie, Tabaknatie, etc..)
- Shipping companies active in international and intra-European tramp and liner shipping activities;
- Wholesalers, import/export companies and retailers;
- Industrial companies and cargo owners/shippers;
- IT-driven actors such (e.g. Amazon, Google, Alibaba, software development companies, etc..) and information brokers

Figure 6.8. How will the power relations in supply chains change in the coming ten years?



Source: ING survey results as reported in Notteboom and Neyens (2017)

Figure 6.8 reveals that shipping companies, industrial companies, large 3PL companies and IT-driven actors are seen as the players with the strongest role in the supply chains in the future. The role of IT-driven actors is expected to increase the most. Many respondents see the role of 3PL companies grow from modest or important now to extremely important/ dominant in the future.

According to the 2017 survey, the role of small and medium-sized (traditional) forwarders is expected to decline sharply. About 40% of the respondents only sees a minor or even no role for forwarders in the coming ten years.

Except for the forwarder group, respondents expect that all other market players will increase their role in the future. This might indicate that the future will bring increased competition among market players. However, at the same time this observation might pave the way for balanced partnership arrangements among (strong) market players in view of achieving a higher level of supply chain integration. Such initiatives have already emerged in the form of vertical collaboration between different actors in the same chain or horizontal collaboration between similar actors (for example two shippers who jointly develop cargo bundle solutions).

6.3.2. Mounting pressures on freight forwarders?

The increasing involvement of large 3PL companies and shipping lines in the streamlining of supply chains and the advances in data analytics and visibility, put an increasing pressure on *traditional freight forwarders*. New technology can make traditional freight forwarders largely obsolete as forwarding can rapidly go digital in its transactional form, with online sales, instant orders and automated processes. This is particularly the case for the spot business and basic port-to-port transport which are easier entry points for e-forwarding. At the same time, shippers will get better information using Big Data solutions and e-market places. This will result in a higher rate transparency and a better visibility of liner service schedules, shipment service attributes, overall performances and equipment availability.

Intermediary forwarding agents are most at threat from new technology providers or business models unless they adapt to or embrace change by, for example, offering easy visibility across the whole market. Differentiation and cost optimization can be achieved through improved online customer experience and automation. Major freight forwarding and third-party logistics providers thus have the responsibility to develop innovative new booking and logistics platforms in order to see off a potential threat from “disruptors” coming from within or outside the logistics sector. New technology-driven companies, particularly those within the e-commerce space such as Google, Alibaba or Amazon, or as yet unidentified players, are likely to enter or have already entered the transport and logistics arena to give them a competitive edge or seeing a competitive opportunity to bring new models to the market. A good example is Cainiao, the logistics arm of Alibaba which controls a vast e-commerce delivery network in China and abroad.

Drewry (2016b) points out that the small and mid-size shipper, spot shipment and LCL segment will move online extensively through complete web based forwarding services (from instant quote, booking, up to payment) as well as online sales platforms which dynamically push public and customer-specific rates. These platforms may only target and penetrate specific markets where a certain degree of automation can be achieved. Customer profiling and market segmentation will be at the core of the business model of these online sales channels. Large shippers will have access to more procurement options, benchmarking and insight capabilities. Large exporters and importers will continue to tender their sea-freight (port-to-port or port-to-rail ramp) and land transport, directly with their core carriers and with their forwarders for some part of their volumes. This practice will be available to many at a lower transactional cost with more flexibility using tailored e-tools. E-forwarding and spot procurement will complement traditional contract-based procurement channels.

6.3.3. The way forward

The freight forwarding industry understands digital transformation is a key ingredient for its future success. Forwarders are challenged to opt for collaborative technology driven networks. Digital transformation demands greater collaboration among market players. FIATA (2022) underlines industry digitalization efforts are crucial for greater optimization and efficiency in the supply chain. However, it is important to ensure that this is effectively organized in a manner that does not inadvertently result in a data monopoly by certain actors holding the data, who can then utilize such data to compete unfairly with other actors in the supply chain. Thus, all actors across global supply chains should continue to have (or have to get) access to trade logistics and should not run the risk of being cut out of the system due to lack of resources or connectivity. For this to materialize, one has to rely more on decentralized systems which do not privilege one single standard or type of system, but that instead are interoperable with each other.

Technological advances make it increasingly possible in real time to dynamically integrate pricing, schedules, bookings, shipment visibility with customers, carriers and market places. Rate automation and shipment visibility technology facilitates online sales. This can create new opportunities for (larger) forwarders, as the use of these decision tools enable a deeper integration with carriers which will further facilitate shipment and allocation optimization.

In order to face the digital challenges, freight forwarders would also need to recruit new talent from outside of the traditional freight forwarding and logistics sector, including coming from IT-driven potential disruptors. Persuading the right people from innovative technology companies to join the freight forwarding and logistics sector is quite a task given the lack of a strong public image and brand image of the logistics sector. Moreover, integrating new business approaches and models in the relatively conservative freight forwarding businesses will require an open mind towards change.

6.3.4. Structured summary on proposition 3.3

Proposition 3.3. "Small and medium-sized freight forwarders without a strong digital backbone will struggle to survive."

Overall evaluation: Accept

Arguments & observations in support of the proposition	Arguments & observations going against the proposition
1. Shipping companies, industrial companies, large 3PL companies and IT-driven actors are seen as the players with the strongest role in the supply chains in the future. The role of small and medium-sized (traditional) forwarders is expected to decline sharply (ING survey 2017) 2. E-forwarding can make non-digital freight forwarders largely obsolete in the spot business and basic port-to-port transport. 3. Large shippers have access to more procurement options, benchmarking and insight capabilities. Higher rate transparency and a better market visibility put pressure on forwarders' margins. 4. To see off a potential threat from disruptors coming from within or outside the logistics sector, forwarders have no other choice than to becoming technology providers offering easy visibility and improved online customer experience through new booking and logistics platforms.	1. Forwarders have a role to play in the trend towards increased cooperation and partnership arrangements between market players in view of achieving a higher level of supply chain integration. 2. An individualized customer approach and the market segmentation in logistics will continue to give room to some less digitalized niche market forwarders. 3. Decentralized systems which do not privilege one single standard or type of system reduce the risk for less digitalized forwarders of being cut out of the system due to lack of resources or connectivity.

6.4. Proposition 3.4

Proposition 3.4. Conventional general cargo will remain an important market for the Rhine-Scheldt Delta ports.

6.4.1. Origins and growth of the conventional general cargo market

Conventional general cargo is general cargo, loaded into a ship or transport mode as individual or bundled pieces, not stowed into a container, or not transported in ship-sized liquid or dry bulk loads.

Conventional general cargo encompasses a myriad of different commodities:

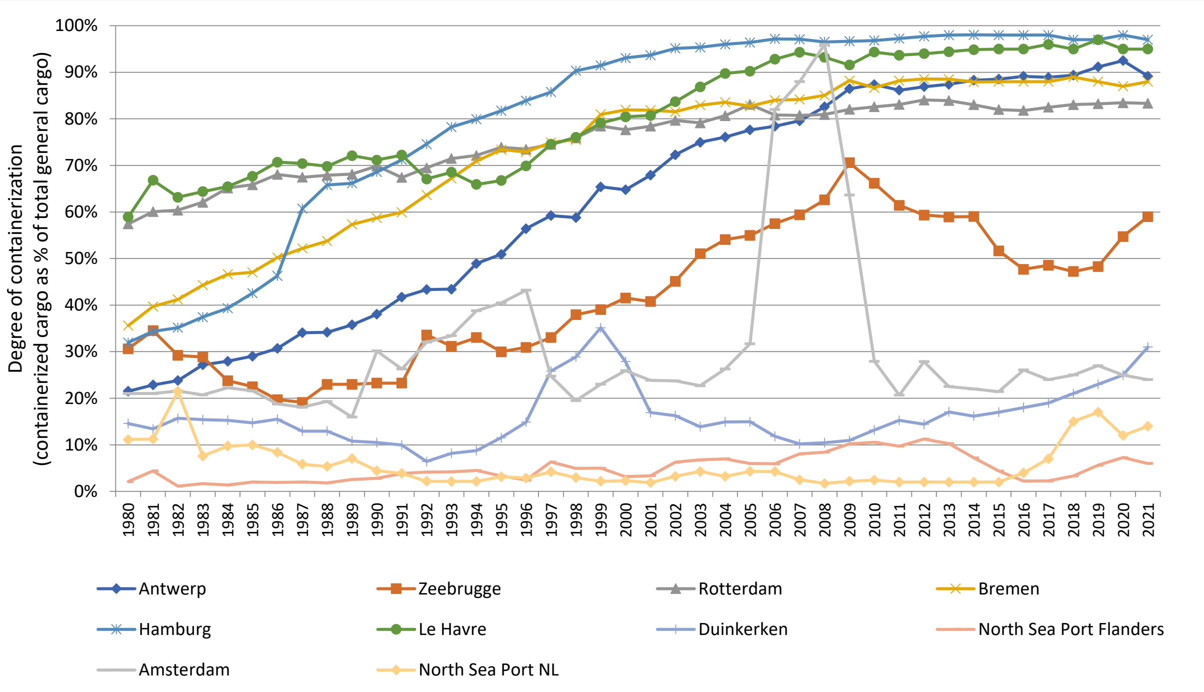
- **Project cargo**. Power generation equipment such as generators, turbines, wind turbines, equipment for the oil and gas industry, such as subsea systems, cables on reels, gas tanks, modules, petrochemical plants, mining equipment, building and construction equipment, brewery tanks, silos, and heavy machinery.
- **Iron and steel products**. Including coils, plates, steel bars, slabs, plates, steel wire, pipes, and tubes.
- **Forest products**. Including wood and paper products
- **Parcels** such as malt, fertilizer, sugar, and rice.
- **Reefer vessel trades** that mostly concern fruits and meat.
- **Break bulk shipments** of smaller lots such as big bags, skidded, and palletized cargoes.

Before the Second World War, all transport was done in the form of break bulk and could be described as general cargo. After World War II, some specialization appeared with dedicated merchant vessels designed for specific cargoes like bales of wool, wood logs, and liquid bulk. Slowly but surely, economies of scale were gaining importance. Up to the late 1950s, dock work basically involved unskilled work requiring little training, except for the operation of the mechanical devices.

In the late 1960s, containerization reached the Rhine-Scheldt Delta resulting in faster vessel turnaround times in ports, reduction in the level of damages and associated insurance fees, and better integration with inland transport modes such as trucks, barges, and trains. Containerization brought a substitution process with the gradual capture of the break bulk cargo market. Many segments of the traditional pre-container general cargo market are already containerized. Many raw materials and food commodity chains are still in the process of being containerized. Some commodities are already fully containerized (e.g. coffee, tobacco). Goods that can easily be stuffed in a container have been massively containerized, partly because of relatively stable and even declining container shipping costs and a growing number and availability of containers in transport markets worldwide. However, temporal shortages of containers and specific container sizes and high container freight rates can hamper further containerization in some markets or temporarily reverse the containerization trend.

The containerization process of general cargo has also been visible in the main container ports in the Rhine-Scheldt Delta, as illustrated in Figure 6.9 by rising containerization degrees, which is the ratio between containerized throughput of the port and its total general cargo volumes. The large container ports in the Le Havre-Hamburg range have very elevated containerization degrees. Already in 1998, the port of Hamburg reached a degree of more than 90%. Le Havre has always had a rather elevated containerization degree which peaked in 2019 to 97%. Despite the observed growth in its container handling activities, Rotterdam's containerization degree did not increase in a spectacular way: it rose from about 60% in the early 1980s to 83% in 2005. Since then, Rotterdam's containerization degree remained stable at 82-83% as the combined growth in roro and conventional general cargo matched the container growth rate. In contrast, Antwerp's containerization degree only amounted to 22% in 1980 pointing to a very strong conventional general cargo segment. Even in the late 1990s, Antwerp's containerization degree remained far below the degrees observed in other large container ports. However, Antwerp has caught up with Rotterdam in 2007. In 2020 the containerization degree in Antwerp even reached 93% to fall back to 89% in 2021.

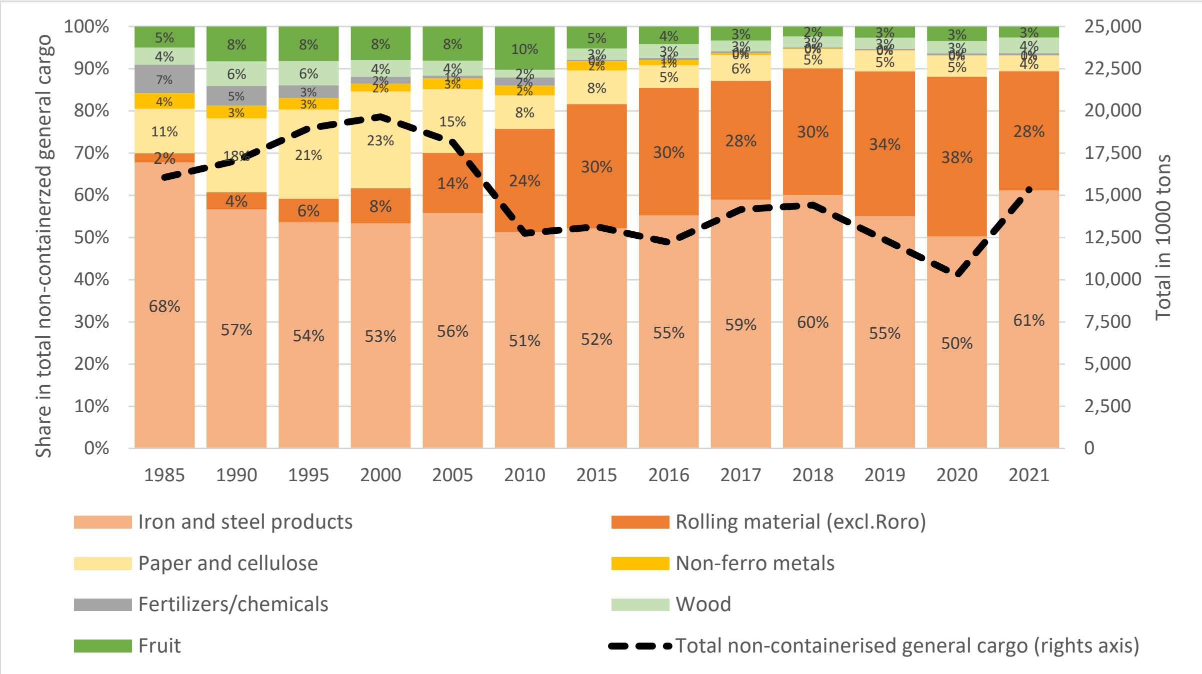
Figure 6.9. Containerization degree in ports of the Le-Havre-Hamburg range

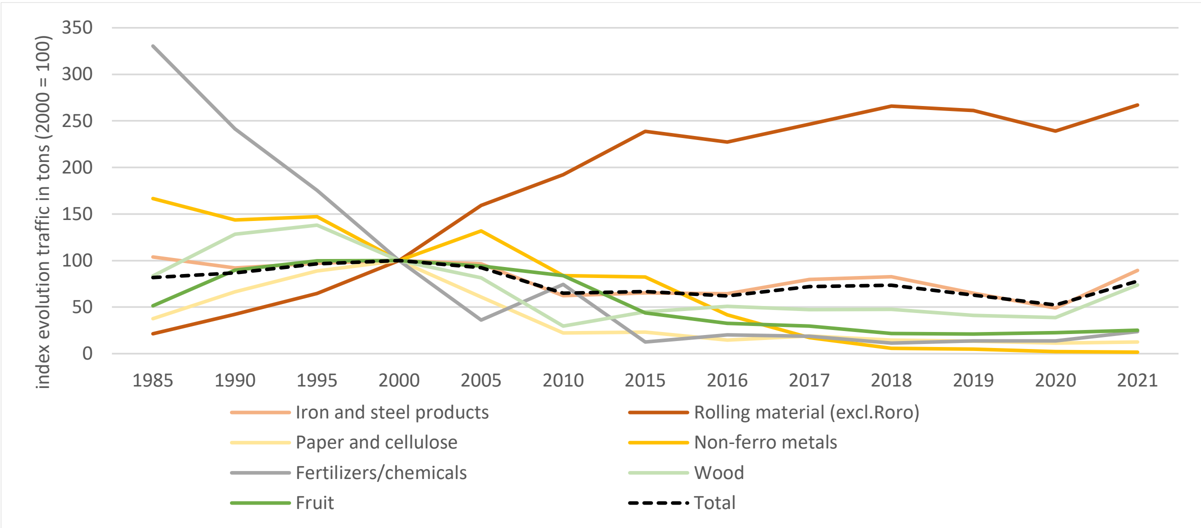


Creating a competitive advantage in the conventional general cargo markets is not only a question of operating modern terminal equipment but also a matter of ensuring that the most efficient human resource system is in place to operate the terminal equipment. Given the size of some of the customers, a loss or gain of a large customer can exert a major impact on the port and is directly reflected in the number of dockworkers required. The past decade has demonstrated that conventional general cargo flows handled in the Rhine-Scheldt Delta port region can easily shift between ports, leading to changes in market shares and activity levels. Land availability at competitive rates and flexible and cost-competitive dock labour arrangements were among the main drivers of such observed shifts. Zeeland Seaports (now part integrated in North Sea Port) was a typical example. The ING report on the breakbulk market revealed that the market share of Zeeland Seaports in the Hamburg-Le Havre range increased to 17% in 2010 compared to 1.6% in 1985 while Antwerp witnessed a sharp decline from 40% in the early 1990s to a modest 22.6% in 2010 (Vonck and Notteboom, 2012).

Figure 6.10 provides more detail on the evolution in the composition of non-containerized general cargo in the port of Antwerp. The line graphs show that, compared to the 1980s and 1990s, the tonnage of non-containerized paper and cellulose, non-ferro metals, fruit and fertilizers/chemicals handled in the port saw a sharp decline. This is a combined result of increasing containerization of these flows and more intensive competition from North Sea Port and Rotterdam. Iron and steel products also saw a decline, but less pronounced compared to the earlier mentioned flows. Rolling material is the only non-containerized general cargo category that saw strong volume growth in the past 35 years. In 2021, most general cargo flows bounced up strongly after years of gradual decline. COVID-19 brought a strong growth in conventional general cargo in Antwerp in particular as the high freight rates and disruptions in the global container shipping and terminal network led to a 'decontainerization' of some general cargo flows. Iron and steel products dominate Antwerp's conventional general cargo business expressed in tons handled.

Figure 6.10. Composition of non-containerized general cargo in the port of Antwerp, 1985-2021 (top) and index evolution year 2000 = 100 (bottom)





Source: own compilation based on Statistics Yearbook 2021, Port of Antwerp-Bruges

6.4.2. The economic importance of conventional general cargo

Conventional general cargo handling creates jobs at terminal and stevedoring companies in the form of dockworker and management positions. Dock labor needs are very dependent on the cargo flows handled in the port. Other cargo service-related jobs include cargo survey, land transport and storage, and port-related storage. Compared to the handling of commodities such as crude oil or major dry bulks, conventional general cargo is much more labor-intensive. It generates a substantially higher added value per ton (Textbox 6.1) and is the largest generator of dock-related jobs per volume unit, although a significant difference might exist among commodities and ports.

Textbox 6.1. Intrinsic cargo handling values

Several studies have attempted to measure intrinsic cargo handling values by presenting the relative added value associated with the handling of one ton of cargo. The methodologies deployed range from bottom-up to top-down approaches (Table 6.1):

- The Port of Hamburg presented the Hamburg Rule in 1976, which became the reference standard.
- The Bremen Rule was presented in 1982 by the port of Bremen. It was based on the differences in labor costs for handling cargo and provided the following relative weights: 1 ton of general cargo equals three tons of dry bulk or 12 tons of liquid bulk.
- The Rotterdam Port Authority introduced the Rotterdam Rule in 1985 and refined the method further in 1991 with more detailed dry bulk classes.
- In 1986, the Dupuydauby Rule came with revised relative weights in cargo handling value per ton. It particularly underlines that containerization was becoming less labor-intensive, with an intrinsic value changing from one to three.
- The Antwerp Rule is based on data from the Antwerp port and distinguishes 13 traffic categories. Based on these figures, the highest added value per ton in the port of Antwerp is created by the handling of fruit. As the Antwerp Rule is only based on Antwerp data, the University of Antwerp also developed a Range rule based on data for ports in the Hamburg-Le Havre range.
- The Antwerp rule was updated and refined in 2008 and 2015 (New Antwerp Rule). It clearly underlines the growing productivity of containerization from a labor perspective.

Table 6.1. Intrinsic cargo handling values

<table>
<tr><th>Rule</th><th colspan="3">Liquid Bulk</th><th colspan="4">Dry Bulk</th><th colspan="2">Containers</th><th>Roro</th><th colspan="2">Conventional cargo</th></tr>
<tr><td>Hamburg (1976)</td><td colspan="3">15</td><td colspan="4">5</td><td colspan="5">1</td></tr>
<tr><td>Bremen rule (1982)</td><td colspan="3">12</td><td colspan="4">3</td><td colspan="5">1</td></tr>
<tr><td>Dupuydauby rule (1986)</td><td>Crude oil
12</td><td colspan="2">Other LB
9</td><td colspan="4">6</td><td colspan="2">3</td><td>3</td><td colspan="2">1</td></tr>
<tr><td>Rotterdam rule (1991)</td><td>Crude oil
15</td><td colspan="2">Other LB
2.5</td><td>Cereals
4</td><td>Coal
10</td><td>Steel
12.7</td><td>Other DB
7.5</td><td colspan="2">3</td><td>8</td><td colspan="2">1</td></tr>
<tr><td>Antwerp rule and Range rule (2000)</td><td>Crude oil
18</td><td colspan="2">Other LB
2</td><td colspan="4">4</td><td colspan="2">3</td><td>1</td><td colspan="2">1</td></tr>
<tr><td>Antwerp rule (2008)</td><td>Crude oil
12.3</td><td colspan="2">Other LB
5</td><td>Steel
3.5</td><td colspan="3">Other DB
10.6</td><td>Import/export
6</td><td>Transhipment
10.2</td><td>2.6</td><td colspan="2">1</td></tr>
<tr><td>New Antwerp rule (2015)</td><td>Crude oil
7</td><td>Other LB
5</td><td>Chemical products
5</td><td>Ores
4</td><td colspan="3">Other DB
4</td><td colspan="2">5</td><td>2</td><td>Steel
1</td><td>Fruit
2</td></tr>
</table>

Source: own compilation based on Huybrechts, et al. (2001) and Haezendonck and Moeremans (2019)

Employment in ports is also affected by the combination of quay-related cargo-handling activities at terminals and a wide array of logistics activities at warehouses or near the terminals. As such, a mix of pure stevedoring activities and logistics activities occurs, each requiring people with the necessary skills and know-how. As a large part of the experienced dock workers at conventional general cargo terminals are in their late 40's and 50's, there is a constant need to transfer knowledge and know how to younger generations. The break bulk market segments, as important sources of employment in ports, impact port labor requirements. Large break bulk customers and large cargo handling companies can exert a significant impact on port labor. As these companies often develop a strong network focus by their presence in several ports, the experience they gain at different ports is the basis for explicit or implicit port labor benchmarking exercises comparing the turnaround time in each port, terminal productivity, flexibility in working practices, and cost profiles.

6.4.3. Common developments in conventional general cargo markets

The classic definition of break bulk concerns goods that do not fit into a container. In reality, it is more complicated to propose a comprehensive definition of the modern break bulk sector. Thus, the conventional general cargo sector is very heterogeneous. While this report does not aim to analyze the developments in each market segment in detail, some common developments can be identified.

First, markets are characterized by consolidation, both on the supply and the demand side. Mergers and acquisitions shape the contemporary business environment, also in the conventional general cargo market segments. The consolidation trend puts additional pressure on intermediary parties (such as cargo handling terminals), which now have to deal with large ship operators and shippers or consignees with strong bargaining power. Most sectors are quite susceptible to changes in business outlook or are faced with increased competition and low margins, thus creating an extra incentive for value-added activities in order to raise margins and profitability.

Second, environmental issues are having an ever-larger impact on conventional general cargo shipping and ports. Shipping lines and terminal operators must demonstrate a high level of environmental performance in order to ensure a license to operate and attract trading partners and potential investors. Old heavily polluting plants and transport and cargo handling methods are being phased out and steadily replaced by new units and processes having less environmental impact. The energy transition has given rise to new and fast growing conventional general cargo markets in the area of project cargo, heavy lifts, and machinery. In particular, the offshore wind turbine industry has generated new activities in ports such as Flushing, Ostend and Groningen Seaports. Wind blade and turbine equipment is estimated to constitute roughly 20% of ocean-borne multi-purpose heavy lift cargo.

Third, logistics integration levels in many of the conventional general cargo sectors are increasing. Large logistics operators have emerged with control over many segments of the supply chain. The integration strategies of the market players have created an environment in which ports are increasingly competing not as individual places that handle ships but within transport networks or supply chains. Break bulk terminals are no longer quayside areas where cargo is simply shifted from land to sea. They have become vital links in global supply chains and international transport networks. The emergence of more and more value-added activities at terminals are a testimony of the increasing role of terminals in the respective supply chains. The Rhine-Scheldt Delta seaports strongly focus on developing a strong customer-oriented focus to secure their position as decoupling points in conventional general cargo supply chains.

Fourth, seaport competitiveness in the various conventional general cargo markets is not only dependent on out-of-pocket cost considerations. Reliability, capacity considerations, proven expertise, quality of information services, and a commercial and customer-oriented approach characterized by a clear ability to think along with the customer (not only in the port but throughout the supply chains and networks) are becoming ever more important in competing effectively in the break bulk cargo handling markets.

Fifth, many of the conventional general cargo sectors can obtain major benefits from clustering. The port of Antwerp is a prime example with many terminals able to handle conventional cargo, a broad range of available cranes (including mobile and floating cranes) and warehousing facilities, value-added services (such as project cargo packaging stations, warehousing, etc.) and extensive know how in the many companies of the cluster. Not only from an economic point of view with economies of scale and added scope but also for environmental considerations. Closed production cycles are good examples leading to a concentration of industrial activities within ports, benefiting major seaports and allowing for increased use of intermodal options like barge and rail.

6.4.4. The future of conventional general cargo in the Rhine-Scheldt Delta ports

It may be erroneously assumed that break bulk or conventional general cargo is destined to disappear as an outdated way of transporting goods. In reality, the break bulk sector has not disappeared but changed in nature as a result of increased containerization. It has become a specialized/niche sector, handling the goods which are too challenging to transport in containers or where containerization does not represent a valid and cost-efficient proposition. The ports in the Rhine-Scheldt Delta have a lot to offer in terms of geographical location and nautical accessibility, port labor, hinterland accessibility, cargo generating capacity, innovation, etc. Several developments will have an impact on the future of conventional general cargo in the region:

- **Containerization degrees**: The large container ports in the Le-Havre-Hamburg range already have very elevated containerization degrees (see earlier Figure 6.8), thereby leaving little room for further containerization of conventional general cargo. The recent high freight rates and supply chain disruptions in the container shipping market have even demonstrated that competition between containerized vs. non-containerized ways of transport has intensified, with some flows now opting for conventional maritime shipping instead of container ships. We expect that such competitive pressures on the container market are not unique but will occur more frequently in the future, thereby giving conventional general cargo operators some room to 'win' back a small portion of the flows that have been containerized in the recent past. Differences in freight rates, equipment availability, delays and carrier choice are expected to play a key role in the choice between containerized and non-containerized transport. Nearshoring trends (see proposition 1.2) and the focus on sustainability could provide new opportunities for intra-European shortsea shipments of breakbulk cargo.

- **Geographical location and cargo generation**: all RSD ports are located centrally in the European Union, in the middle of the Blue banana. Being close to the markets is a major advantage, since shipping companies prefer to unload their cargo as close as possible to the final destination. The RSD ports are ideally positioned to act as gateways towards the European hinterland. The presence of knowhow, availability of backhaul/return cargo and the ability to cope with peak supply make the region a premium option.

- **Nautical and hinterland accessibility**: While draft restrictions do not pose a problem in break bulk shipping, some concerns remain in the area of the availability and cost of pilotage and towage services and the impact of the priority given to other vessels (mainly ultra large container vessels) on break bulk vessel operations. The realization of the Kieldrechtlock in Antwerp and Sealock

Ijmuiden near Amsterdam as well as the ongoing construction of a new lock in Terneuzen are instrumental for consolidating the position of the Delta in the break bulk market. The RSD port region faces hinterland accessibility challenges due to dense traffic around the port cities and economic centers in the near or more distant hinterland. The creation of inland terminals mainly benefited container flows, but also break bulk flows increasingly use rail and barge. The further development of major inland ports and the development of the Seine-Nord Canal are expected to boost the use of barges in the break bulk cargo trade even further. The new Seine-Nord connection is expected to particularly strengthen the role of North Sea Port as a barge hub.

- **Land availability**: The availability of port land remains a concern to most ports in the Hamburg – Le Havre range. A limited amount of free space affects the willingness of major companies to invest. Different stakeholders try to enforce their rights on the available lands. Not only economic and industrial applications are demanded but also ecological motives are endeavored like the creation of nature compensation areas. Many RSD ports are facing land availability challenges whilst at the same time they need land for realizing projects in the field of energy transition and the circular economy. The growth of container and liquid bulk flows makes competition for many of the prime water locations more intense and can delay possible expansion projects of a break bulk terminal facility. This combination can render it more difficult to meet the demand for conventional general cargo handling in the port. Port authorities are challenged to ensure that the necessary land is in place for further growth in the break bulk cargo handling market.

- **Dock labor**: Up to 70% of the operating costs of break bulk terminals are linked to dock labor. Consequently, the flexibility, productivity, quality and cost efficiency of dock workers contribute to the competitiveness of port-related and logistics companies in the break bulk markets. In the Flemish ports, port labor is ruled by the 'Major Act', but still there are quite a number of differences between local port regulations (Codex) in terms of the hiring system, the possibility to have half shifts, the mobility between job categories and shifts, the recognition process of new dockers and weekend work. In light of increased competition from a.o. Flushing and Rotterdam, mainly break bulk operators in Antwerp have shown concerns on a possible mismatch between the market evolutions and some of the practical arrangements in the dock labor system. In comparison, the port labor organization in Flushing, one of the main competitors, is characterized by a high degree of flexibility in terms of the access to the profession, the recruitment of casual dockers, the deployment of multi-skilled dock workers, the composition of the gangs, etc. Through social dialogue, employers and employees are involved in a continuous process to further optimize the current dock labor arrangements in an effort to improve the competitive position of the ports in the labor-intensive break bulk markets. Furthermore, the stakeholders should ensure a continuous improvement in training and development of know how in order not to fall behind in dealing with the quality requirements in the break bulk cargo segment.

- **Innovation**: The conventional general cargo market is not to be considered as a marginal activity in the RSD, but a value-adding sector with a high level of competence-building and expertise. It is important to ascertain that an efficient and competitive break bulk cargo handling market in the ports supports the competitiveness of import and export-oriented firms and commodity traders. By striving for competitiveness and efficiency improvements, the break bulk sector plays its role in making seaports drivers of innovation. The industry tends to invest in new higher capacity ships putting a strain on the existing terminal capacity and capabilities. Continuous investments will be required in order to keep the terminal equipment and superstructure up to par with the growing demands of shippers. The RSD seaports are innovating in technologies and processes, not only to keep the ports competitive, but also to demonstrate that they can take up a European leader role in a responsible and innovative way, driven by market responsiveness and sustainability. The sense for innovation and knowledge transfer in the break bulk sector can be further strengthened by a good port cluster management that enhances knowledge exchanges among companies in and outside the port.

6.4.5. Structured summary on proposition 3.4

Proposition 3.4. "Conventional general cargo will remain an important market for the Rhine-Scheldt Delta ports."	
Overall evaluation: Accept conditionally	
Arguments & observations in support of the proposition	**Arguments & observations going against the proposition**
1. The break bulk sector has not disappeared but changed in nature as a result of increased containerization. It has become a specialized/niche sector. 2. The large container ports in the Le-Havre-Hamburg range already have very elevated containerization degrees, thereby leaving little room for further containerization of conventional general cargo. 3. Competition between containerized vs. non-containerized ways of transport has intensified in the past few years. 4. The presence of knowhow in an extensive general cargo cluster, a wide range of terminals, availability of backhaul/return cargo, and the ability to cope with peak supply make the region a premium option. 5. The conventional general cargo market is relatively small in tonnage, but very important in value added per ton.	1. The growth paths in conventional general cargo differ greatly among the Rhine-Scheldt Delta ports with market leader Antwerp having lost market share to other ports in the region. 2. Competition for prime water locations will become more intense, potentially hindering break bulk terminal projects. 3. Flexible and cost-competitive dock labor arrangements are required to remain competitive. As a large part of the experienced dock workers at conventional general cargo terminals are in their late 40's and 50's, there is a constant need to transfer knowledge and know how to younger generations. 4. The RSD port region faces hinterland accessibility challenges.

7. Theme 4: The role and functioning of managing bodies of ports

7.1. Proposition 4.1

Proposition 4.1. The role adopted by managing bodies of ports in the Rhine-Scheldt Delta should not go beyond the role of 'facilitator'.

7.1.1. The role and function of the managing body of the port

A port authority or managing body of a port can be defined as the entity which, whether or not in conjunction with other activities, has as its objective under national law or regulation the administration and management of the port infrastructures, and the co-ordination and control of the activities of the different operators present in the port (Commission of the European Communities, 2001; Verhoeven, 2010). Managing bodies of ports are continuously challenged to adapt to a changing port ecosystem. The managing bodies of the Rhine-Scheldt Delta ports are no exception.

The landlord model is the common model of port administration in the Rhine-Scheldt Delta. The term 'landlord' derives from the simple fact that the managing body of the port, among its many other responsibilities, is the 'curator' and the 'authorized manager' of port land and adjacent aquatic surfaces, to be rented out (leased) for economic profit to the private sector. As a landlord, the managing body of the port must optimize the use of its domain by earmarking port areas for specific uses; awarding concessions and authorizations to a carefully selected 'mix' of companies; adopting an appropriate pricing system.

Connected to the above, every port is confronted with specific challenges and opportunities in terms of economic and social development priorities, port-city relations, spatial dynamics, environmental pressures, and more. This regional embeddedness implies that ports may go different ways in terms of the tasks, roles and activities they develop and, sometimes, this may require a different management approach. As a result, some diversity exists between the roles adopted by the managing bodies of the RSD ports, even when considering they basically adopted a similar port management governance model (see section 2 of this report).

Port economics literature is presenting us with possible discrete levels of engagement of a port authority (see the passive, facilitator or entrepreneur categorization in Table 7.1) and a port's specific roles (e.g. landlord, regulator and operator, see Baird, 1995; Baltazar and Brooks, 2001). It has been argued that the port authority should play a more proactive role in facilitating and coordinating stakeholders in logistics networks, and in developing the necessary competencies to succeed in a highly competitive market (see Notteboom and Winkelmans, 2001; Comtois and Slack, 2003; Van Der Lugt and De Langen, 2007), perhaps even by adopting a more entrepreneurial role (Verhoeven, 2010). Port authorities have also been encouraged to add a functional role as cluster or ecosystem managers and community managers (Chlomoudis et al., 2003), to solve collective action problems in and around the port domain.

Table 7.1. Typology of port authorities

	Conservator	Facilitator	Entrepreneur
Landlord	• Passive real estate manager	• Active real estate broker • Mediator in B2B relations • Strategic partnerships beyond port perimeter	• Active real estate developer • Direct commercial B2B negotiations • Direct investments beyodn port perimeter
Regulator	• Passive application and enforcement • Rules set by others • Financial revenues on tariff basis	• Active application and enforcement • Other + own rules • Provide assistance in compliance • Tariffs + differential charging options to promote sustainability	• Idem facilitator • Idem facilitator + commercialising expertise and tools outside port • Financial revenues on commercial basis
Operator	• Mechanistic concession policy	• Dynamic concession policy • Leader in dealing with dissatisfaction • Provide public services/specialised services	• Dynamics concession policy • Shareholder in private service providers • Provide commercial and public services
Community manager	• Not actively developed	• Solve economic bottlenecks • Provide public goods • Solve conflicting interests • Promote positive externalities	• Idem facilitator but more direct commercial involvement
	Local	**Local + regional**	**Local + regional + global**

Source: based on Verhoeven (2010) and ESPO (2011) Fact Finding Report

Many landlord port authorities across Europe have adopted a more active role either as facilitator or entrepreneurial port authority (Verhoeven, 2010). In the past two decades, the role of port authorities in specific activity areas has been further examined:

- intermodal transport and hinterland development (Notteboom and Winkelmans, 2001; De Langen and Chouly 2004; Notteboom and Rodrigue, 2005; Van Der Horst and De Langen, 2008; Van den Berg and De Langen, 2011; Mangan and Van Der Horst, 2020);
- land management including terminal concessions/leases (Notteboom, 2006; Notteboom et al., 2012; Ferrari et al., 2015);
- digital transformation as a key enabler of cargo flow facilitation and supply chain coordination;
- sustainability (Lam and Notteboom, 2014; Acciaro et al., 2014; Ashrafi et al., 2020);
- green supply chain management in ports (Notteboom et al., 2020);
- the green port concept (Pavlic et al., 2014);
- energy efficiency (Iris and Lam, 2019);
- energy transition (Hentschel et al., 2018; Wang and Notteboom, 2015);
- the circular economy (De Langen and Sornn-Friese, 2019; Mańkowska, et al., 2020);
- port marketing (Parola et al., 2018).

In the next sections we elaborate on three areas: intermodal transport and hinterland development; sustainability; and risk and resilience.

7.1.2. Role in intermodal transport and hinterland development

Port authorities have a role to play in shaping efficient hinterland networks. But they have to start from the knowledge that their impact on cargo flows and on hinterland infrastructure development is limited to that of facilitator. Port authorities can add value by setting up task forces together with various stakeholders (carriers, shippers, transport operators, labor and government bodies) to identify and address issues affecting logistics performance. These issues can relate to the bundling of rail and barge container flows in the port area and the development of rail and barge shuttles. For example, port authorities are facilitating structural sector-wide negotiations between all players in the container chain (shippers, shipping companies, freight forwarders, barge operators, inland terminals, deep-sea terminals and empty depots) to work together on a more transparent and efficient structure for the inland container transport chain. The rail operators continue to bear the market risks associated with the new rail links. Apart from port authorities, also branch associations are adopting a role as facilitator in dealing with inland transport issues (e.g. Alfaport and Deltalinqs).

Most port authorities stand at the sideline when it comes to inland terminal developments and the creation of logistics zones along hinterland corridors. Port authorities are rather reluctant to engaging in advanced forms of strategic partnerships with inland ports, e.g. through strategic alliances, (cross-) participation, joint-ventures or even mergers and acquisitions. More room is created for forms of indirect co-operation, for example through joint marketing and promotion, which are less binding and require less financial means. Still, ports such as Rotterdam, Antwerp-Bruges, Barcelona, Le Havre, Marseille and Lisbon have become more active in this field as they understand that with the creation of logistics poles, port benefits might leak to users in inland locations. Also, inland locations can help the port to preserve its attractiveness and to fully exploit potential economies of scale. The corridors towards the inland terminal network can create the necessary margin for further growth of seaborne container traffic. Inland terminals as such acquire an important satellite function with respect to the port, as they help to relieve the seaport area from potential congestion. Still, many port authorities are struggling to define their role (or to create one for themselves), to enhance collective actions, and to achieve visible positive results in the field of intermodal hinterland transport, including connectivity and the port's relations to inland ports (see case studies in Magnan and Van der Horst, 2020).

In the Rhine-Scheldt Delta context, the survey results of the 2017 ING study on the future of supply chains (Notteboom and Neyens, 2017) showed mixed views on assigning a stronger role to port authorities in view of supply chain co-ordination and co-operation: 50% of the respondents see room for a stronger role of port authorities while 26% of the respondents argue that this is not recommended or should even be avoided. It is difficult to judge whether the latter group of respondents thinks port authorities have already adopted a sufficiently strong role to facilitate supply chain co-ordination and co-operation or, alternatively, argue that port authorities should not adopt a strong role in facilitating co-ordination or co-operation. Overall, the survey revealed port logistics companies and the industry see branch organizations and port authorities, specialized in community and inter-community development, as facilitators but not necessarily as leaders in port-related supply chain coordination and co-operation.

7.1.3. Role in sustainability

The 2019 ING study revealed port authorities in the Rhine-Scheldt Delta are very visible in facilitating the greening of supply chains and the transition to a circular economy and non-fossil fuel-based economy. Examples include voluntary programs to promote the development and use of green ships, extensive coordinated initiatives to enhance a modal shift and synchromodality in hinterland transport and a whole range of actions and plans in the area of CCU and energy transition (see Notteboom et al., 2019). Other current challenges include the role of port authorities in the large-scale implementation of cold ironing solutions for deep sea vessels (Arduino et al., 2011; Tseng and Pilcher, 2015; Innes and Monios, 2018; Lorange, 2020) or the greening of terminal concession procedures and agreements

(Notteboom and Lam, 2018; see also proposition 4.2 for a detailed analysis). In some cases, port authorities might move beyond the pure facilitating role by entering into key investments, particularly in those cases where private investors show more reluctance to do so.

7.1.4. Role in dealing with risk and promoting port resilience

Risk taking has always been an inherent part of business. Today's unpredictable conditions in which a port operates demand a resilient, flexible and adaptive strategy that can adjust to uncertainty and change and which is built into the core foundations of the strategies of port authorities and port-related companies.

Uncertainty faces port authorities with a range of challenges in the context of port planning. Current approaches to port planning, design, and evaluation prove inadequate under changing requirements. Flexible or adaptive port planning is one possible solution in dealing with the changing port environment in the planning phase of new investments. Uncertainty is not described as a description of possible futures and their respective probability of occurring but rather the formulation of strategies and actions aimed at minimizing the chance of a catastrophic plan failure.

The uncertain and highly volatile environment also makes that some actions initiated by the managing body of the port might be the result of ad hoc decisions and investments, fueled by windows of opportunity that arise suddenly at a specific point in time. The increasingly volatile market environment implies port management in the Rhine-Scheldt Delta needs to be increasingly tailored towards more flexible ad hoc type of decisions. Such an approach has the potential of increasing port resilience by continuously adapting the port to opportunities arising from a changing economic geography, economic shocks, sustainability needs or major shifts in the corporate world.

7.1.5. Exploring new revenue/business models for port authorities

The business model adopted by a managing body of a port will be influenced by its mission, vision and objectives, and the governance structure and external environment in which it operates.

While the managing bodies of the Delta ports have seen major changes in the past decades on how (public) port investments are funded, most ports held on to their traditional revenue base and pricing system. More specifically, the financial backbone remains heavily dependent on port dues (i.e. marine charges and cargo dues) and land fees, often designed using very simple and rather rigid pricing methods (e.g. a fixed rate per square meter per year for land/concession fees, or a fixed amount per Gross Ton for marine charges). In a few cases, more 'intelligent' pricing methods have been invented, aimed at attracting to the port those ships for which the port maintains a comparative advantage. A good example of this is the pricing (dues) system of the Port of Rotterdam, favoring the calling of ships of the latest generation (in terms of size).

The current market environment of highly volatile trade and cargo flows and fierce inter-port competition causes fluctuations in port dues. In the medium to long term, the energy transition away from fossil fuels will negatively affect the revenue streams brought by oil tanker and bulk carrier calls, and fossil fuel related terminal and industrial activities in the port. Furthermore, the land fee system used by a port authorities needs to constantly adapt to reflect the actual net land availability in the port and the dynamics in the availability of and pricing at alternative locations in other ports or the hinterland.

Thus, there is room for revisiting port pricing strategies and revenue models of managing bodies of the Delta ports, for example, by exploring the possibility of designing more dynamic, flexible and differentiated pricing methods that take into account actual market conditions, trends in ship sizes, the price elasticity of port users, the nature of port activities, environmental targets and the port's current and anticipated future financial position and needs.

The ports in the Rhine-Scheldt Delta might also consider complementing cargo volume dependent revenues (port dues and partly also land fees) with other revenue streams, particularly if they are operating in a market environment characterized by highly volatile or declining cargo volumes. Targeted investments in digital transformation, energy transition and the circular economy can open the door to new sources of revenue streams which might be less dependent on the vessel and cargo activity level in the port area. However, this brings us back to the discussion on the desirability of having an entrepreneurial managing body of the port.

Port pricing by port authorities might have to adapt to the sustainability challenges that lie ahead, but also here some caution is justified. We believe that port authorities have a role to play to initiate, facilitate and co-ordinate a range of schemes to promote sustainability. Given the position of seaports as key nodes in global supply chains and logistics networks, it is tempting to push port authorities to take up a role as tax collectors for environmental damage caused throughout these chains and networks. Port authorities should not be forced by policy makers at the supranational or national level to act as the convenient tax collectors for the greening of supply chains. In line with the 'polluter pays' principle, any internalization of environmental costs should target the polluter at the source and cannot lead to an obligation for port authorities to punish for externalities or to reward environmental performance. Obviously, the above point does not imply that port authorities should refrain from launching such schemes on a voluntary basis individually or together with other ports.

7.1.6. A differentiated approach to the role of managing bodies of ports

In each area of port activity and for every individual initiative ports might be willing to undertake, port authorities and their stakeholders should evaluate whether a) the port authority may have a statutory role to play and b) if so, whether such involvement is likely to lead to a superior outcome, compared to no involvement. In the context of such considerations, the managing body of the port needs also to decide on whether its involvement should be restricted to its statutory domain, or extend beyond the confines of its legal responsibility; what tools or instruments to use (e.g., regulation, penalty or incentive pricing, knowledge development, data sharing, investments, etc.); whether or how to co-ordinate or form partnerships with other actors; and, finally, whether the port authority should act as facilitator or entrepreneur. Thus, the role and function of a port authority needs to be contextual: the managing body of the port can be an investor/entrepreneur in one area of activity but remain the usual 'onlooker' in another.

In line with the above, a number of port authorities in the Rhine-Scheldt Delta move beyond the pure facilitating role by entering into key investments, particularly in those cases where private investors show reluctance to do so, or when there are possibilities to partner with private or public entities. Ports today, however, cannot blindly roll out investments without a Cost-Benefit analysis, included in a positive business plan. Investments are often embedded in a masterplan which is a useful planning instrument and, among others, aims to maximize port efficiency.

Stakeholder 'resistance' can arise, when a public port authority attempts to develop a strong entrepreneurial role. Such resistance can manifest itself in the form of rising conflicts with customers and supply chain actors, about commercial investments of the port authority which could potentially undermine its presumed market neutrality, or conflicts with local community groups on the correct local input payback, or relevance of investments made beyond the port perimeter or even overseas.

Finally, as was discussed earlier, port authorities in the Delta have a facilitating role to play (and do play) as community builders. For example, the port authorities work together with multiple organizations in order to improve the perception of the ports for the surrounding communities with a myriad of active port promotion projects. Port authorities also play an active role in pushing ecosystem/cluster creation further by improving social interactions between companies and their employees.

7.1.7. Structured summary on proposition 4.1

Proposition 4.1. "The role adopted by managing bodies of ports in the Rhine-Scheldt Delta should not go beyond the role of 'facilitator'"	
Overall evaluation: Refute conditionally	
Arguments & observations in support of the proposition	**Arguments & observations going against the proposition**
1. Port authorities in the Delta already play a facilitating role in shaping efficient hinterland networks, land management, digital transformation, green supply chain management, energy efficiency, energy transition and the circular economy. 2. Port authorities in the Delta have an important facilitating role to play (and do play) as community builders. 3. Stakeholder 'resistance' can arise, when a public port authority attempts to develop a strong entrepreneurial role.	1. In each area of port activity and for every individual initiative, port authorities and their stakeholders should evaluate whether a) the port authority may have a statutory role to play and b) if so, whether such involvement is likely to lead to a superior outcome, compared to no involvement. 2. A port authority can move beyond the pure facilitating role by entering into key investments, particularly in those cases where private investors show reluctance to do so, or when there are possibilities to partner with private or public entities. 3. A port authority can be an investor/entrepreneur in one area of activity but remain the usual 'onlooker' in another. 4. Commercial investments of the port authority in or outside the port perimeter do not by definition undermine its presumed market neutrality.

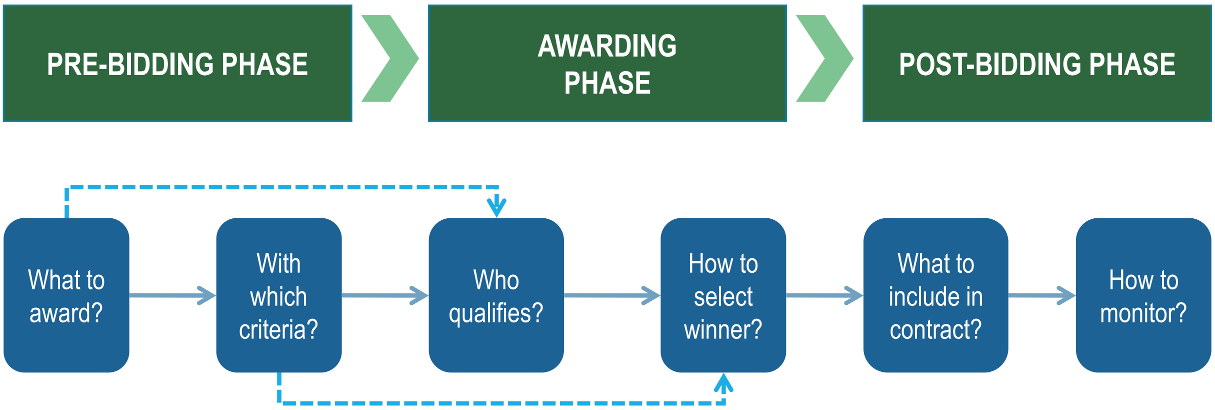
7.2. Proposition 4.2

Proposition 4.2. Concession policy in ports should focus more on sustainability while guaranteeing flexible business development for new and existing concessionaires.

7.2.1. Terminal concessions

Many ports, among which ports in the Rhine-Scheldt Delta, have adopted some sort of landlord port authority model. Under this model, the landlord port authority typically is a separate entity under public law established by a specific legislation with the capacity to conclude contracts, to enforce standards, and to make rules and regulations applicable within the port area. Port operations (especially cargo-handling) are carried out by private companies. Under the landlord model, the concessioning of terminal operations to private operators has become common practice. A terminal concession is a grant by a government or public port authority to a (private) terminal operator in view of providing port terminal services. Landlord port authorities are challenged to develop effective terminal awarding procedures in view of attracting private terminal operating companies. At the same time, port authorities can use a well-designed concession policy to retain some control on the supply side of the port market and to optimize the use of scarce resources (Notteboom, 2006; Pallis et al., 2008; Notteboom and Lam, 2018).

Figure 7.1: Phases in the concession procedure



A typical terminal awarding procedure consists of three phases: the pre-bidding phase, the selection phase, and the post-bidding phase (Figure 7.1). In the pre-bidding phase, the port authority makes the necessary preparations for the awarding taking into account prevailing regulatory conditions. This includes decisions on criteria related to the qualification and selection of candidates and the desirable concession duration. In the awarding phase, the eligible candidates are screened, bids are evaluated, and the most appropriate candidate is selected. This could be preceded by a qualification round in which the number of potential candidates is narrowed down using thresholds in terms of, e.g., financial strength or experience. In the post-bidding phase, a legally binding concession agreement is signed with the selected candidate, and the company's performance is monitored during the contract term. If necessary, correcting measures are taken and disputes are settled.

In the Rhine-Scheldt Delta, quite a few port authorities are evaluating existing practices and exploring new methods to structure terminal awarding processes and to design agreements between port authorities and terminal operators. The granting of terminal concessions and leases in seaports is a highly complex matter guided by regulatory, economic, environmental, and technical considerations. Key issues in the concessioning of terminals include the allocation mechanisms used for granting seaport concessions, the determination of the concession term (and possible prolongation) and concessions fees, and the inclusion of special clauses (e.g., throughput guarantees) in the concession contract aimed at assuring that the terminal operator will act in the interest of the port authority and the wider community. Ports in the Rhine-Scheldt Delta typically have general rules applicable to all concessions ('algemene voorwaarden') and specific conditions ('bijzondere voorwaarden) that relate to an individual concession. There is quite some literature available on the design of effective terminal awarding procedures and on key issues in drafting of general and specific conditions (see e.g. Theys and Notteboom, 2010; Ferrari and Basta, 2009). Notteboom et al. (2012) discuss the development of a "good practice guide" to help individual port authorities in Europe with the development of sound and effective terminal award procedures and contracts.

7.2.2. Sustainability and concession policy

The 2019 ING report on green supply chain management in ports (Notteboom et al., 2019) demonstrated that ports in the Rhine-Scheldt Delta are at the forefront of the greening of ports. They recognized quite early the necessity to carefully consider environmental issues in their strategic planning and behavior, and to communicate actively with the entire range of stakeholders through - amongst others - sustainability reports. They are also very instrumental in enhancing cooperation among ports on environmental matters (for example through the Ecoports foundation, the Environmental Ship Index, etc.).

Terminal activities are prime sources of the environmental impact of seaports which can be summarized into several categories, namely, 1) port construction-related pollution, 2) air emissions of ships at berth and terminal handling equipment (such as cranes and yard equipment), 3) noise associated with cargo handling operations, and 4) the environmental effects and potential congestion associated with landside operations of barges, rail, and trucks. Environmental impacts occur at all stages of a site's life cycle, i.e., port planning, terminal construction, terminal operation, terminal expansion, or terminal closure/termination.

While ports communicate extensively on new and existing initiatives in the fields of energy transition, the circular economy, green ships, green hinterland transportation and broader sustainability issues, it is not always clear how the focus on (environmental) sustainability is translated into terminal awarding processes and broader concession policy. More in particular, significant differences can be observed among individual concession procedures and ports in terms of:

- The inclusion of environmental aspects in the general conditions of the port's concession policy;
- The information the candidates have to provide during the selection phase on the expected environmental and territorial impact of the site's activity and the actions candidates propose to eliminate, reduce, or mitigate certain effects;
- The inclusion and role/weight of environmental criteria as part of the final selection round (i.e. environmental performance as a factor in the qualification and selection phases of a terminal awarding process);

- The inclusion of green performance clauses in the post-bidding phase, particularly when drafting the concession agreement. This could refer, for example, to clauses related to (compulsory) environmental reporting, the use of investment thresholds in specific technical equipment (e.g. cold ironing/on-shore power for vessels at berth, or the use of electric/hybrid yard equipment) or hard or soft modal split targets in hinterland transport.

Given the potential environmental impacts of terminal development and operations, port authorities or any other managing body of a seaport are challenged to avoid and or reduce effects through a range of green management instruments. These instruments can be classified in four distinctive groups: 1) penalty and incentive pricing, 2) monitoring and measuring, 3) market access control, and 4) environmental standard regulation. Such type of instruments could in principle also be considered to extend sustainability considerations in each of the four phases of the terminal concession procedure. Examples of instruments to increase environmental sustainability in concession procedures are included in Figure 7.2.

Figure 7.2. Instruments potentially available to port authorities to reduce environmental impacts of terminals (TO = terminal operator).

INSTRUMENTS THAT DIRECTLY LIMIT ENVIRONMENTAL IMPACTS	
Setting of fixed impact reduction targets	
Single-source instruments ("command and control")	
TO needs to comply with an emission limitation or face penalties	
Harm-based standards	Description of required end results (e.g. cap on CO2 emission of terminal)
Design standards	Description of required emission limits based on model technology
Technology specifications	Specification of the technology the TO must use to control its pollution
Bans and limitations	Ban or restrict equipment or operations that present unreasonable risks
Multi-source instruments (limits on cumulative impacts from multiple sources)	
TO has some flexibility in how it complies with specific environmental targets => change own behavior or make other entities comply on the TO's behalf	
Integrated permitting	Multiple requirements into a single permit
Tradeable emissions	Allow TOs to trade emission control repsonsibilities among themselves given an aggregate regulatory cap on emissions
Challenge regulations	TOs are given responsibility for designing and implementing a program to achieve imposed target.
INSTRUMENTS THAT DO NOT DIRECTLY LIMIT ENVIRONMENTAL IMPACTS	
Encouragement of pollution control without setting specific emission targets	
Pollution charges	TO pays fixed amount for each unit of pollution (no ceiling)
Liability	TO pays compensation to those that are harmed by impacts
Information reporting	TO needs to report impacts publicly
Subsidies/discounts	Financial assistance or discounts to TOs as an incentive/carrot to change their behavior, or to help defray costs of mandatory standards.
Technical assistance	Knowledge support to TOs (good practice guide, training, information centre)

Source: adapted and extended from Office of Technology Assessment (1995) and Notteboom and Lam (2018).

7.2.3. Key issues related to sustainability and concession policy

There are a number important considerations in this regard, which are discussed below.

Changes in general conditions: In case the port has general conditions ('algemene voorwaarden') applicable to all existing and future concessions, any changes in these conditions (for example to promote sustainability) need to be carefully evaluated on their desirability, feasibility and expected effectiveness. Historic concessions can be strongly negatively affected by unilateral changes in the general conditions enforced by the port authority. To avoid unintended consequences and collateral damage, dialogue between branch associations, individual concessionaries and the port authority is key to effective concession reforms. During such discussions, which do take place in RSD ports, it should be acknowledged that not all concessionaires have the same bargaining power.

Finding a balance: It is imperative to find a balance between, on the one hand, the flexibility and commercial freedom of the concessionaire, and, on the other hand, the desire of the managing body of the port to deploy concession policy in view of reaching certain economic and sustainability objectives. Concessionaires typically demand **legal certainty** and **a level playing field** so that they can build up commercial activities on the site during the allocated concession term without being pushed in a rigid straightjacket by the port authority, or ending up in a disadvantaged position vis-à-vis other concessionaires. While port authorities might feel the urge to increase their control over and involvement in the detailed modalities for port land use (particularly when there is a strong demand for port sites)[6], some level of **hands-off approach** is beneficial to gain voluntary commitment of concessionaires in terms of business development and sustainability on the respective allocated sites.

Throughput guarantees are among the most commonly used performance clauses in concession contracts. They are a popular way for port authorities to secure efficient and rational land use. Stringent demands regarding the use of space by the concessionaires can in principle lower the entry barriers to newcomers. In theory, a port authority could retract or reallocate certain parts of the site due to under-utilization. By integrating hard throughput guarantees, efficient land use becomes a shared responsibility between port authority and terminal operator.

Although some contracts mention throughput guarantees, ports such as Antwerp-Bruges generally apply the **investment amount** per m^2 as the dominant guiding principle for determining the concession term. In some cases, the concessionaire is given a further limited extension of the concession term subject to meeting some criteria in terms of investments or operational performance. First, the setting of investment thresholds could ideally follow a **differentiated approach by taking into account the type of activity**. Indeed, some port activities are by nature very asset-heavy implying huge investments, while other types of activities might require far less investment. Not opting for such a differentiated approach might imply that some essential port activities could be gradually squeezed out by very capital-intensive activities or sectors, thereby reducing the port's diverse activity portfolio. Second, it is also worthwhile exploring to what extent these investment thresholds could be **differentiated based on the sustainable nature of the investment**. Such an approach would imply that investment in, for example, electric/hybrid terminal equipment or on-shore power facilities would have a higher weight in the investment assessment than investments that do not really promote sustainability.

In general terms, a concession policy focused on **incentives and rewards** has more appeal to concessionaires than one based on **rigid enforcement linked to penalties**. Hard rigid performance targets linked to penalties might only work when the terminal operator feels he has full control of the situation under which the targets need to be achieved, and when the port authority has uncontestable tools available to objectively observe the enforcement of the clause in the concession agreement.

[6] An example: some port authorities are exploring ways to have a say whenever the shareholding/ownership of a terminal operator changes. Also, they might want to extract some of the surplus value a company realizes when transferring its concession.

However, even then, hard targets combined with high penalties will give the contract a rigidity that could be inefficient. Only credible threats should be included into a concession agreement. In a well-tailored concession contract, sanctions are such that the parties do not respect the rules when and only when it is optimal not to respect them. Penalties (but also bonuses/rewards if any) should ideally reflect the economic costs and benefits of the behaviors that they are trying to prevent or promote. Non-credible threats and sanctions are not effective because their presence in the concession agreement weakens the reliability and legal certainty of the whole text. As terminal operators do not take them into account and as the port authority does not punish the violation of them, the port authority acquires a reputation of non-enforcement that induces the terminal operator to violate the rules or try to renegotiate any decision it does not like. The same principles apply if one would consider the inclusion of rigid environment-related performance clauses in concession agreements such as modal split guarantees with respect to hinterland transport.

A **soft target approach** is preferred over hard sustainability targets. However, such a soft target approach works best when it is combined with a periodical dialogue between port authorities and concessionaires. Through periodical dialogue soft targets can be revised based on an evaluation of the current market conditions and strategies. This approach can be combined with a ‘carrot’ policy whereby a port authority rewards terminal operators who are doing much more than the soft target. These incentives can, for example, take the form of a differentiated discount or rebate on concession fees linked to how much better the concessionaire is performing above the soft target level. The most obvious drawback is that soft targets are not legally binding. So, soft targets only work if both concessionaires and port authorities are committed to reach a better economic and environmental performance. As soft targets do not really have a legal binding nature, it is often difficult to include them as a clause in the concession agreements.

A key question remains whether or not **specific economic and/or environmental targets** should be used in the first place to influence the behavior of the concessionaires. It may be more appropriate in some cases to achieve the objective through the basic allocation of responsibilities or a modification of the concession fees. Moreover, specific performance guarantees will deliver the expected results only if the performance of the terminal operator can be adequately monitored and if the (hard) targets can be enforced.

Finally, while policy de facto supports the role of ports in energy transition and environmental sustainability, the **regulatory complexity in infrastructure projects and land management** might undermine the potential to reach targets. For example, the capacity of the installed capacity of wind turbines and solar panels on a concession is strongly determined according to subsidy schemes and opportunities. This can lead to a situation whereby concessionaries can/will not install the maximum capacity in every place where a permit is obtained, but let it depend on which subsidy one can get.

7.2.4. Structured summary on proposition 4.2

Proposition 4.2. "Concession policy in ports should focus more on sustainability while guaranteeing flexible business development for new and existing concessionaires."

Overall evaluation: Accept

Arguments & observations in support of the proposition	Arguments & observations going against the proposition
1. There is more regulatory pressure from supranational and national authorities and suppliers/customers to promote sustainability in ports. 2. To avoid unintended consequences and collateral damage, dialogue between branch associations, individual concessionaries and the port authority is key to effective concession reforms. 3. While port authorities might feel the urge to increase their control over and involvement in the detailed modalities for port land use, some level of hands-off approach is beneficial to gain voluntary commitment of concessionaires in terms of business development and sustainability on the respective allocated sites. 4. When using investment thresholds in a concession context, it is worthwhile to consider a differentiated approach by taking into account the type of activity and the sustainable nature of the investment. 5. A concession policy focused on incentives and rewards typically has more appeal to concessionaires than one based on rigid enforcement linked to penalties. 6. A soft target approach is preferred over hard sustainability targets.	1. Significant differences exist among individual concession procedures and ports in terms of the inclusion of environmental aspects in concession policy. 2. Risk of divide between existing/historic and new concession procedures/agreements negatively affecting the level playing field between concessionaires. 3. Regulatory complexity in infrastructure projects and land management might undermine the potential to reach sustainability targets.

8. Theme 5: Sustainable ports

8.1. Proposition 5.1

Proposition 5.1. In the medium term, any large-scale hydrogen adoption will rely on blue hydrogen and less on green hydrogen.

8.1.1. The future energy landscape

The majority of the required energy for the coming decade will still be produced from fossil sources. The largest growth rate, however, will be seen for renewable energy sources. Recent reports on 'The World Energy Outlook' of the International Energy Agency (IEA) summarize the main issues affecting the longer-term global energy mix:

- The world's energy needs continue to grow. The IEA main scenario points to a 30% rise in global energy demand to 2040. Still, a higher energy efficiency and a growing use of cleaner energy sources worldwide should help to curb energy-related CO2 emissions.
- The share of electricity in global final energy consumption is approaching 20% and is set to rise further. Electricity is increasingly used in economies focused on lighter industrial sectors, services and digital technologies. In advanced economies, electricity demand growth is modest, but the investment requirement is still huge as the infrastructure needs to be upgraded.
- Efficiency gains from more stringent energy performance standards play an important role in the evolution of energy demand.
- Renewable energy is expected to see the fastest growth. Natural gas is expected to be the strongest grower among the fossil fuels, with consumption rising by 50% by 2040. Coal use saw strong growth in recent years, but for the future no further growth is expected. Growth in oil demand is expected to slow to 103 million barrels per day (mb/d) by 2040. By the mid-2030s developing countries in Asia are expected to consume more oil than the entire OECD.
- Countries are generally on track to achieve, and even exceed in some instances, many of the targets set in their Paris Agreement. While these efforts are sufficient to slow the projected rise in global energy-related CO2 emissions, they are insufficient to limit warming to less than 2 °C. Therefore, the EIA underlines the importance of the five-year review mechanism, built into the Paris Agreement, for countries to increase the ambition of their climate pledges. This should include actions in the field of (1) the acceleration of the deployment of renewables, nuclear power and carbon capture and storage; (2) greater electrification and efficiency across all end-uses; and (3) clean energy research and development effort by governments and companies.
- The main scenario in the EIA study shows that about 60% of all new power generation capacity to 2040 will come from renewables. The majority of renewables-based generation will be competitive without any subsidies. Therefore, EIA expects that by the 2030s global subsidies to renewables will start declining. However, cost reductions for renewables will be insufficient to secure an efficient decarbonization of electricity supply. Structural changes to the design and operation of the power system are needed to ensure adequate incentives for investment and to integrate high shares of variable wind and solar power.

- The rise of solar power and wind power gives unprecedented importance to the flexible operation of power systems in order to secure enough energy at all times. The cost of battery storage declines fast, and batteries increasingly compete with gas-fired peaking plants to manage short-run fluctuations in supply and demand. However, conventional power plants remain the main source of system flexibility, supported by new interconnections, storage and demand-side response.
- Despite the above ambitions and expectations on the use of renewables, fossil fuels such as natural gas and oil will continue to form the backbone of the global energy system for the coming few decades. By 2040 oil demand is expected to return to the levels of the late 1990s while the use of coal will move to levels last seen in the mid-1980s. Only gas will see an increase relative to today's consumption level. Based on an increase of the oil price in the long-term, the trend for exploration of fossil energy sources will continue to offshore locations rather than onshore and to deeper waters and harsher environments. More complex energy sources such as tar sands or methane hydrates will also be exploited. Energy production on offshore wind farms will significantly increase and also other water-based energy production devices using wave and tidal current energy will have a larger market. These developments will lead to a large increase in renewable energy, particularly in Europe. It will also result in a significant increase in production and transport of cleaner fuels such as hydrogen.

8.1.2. The rising focus on renewable/green hydrogen

Hydrogen accounts for less than 2% of Europe's present energy consumption and is primarily used to produce chemical products, such as plastics and fertilizers. 96% of this hydrogen production is through natural gas. This is called grey hydrogen using a process of steam methane reforming, where natural gas is mixed with very hot steam and a catalyst. Blue hydrogen is also hydrogen produced from natural gas, but this process is made carbon-neutral by capturing and storing the CO_2 emissions (also called Carbon Capture and Storage or CCS). For the start-up phase of large-scale hydrogen, it is expected that blue hydrogen combined with CCS will play a major part.

Renewable or green hydrogen can be obtained via electrolysis using renewable electricity to split water into hydrogen and oxygen. Green hydrogen is said to have no carbon impacts as the energy used to power electrolysis of water comes from renewable sources like wind, water or solar. The use of green hydrogen as a raw material and fuel can reduce emissions in industry and make a major contribution to the 2030 and 2050 climate targets. When produced at times when solar and wind energy resources are abundantly available, renewable hydrogen can also support the electricity sector, providing long-term and large-scale storage and improve the flexibility of energy systems by balancing out supply and demand.

Green hydrogen has made an undulating movement as an alternative energy source in the past decades. It came and disappeared from the radar again and again. The latest wave is very massive with large investment budgets and countless projects being released. At the same time, the search for the cheapest way to produce and transport hydrogen has intensified. Key questions include: 'From what distance is it worth transporting via ships?', 'When do we use pipelines?' and 'Under which form are going to transport hydrogen?' (i.e. gaseous, liquid, bound with metals (metal hydrides) or carbon) and 'When can we avoid conversion again ? (e.g. immediately enter the industry in gaseous form). The 2020s present a big race for technology leadership, as costs are likely to fall sharply with learning and scaling-up of needed infrastructure. But demand is expected to only take off in the mid-2030s (IRENA, 2022). By that time, green hydrogen will cost-compete with fossil-fuel hydrogen globally, and this is poised to happen even earlier in countries like China, Brazil, and India. There is a strong focus on technological innovations in and the manufacturing of equipment like electrolysers and fuel cells.

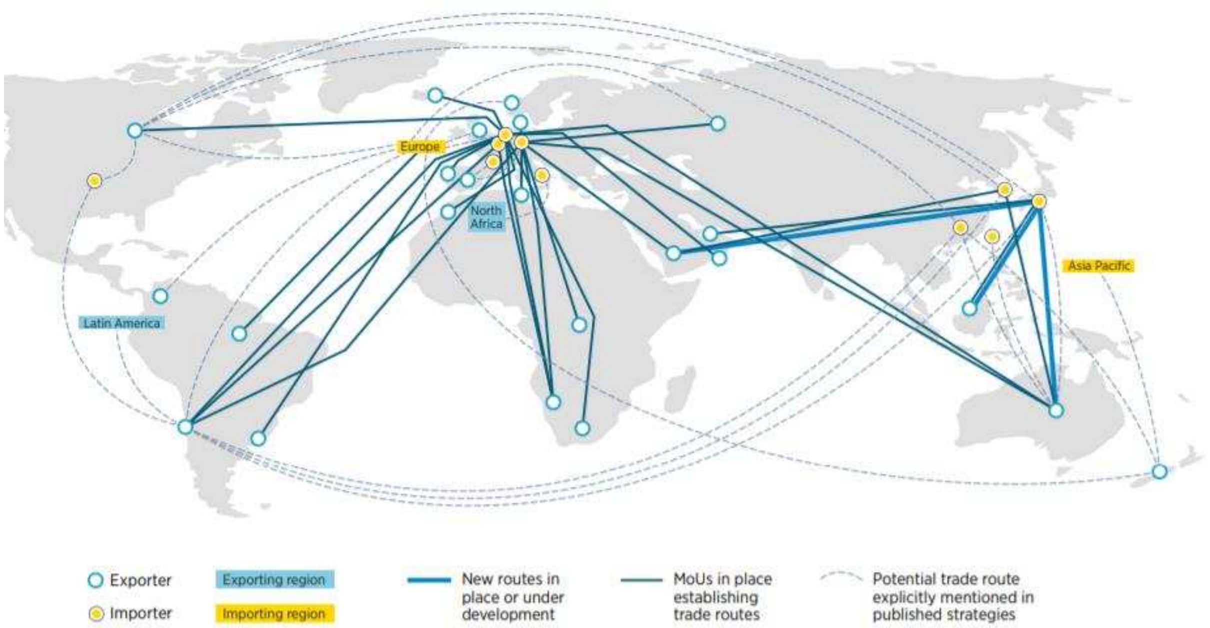
There is also more regulatory and political support in recent years. For example, European policy for a long time was unclear about the potential role of renewable hydrogen in the energy transition and decarbonization debate. In recent years, the European Union has created a new momentum with its Hydrogen Strategy which was adopted in 2020. The EU's hydrogen strategy explores the potential for renewable hydrogen to help decarbonize the EU in a cost-effective way and in line with the European Green Deal. It puts forward a vision for the creation of a European hydrogen ecosystem from research and innovation to scale up production and infrastructure to an international dimension.

8.1.3. The geo-economics of renewable/green hydrogen

According to the International Renewable Energy Agency (IRENA), hydrogen is likely to influence the geography of energy trade, further regionalizing energy relations, with the emergence of new centers of geopolitical influence built on the production and use of hydrogen (IRENA, 2022). At present, over 30 countries and regions are planning for active growth in cross-border hydrogen trade. IRENA estimates that over 30% of hydrogen could be traded across borders by 2050, a higher share than natural gas today.

Net energy importers such as Chile, Morocco, and Namibia are emerging as green hydrogen exporters while fossil fuel exporters, such as Australia, Oman, Saudi Arabia, and the UAE, are increasingly considering green hydrogen to diversify their economies. Some countries that expect to be importers are already deploying dedicated hydrogen diplomacy such as Japan and Germany.

Figure 8.1. An expanding network of hydrogen trade routes, plans and agreements



Source: IRENA (2022)

According to IRENA, hydrogen is set to cover up to 12% of global energy use by 2050. The transition to hydrogen is not a fuel replacement but a shift to a new system with political, technical, environmental, and economic disruptions.

In terms of the supply-demand ratio, the technical potential for hydrogen production significantly exceeds the estimated global demand. Therefore, realizing the potential of regions like Africa, the Americas, the Middle East, and Oceania could limit the risk of export concentration, but many countries will need technology transfers, infrastructure, and investment at scale.

The P4G-Getting to Zero Coalition Partnership analyzed concrete business opportunities in South Africa (Ricardo & Environmental Defense Fund, 2021), Mexico and Indonesia that could tap into their high renewable potential and create an export market for clean hydrogen-derived fuels while creating green jobs (World Economic Forum, 2022). For example, Boegoebaai, a proposed deep water port planned for South Africa's Northern Cape province, is set to become an export hub for green hydrogen and sustainable goods from the province. The country's Hydrogen Valley will aggregate demand to kickstart hydrogen production and leverage economies of scale. A maritime hub in Durban – Richards Bay aims to bunker and export green hydrogen to the maritime market.

8.1.4. Hydrogen valleys

The growing focus on hydrogen has given impetus to the development of so-called hydrogen valleys, which are regional ecosystems that link hydrogen production, transportation, and various end uses such as mobility or industrial feedstock. These hydrogen valleys are considered important steps towards enabling the development of a new hydrogen economy (Roland Berger, 2021). To support the concept, a Hydrogen Valley Platform was set-up commissioned by the European Union and developed by the Fuel Cells and Hydrogen Joint Undertaking. The global information sharing platform to date already features 32 global Hydrogen Valleys spread over 21 countries with a cumulative investment volume of more than 32.4 billion euro (data www.h2v.eu in late August 2022). Hydrogen valleys are thus aimed at building ecosystems around hydrogen locally. By 2050 there would be about 50 in the EU. Worldwide the number is expected to reach 100 in 2030. Ports are important nodes given the high local demand for hydrogen, the landing of offshore parks and as intermodal transport nodes of which some might shift to hydrogen as a fuel.

8.1.5. The Rhine-Scheldt Delta port system and green hydrogen

Royal Haskoning (2022) presents 17 factsheets on the new energy landscape and its impact on ports. Table 8.1 summarizes the general interpretation of the potential physical impact on port infrastructure, but the impact in practice will be port specific. The table is focused on throughput, cargo handling and needed facilities (incl. grid, pipelines, road, rail, water) in the port to service energy related logistics. The highlighted text sections in the second column demonstrate that hydrogen has a role to play in 12 of the 17 aspects of the new energy landscape.

One major asset of companies in the Rhine-Scheldt Delta port area is that they are active in all parts of the hydrogen value chain. With its favorable location, well-developed pipeline network connecting neighboring states, worldwide maritime connections, terminal and logistics infrastructures, industrial clusters and a strong customer base, the Delta is able to take up an important pioneering role to supply Western Europe and to position itself as a hydrogen import, transit and production hub.

Seaports in the Rhine-Scheldt Delta are stepping up their efforts to become energy and feedstock hubs and growing producers of green hydrogen. Ports are aware it is essential that they can offer affordable green energy to all players in the port areas at all times to keep the big industry in the region. Both local production and import play a crucial role for this. The first projects related to the import of renewable energy are expected to take shape between 2025 and the end of this decade. Extensive feasibility studies are conducted to analyze ideal sourcing regions, to prepare the seaports for receiving the hydrogen carriers of the future and to set up specific pilot projects in the context of a sustainable economy.

Table 8.1. 17 aspects of the new energy landscape and potential impact on ports

	Main focus	MARITIME TRANSPORT	WATERWAY & IWT	QUAYS	TERMINALS	STORAGE	PORT AREA NETWORKS	HINTERLAND CONNECTIONS
A. PORT								
A1. Energy saving	Lighting, energy storage/recovery systems, smart energy management technologies, energy efficiency improvements in buildings (such as upgrading insulation), and electrification of mobile equipment			×	×			
A2. Decarbonisation port equipment	Electrification through retrofitting or replacement of existing diesel port equipment with electric/hybrid drives. In the future, complementary to batteries, **low-to-zero carbon fuels such as hydrogen** (combined with a fuel cell or engine).			×	×		×	
A3. Onshore power supply (OPS)	Seagoing vessels and inland barges are (partially) supplied with electricity from shore. In the future, also batteries on board ships could be powered with OPS.	×	×	×			×	
A4. Clean fuel bunkering	LNG, **liquid Hydrogen, Ammonia, and Methanol,** are currently foreseen as most likely maritime fuels. Regardless of which fuel, or combination of fuels, is chosen, ports must plan now (fuel availability, emission targets, safety and handling requirements)	×	×	×		×	×	
A5. On-site renewable power	Localised energy generation from renewable sources such as solar or wind. If linked with Energy Storage Systems (ESS), on site renewables can mitigate peak rate tariffs and provide ports with significant cost savings.				×		×	
B. WIDER PORT AREA								
B1. Waste to energy and chemicals	Incineration (combustion of waste with energy recovery) + waste-to-fuels + waste-to-chemicals. New and emerging technologies can produce energy from waste without direct combustion.	×	×	×	×	×		×
B2. Offshore energy	Energy generated offshore is to typically integrated into onshore power systems (via electricity grid or gas). Two main challenges: (1) Distribution: expansion or upgrade of the current onshore networks; and (2) Storage: **land-side energy storage facilities need to balance the fluctuating supply and demand** and connection between offshore and onshore infrastructure.						×	
B3. Offshore industry	Offshore wind farms (OWF): Europe has a total installed capacity of 25 GW. Targets: at least 60 GW by 2030, and 300 GW by 2050. **The transformation of (excess) wind power to hydrogen** may lead to additional energy infrastructure in ports, for example electrolysers converting power to hydrogen in the port, and pipelines bringing hydrogen produced offshore to the port and further inland.	×	×	×	×	×	×	×
B4. Industry decarbonisation	Decarbonization of energy intensive industries like refineries, steam crackers, **(gray) hydrogen and ammonia producers**, chemical and plastics industry, iron, steel and cement industry through electrification, improved heat integration, using renewable or bio-based fuels and feedstocks, make use of residual heat and/or adding Carbon Capture, Utilisation and Storage (CCUS, for example CO2 as a feedstock to producesynthetic fuels).	×	×			×	×	×
B5. Sustainable urban energy	Ports as energy hubs for the urban distribution of renewable electricity (wind and solar), **renewable fuels (e.g., hydrogen, bio-based fuels)**, renewable and/or residual heat and cooling.						×	
B6. Energy conversion	The conversion between electrons and fuels, through power-to-gas and gas-to-power technologies for a reliable and flexible energy system and to provide carbon neutral fuels and feedstock. The **conversion of hydrogen to zero/low carbon fuels** also lead to the deployment of energy conversion infrastructure.			×	×		×	×
B7. Energy storage hubs	(liquid) storage will play a key role in the energy transition. Fuels that may be transported in ships and impact ports: LNG, **Hydrogen in pure form (GH2 and LH2), Hydrogen carried in other liquids (liquid organic hydrogen carrier or LOHC), and in derived forms (Ammonia and Methanol)**.		×	×	×	×	×	×
B8. CCUS	CCUS is currently one of few solutions available to tackle emissions from heavy or energy-intensive industries, the so-called hard-to-abatesectors, including those typically within or surrounding port areas. **For the start-up phase of large-scale hydrogen, it is expected that blue hydrogen combined with CCS will play a major part**.				×	×	×	×
C. ECONOMY & COMMUNITY								
C1. Zero-/low emission fuel supply chains	Zero/low carbon fuels can be used in industry as a feedstock or fuel, as a fuel for transportation, or as a heat source. **The most frequently mentioned fuels are green hydrogen, green ammonia, green methanol and biofuels.** Ports could play an active role as as facilitator, import/export, bunkering, storage, production, transit of zero/low carbon fuels and carbon capture of fossil fuels and/or **blue hydrogen.**	×	×	×	×	×	×	×
C2. Zero-/low emission electron supply chains	Renewable power generation, mainly by means of solar and wind, requires the availability of a back-up system of conventional power plants. **Seasonal energy storage in the form of hydrogen** could help to decarbonise dispatchable power through gas turbines or fuel cells.					×	×	×
C3. Circular economy	In a full circular economy materials and resources will be used in closed loop systems which can still range over multiple countries. Bio-based materials such as wood and bioplastics and plant-based products will be increasingly used as a fuel, feedstock or material.	×	×	×	×	×	×	×
C4. Decarbonisation of transport	In this transition there are three important developments: electrification:, zero/low carbon fuels (**most promising are bio-based and synthetic fuels including hydrogen**), modal shift.					×	×	×

Source: own compilation based on findings Royal Haskoning (2022)

As of 30 August 2022, three hydrogen valleys are included in the Hydrogen Valley Platform (www.h2v.eu). One of these is *Europe's Hydrogen Hub* (H2 Proposition Zuid-Holland/Rotterdam) with lead developers Port of Rotterdam, Stedin, Innovation Quarter, Economic Board Zuid-Holland, Province of Zuid-Holland and Municipality of Rotterdam. The investment would amount to 1 billion euro for a hydrogen production of 3,180 tons per day. Another one is *HEAVENN* by the New Energy Coalition, a large-scale demo project bringing together core elements production, distribution, storage and local end-use of hydrogen into a fully-integrated and functioning Hydrogen Valley. The third hydrogen valley concerns the *Hydrogen Delta Program* which is a Dutch-Belgium cross-border industrial cluster focused on the implementation of large-scale green (and blue) hydrogen as a feedstock material in the chemical, refinery and steelmaking industry (see https://www.smartdeltaresources.com/ for further info).

In the Summer of 2022, the Dutch Minister for Climate and Energy Rob Jetten announced the final plans for the construction of a national transport network for hydrogen (Figure 8.2). Gasunie will be installing the hydrogen network in the Netherlands in the coming years and will then also assume the role of manager of the hydrogen network. This is a major step in the development of a more sustainable energy system in the Netherlands, although there are major concerns about the future electricity/energy availability in the country. In the coming years, the hydrogen network will connect the seaports with the large industrial clusters and with storage locations for hydrogen. Connections with Germany (Ruhr area and Hamburg) and Belgium are also being realized. In developing the hydrogen network, existing pipelines are mainly used that become available because there will be less and less natural gas transport in the coming years. Approximately 85% of the national network will consist of reused natural gas pipelines.

Figure 8.2. Proposed hydrogen network development in the Netherlands by the year 2030

Source: Gasunie

In late October 2021, the **Belgian federal government** approved its first **hydrogen strategy**. On October 12th 2022, the federal government approved an update of this strategy to reflect the state of its implementation. Additional measures were announced in light of recent developments in the sector. The federal hydrogen strategy aims to use hydrogen and renewable molecules to make certain applications climate neutral where electrification is not economically viable or technically not realistic. This mainly concerns industry and freight transport. The strategy consists of four pillars for which several concrete measures have been identified in which seaports play a key role (FOD Economie, 2022):

- Pillar 1 – Positioning of Belgium as a hub for the import and transit of renewable molecules in Europe
- Pillar 2 – Strengthening the Belgian leadership in hydrogen technologies
- Pillar 3 – Creating a robust hydrogen market
- Pillar 4 – Investing in collaboration for a successful implementation

In the past few years many large scale hydrogen projects in the Rhine-Scheldt Delta have been announced. In July 2022, Shell announced the construction start of **Holland Hydrogen I**, which will be Europe's largest renewable hydrogen plant once operational in 2025. The 200MW electrolyser will be constructed on the Tweede Maasvlakte in the port of Rotterdam and will produce up to 60,000 kilograms of renewable hydrogen per day. The renewable power for the electrolyser will come from the offshore wind farm Hollandse Kust (noord), which is partly owned by Shell. The renewable hydrogen produced will supply the Shell Energy and Chemicals Park Rotterdam, by way of the HyTransPort pipeline, where it will replace some of the grey hydrogen usage in the refinery. This will partially decarbonize the facility's production of energy products like petrol and diesel and jet fuel. An overview of all hydrogen projects in the port of Rotterdam in the field of import, production, pipelines and green mobility can be found at the 'hydrogen in Rotterdam' page[7].

Also in July 2022, Hydrogen company HyCC launched its plans for the construction of **Project H2era**, a 500-megawatt green hydrogen plant at the Port of Amsterdam. HyCC intends to start operations of the new plant in the Amsterdam port area in 2027. HyCC and the Port of Amsterdam have completed a first feasibility study and the project will be further developed during the study phase. It is the intention of H2era to produce green hydrogen and oxygen from renewable electricity and water and to use this hydrogen for the decarbonization of industries in the region and green mobility. In the future, the new plant can also be connected to the proposed national pipeline network to enable the exchange of hydrogen between industrial clusters.

In Belgium, a **hydrogen import coalition** has been launched including the port of Antwerp-Bruges, dredging company Deme, shipping company Exmar, grid operator Fluxys, energy supplier Engie and the organization Waterstofnet. The coalition argues that Belgium must import renewable energy in the form of hydrogen on a large scale if the country wants to be a carbon neutral by 2050. Domestic renewable energy production would not be sufficient to make Belgium's energy needs carbon neutral by 2050. Importing energy assumes that solar and wind electricity is generated elsewhere in the world and converted on site into hydrogen (or another carrier such as methanol or ammonia) and shipped to Belgium, where it can be converted into electricity again. Investigating the technical and economic feasibility of such solutions is the first step in the concrete development of hydrogen-based energy production and consumption. A separate fleet should only be developed for the transport of hydrogen, which is stored at an extremely low temperature. Ideally, these ships also sail on the same fuel that

[7] See https://www.portofrotterdam.com/en/port-future/energy-transition/ongoing-projects/hydrogen-rotterdam

they transport, to ensure that this 'green' energy also reaches its destination in a sustainable way. Zeebrugge is the designated point to bring the energy ashore. Not only because of the LNG terminal there, but also because a lot of offshore energy comes 'onshore' in the coastal region. The port area of Antwerp comes into the picture as a potential major buyer of this energy because of the energy needs in the petrochemical industry. The Belgian pipeline network is then the connecting link. In the search for locations where the 'renewables' are more easily available and in larger volumes, the role of the affiliated ports of Açu, Cotonou and Duqm is also being examined.

In November 2021, the ports of Antwerp and Zeebrugge (now port of Antwerp-Bruges) signed a Memorandum of Understanding (MoU) with the **government of Chile** to set up a corridor to speed up green hydrogen flows between South America and Western Europe. Through its national Green Hydrogen Strategy, Chile has set very ambitious targets in order to become a carbon-neutral country by 2050 and utilize the high-quality and abundant renewable energy resources available to it. The country aims to be producing the cheapest green hydrogen by 2030 and become one of the top 3 exporters of green hydrogen by 2040. The Port of Antwerp-Bruges and the Ministry of Chile will collaborate on a regular basis in order to exchange knowledge, experiences and other information to further explore the possibilities of the cooperation.

The American company **Plug Power** will build a factory in the Port of Antwerp-Bruges for the production of green hydrogen. It involves an investment of almost 300 million euro. Plug Power is a supplier of turnkey hydrogen solutions for the global green hydrogen economy. Plug's electrolysis plant, with a capacity of 100 megawatts, will be located on the Antwerp site NextGen District. Plug will produce up to 12,500 tons of liquid and gaseous green hydrogen per year (approximately 35 tons per day) for the European market. Construction of the plant will begin upon completion of the permitting process, expected at the end of 2023. The first production of green hydrogen is expected at the end of 2024. The factory will be commissioned before 2025. Plug will contribute to the decarbonization of Port of Antwerp-Bruges logistics flows, with material handling solutions, fuel cell vans via HYVIA – a joint venture between Plug and Renault – and stationary energy solutions for shore power.

Virya Energy, Parkwind, Eoly Energy and Fluxys announced a partnership in 2018 to develop the green energy project **Hyoffwind**. The partners want to build a power-to-gas installation to convert renewable electricity into green hydrogen through electrolysis. Hyoffwind, will have an electrolyser of 25 megawatts, which can be scaled up to 100 megawatts in the long run. The Zeebrugge facility will act as an energy hub.

The number of hydrogen projects (blue and green) in North Sea Port is also mounting fast. Companies produce and consume an estimated 0.58 million tons of hydrogen per year in the port zone. This demand for hydrogen in the port zone will double by 2050 and should be fully sustainable by then (Fluxys, 2022). The main projects and realizations include:

- **SeaH$_2$Land**: Ørsted, one of the world's leading offshore wind developer, together with the major industrial companies in the North Sea Port cluster, have launched a vision for a gigawatt scale project to reduce carbon emissions in the Dutch-Flemish industrial cluster with renewable hydrogen. An 1 GW electrolyser and an offshore wind farm will be developed by Ørsted. The electrolyser is proposed to link to 2 GW of new offshore wind capacity. ArcelorMittal, Yara, Dow Benelux and Zeeland Refinery support the development of the required regional infrastructure to enable sustainably produced steel, ammonia, ethylene and fuels in the future. About 45 km of regional hydrogen pipelines between the Netherlands and Belgium will be developed to exchange hydrogen between industrial players in the region.

- In May 2022, it was announced that Gasunie, Fluxys and North Sea Port have joined forces to develop the first **regional cross-border open-access hydrogen pipeline infrastructure** in Europe by 2026. The connection is expected to make a significant contribution towards developing the entire hydrogen value chain in the port zone. It will also create an open market for green and low-carbon hydrogen in the entire port area, connecting suppliers and customers in a robust system. The infrastructure will also be linked to the national hydrogen infrastructure in the Netherlands and Belgium as well as other industrial clusters and ports in Europe;
- Exchange of hydrogen (by-product) via a pipeline between **Dow and Yara** (completed in 2018);
- **ELYGator** is a project of Air Liquide for 200 MW electrolysis in Terneuzen;
- **H2ero** concerns the development of a 150 MW electrolyser in Vlissingen on-site at Zeeland Refinery (TotalEnergies -Lukoil);
- **Haddock** is a 100 MW electrolyser on-site at Yara Sluiskil with Ørsted;
- **Hy2Zer0** at Dow in Terneuzen uses methane-rich waste streams from the cracking process to produce hydrogen and the current crackers are adapted to run entirely on hydrogen;
- **North-C-Methanol** is being used by ENGIE and ArcelorMittal, among others, via the project in Ghent to make methanol from CO_2.

When it comes to overseas investments, the **HYPORT Coordination Company**, a joint venture between DEME Concessions and OQ Alternative Energy acquired a site in Duqm (Oman) to build a green hydrogen plant. This project on a site of 79 ha will have an electrolysis capacity of 500 megawatts. HYPORT signed a second land reservation agreement with the Public Authority for Special Economic Zones and Free Zones (OPAZ) in the port city of Duqm (Oman). The hydrogen plant in Duqm, a partner port of Port of Antwerp-Bruges, will be powered with renewable electricity from wind turbines and solar panels with a combined capacity of 1.3 gigawatts. All of this is located in the renewable energy area of the Special Economic Zone, where HYPORT Duqm was allocated an area of 15,000 ha. A high-voltage transmission line will come from the solar and wind farm to the factory. There, the green electricity is used to produce desalinated water, hydrogen and then converted it into green ammonia. It is stored and shipped from the port of Duqm to Europe and other markets.

Also end users are developing (smaller scale) initiatives. For example, Tailormade Logistics has concrete plans to produce green hydrogen on its site by using electricity provided by the solar panels on its warehouses. The produced hydrogen would be used for powering its dual-fuel hydrogen trucks. Another example is Antwerp Euroterminal (AET) in the Antwerp port area. In 2021, the innovation platform VIL demonstrated the supply of internal company transport on hydrogen via a mobile filling station at the terminal. As one of the eighteen companies participating in the pilot project, AET is the first within the **'Hydrolog' project** to experiment with hydrogen technology. The terminal experimented both with the mobile hydrogen filling station and with a hydrogen-powered electric tractor and forklift for handling containers.

Overall, hydrogen connects different parties and stimulates cross-value chain collaboration in and outside seaports. There are many examples of this such as the PIONEERS consortium (https://pioneers-ports.eu/) funded by the European Commission and uniting 46 partners to work together to address the challenges faced by European ports to reduce their environmental impact. PIONEERS builds on the commitment of lighthouse port Port of Antwerp-Bruges to scale-up the current state-of-the-art and to demonstrate applicability and feasibility through several demonstrations. The port of Barcelona, Constanta and Venlo are also involved to test these demonstrations, during the project lifecycle. Furthermore, the Port of Antwerp-Bruges is member of Hydrogen Europe, co-chair of the Clean Hydrogen Alliance and has joined the German H2Global Foundation. The foundation has set itself the goal of making green hydrogen acceptable as an energy substitute in Europe – thereby advancing the energy transition and independence from Russian gas supplies.

8.1.6. The opportunities and challenges in the transition to green hydrogen

There is a clear policy support in Europe for renewable hydrogen. In July 2020, the European Commission launched a strategy for energy system integration and a separate **hydrogen strategy**. The latter identifies the necessary steps on making renewable and low carbon hydrogen a key commodity in the energy system. In the same month, the **European Clean Hydrogen Alliance** was created to support the large-scale deployment of clean hydrogen technologies by 2030 by bringing together renewable and low-carbon hydrogen production, demand in industry, mobility and other sectors, and hydrogen transmission and distribution. In July 2021, the European Commission proposed the revision of the **RED II** (Directive (EU) 2018/2001) under the Fit for 55 package of legislative proposals. The RED II directive sets targets for the use of renewable energy in transport fuels, basically requiring investments in green hydrogen-based fuels. Also, the **EU Green Deal** identifies hydrogen as one of the priorities in the energy transition. The plan **REPowerEU**, which was initiated in 2022, gives further impetus to the hydrogen economy. The plan states that an additional 15 million tons (of which 5 produced in Europe and the remainder imported) of renewable hydrogen is required to replace imported Russian gas. The 5 million tons of hydrogen produced in Europe is additional to the 5 million tons already planned in **Fit for 55**. In September 2022, the European Union announced the setting up of a **European Hydrogen Bank** to help create a market for hydrogen. The bank will receive 3 billion euro in cash to bridge the investment gap and connect the supply and demand of the future. The new European Hydrogen Bank will help with guarantees for the purchase of hydrogen, including funding from the EU's Innovation Fund. Also in September 2022, the European Commission approved up to 5.2 billion euro of public support by thirteen[8] Member States for the project **IPCEI Hy2Use** which is the second Important Project of Common European Interest (IPCEI) in the hydrogen value chain. The 5.2 billion euro in public funding by the mentioned Member States is expected to unlock an additional 7 billion euro in private investments. 29 companies will participate in 35 projects related to the construction of hydrogen-related infrastructure (large-scale electrolysers and transport infrastructure) and the development of innovative and more sustainable technologies for the integration of hydrogen into the industrial processes of multiple sectors. Various large-scale electrolysers are expected to be operational by 2024-2026 and many of the innovative technologies deployed by 2026-2027. The completion of the overall project is planned for 2036, with timelines varying in function of the project and the companies involved. Hydrogen infrastructure companies involved from the side of Belgium and the Netherlands include Air Liquide Netherlands, ENGIE Belgium, ENGIE Netherlands, Fluxys, H2-Fifty, HyCC, Orsted, Shell and Uniper (European Commission, press release 21 September 2022).

Since 2014, the **European Investment Bank (EIB)** has supported over 1.2 billion euro in overall investment related to hydrogen technologies by providing over 550 million euro in direct financial support to technologies such as electrolysers, catalysts and fuel cells and the co-financing of large-scale hydrogen production, carbon capture and storage and hydrogen stations (EIB, press release 16 March 2022).

[8] Austria, Belgium, Denmark, Finland, France, Greece, Italy, the Netherlands, Poland, Portugal, Slovakia, Spain and Sweden.

Despite the policy support and the large number of projects in the field, the rise of hydrogen comes with a number of challenges:

a) **Scalability**: Even considering the many renewable energy projects currently underway or planned, the **challenge of scalability** remains. As mentioned earlier, less than 2% of Europe's energy consumption comes from hydrogen, and that is mainly used for making chemical products like plastics and fertilizers. Moreover, 96% of all hydrogen is made from natural gas, emitting significant amounts of CO_2 emissions in the process (figures European Commission). Most scenarios do not foresee green hydrogen playing a significant role in Europe before 2030. Mobilizing investment to scale up the production of green hydrogen in a just and equitable fashion will require continued efforts towards more international collaboration to shape policy, regional and multilateral agreements and supportive frameworks from regulatory bodies.

b) **Decarbonize hydrogen production**: Blue hydrogen is often said to play a role in the transition phase from grey to green hydrogen, although some scholars argue that the greenhouse gas footprint of blue hydrogen is worse than if you simply burn the natural gas directly for fuel instead, mainly due to associated fugitive methane emissions (Howarth and Jacobson, 2021). A big challenge is therefore how to decarbonize hydrogen production. Using four scenarios (two scenarios where hydrogen could only be produced via electrolysis and two where blue hydrogen from natural gas with CCS was also allowed), Cloete (2020) concluded that blue hydrogen should not be dismissed from the policy agenda as using hydrogen to integrate higher shares of wind and solar brings considerable costs. For example, when electrolysers are located near the energy users, expensive transmission network expansions are required to transmit wind and solar production peaks to electrolysers. When electrolysers are located close to wind or solar power, large hydrogen transmission and storage capacity is required to handle hydrogen.

c) **CCUS**: Blue hydrogen relies strongly on **CCUS**. Although the concept of CCUS is not new and despite technology development in the last 50 years, CCUS remains in its early stages and is considered as emerging. Deployment had stalled in earlier years, and it is only relatively recently that a surge in planned CCUS projects has been seen for development towards realizing commercial projects, in Europe and elsewhere. The use of CCUS in general will be essential for CO_2 intensive industries to achieve net zero emissions, especially in hard-to-abate sectors with processes inherently generating CO_2 emissions. On the positive side, CCUS projects are taking off in the Rhine-Scheldt Delta. For example, **Porthos** (Port of Rotterdam CO_2 Transport Hub and Offshore Storage) is developing a project to transport CO_2 from the industry in the Port of Rotterdam and store this in empty gas fields beneath the North Sea (https://www.porthosco2.nl). In August 2022, Fluxys, ArcelorMittal Belgium and North Sea Port announced the start of a feasibility study for the **Ghent Carbon Hub** project, an open-access CO_2 storage and liquefaction hub in the Ghent part of North Sea Port. Commissioning is targeted for 2027. The Ghent Carbon Hub would have a capacity to process 6 million tons of CO_2 per annum (MTPA), equivalent to around 15% of Belgian industrial CO_2 emissions (press release North Sea Port, 18 August 2022). In the 2019 ING study (Notteboom et al., 2019) it was concluded that CCU and CCS will be indispensable in view of meeting the CO_2 reduction targets. The emerging cross-border and inter-port co-operation in this area is a positive step to bring its implementation to the next level.

d) **Production cost**: There is still a large **production cost difference between green and blue/grey hydrogen**. Around 70% of hydrogen cost is directly related to (renewable) electricity, so the price of electricity to a large part determines the price of green hydrogen. The production of green hydrogen costs between two and three times more to produce than grey or blue hydrogen (IRENA, 2022). As of July 2022, green hydrogen costs around 13 euro per kilo in Europe, against 6.50 euro per kilo for blue hydrogen (ING, 2022a). However, the cost of green hydrogen production is going down thanks to the investments being made, the long-term trend of decreasing costs of wind and solar power and the expected longer term price increases in fossil fuels. Wood Mackenzie[9] estimates that average green hydrogen production costs will equal fossil fuel-based hydrogen by 2040. In some countries, such as Germany, that arrives by 2030. The cost of grey hydrogen would rise by 82% by 2040 and blue hydrogen combined with CCS by 59%, mainly because of rising natural gas prices. A series of studies of Aurora Energy Research in 2022[10] analyzed the cost of producing hydrogen from electrolysers under four different business models in eight European countries. They conclude that green hydrogen could be produced in some European countries in 2030 for around 3 euro per kg, thus reaching cost parity with blue hydrogen. In order to compete with grey hydrogen, the costs would have to drop to around 2 euro per kg. Germany would have one of the highest production costs and will not reach cost parity with blue hydrogen until the mid-2030s. Germany would most benefit from grid-connected electrolysers that can be operated flexibly. In countries such as Norway, Spain and Great Britain, the cheapest way to produce green hydrogen would be to couple an electrolyser with solar and wind energy systems directly on site.

e) **Project finance**: Large green hydrogen projects demand significant investment requiring the full spectrum of sustainable finance instruments (see proposition 6.2 for more on sustainable finance). Project finance for green hydrogen currently makes most economic sense where it can replace grey hydrogen that is already in use in industrial processes, and where there is already a hydrogen customer in place (e.g. the fertilizer industry and refineries using hydrogen as energy source or feedstock) and contracted future cashflows can be used to structure a bankable financing structure. Highly speculative hydrogen projects will find it much more difficult to get financed, and will therefore need to rely on public support in view of their realization.

f) **Technological progress and policy support**: A study by the Oxford Institute for Energy Studies (2022a) argues there are two important key developments which should foster **cost reduction in green hydrogen production**: technological progress and policy support mechanisms. In terms of technological progress, the main focus is on minimizing the use of scarce materials for electrolysers, increasing the stack lifetime and system size so that large-scale production can be initiated, and reducing cold start-up time (solid oxide systems). In terms of policy support mechanisms, direct financial support and fiscal incentives for R&D and production is key at the first stages of market entry and scale-up. Once the technology reaches maturity and after commercial scale up, there will be a need for strong fiscal declines as investors are more likely to be more active once a technology is commercialized. Apart from electrolysers, supportive policies should also promote renewable electricity and the build-up of infrastructure as well as demand among end users (e.g. industries and transport).

g) **Land availability**: The production and storage of green hydrogen requires **large surfaces**. This challenges ports to make enough land available for production and storage activities, which is not an easy task in case land availability is very restricted (see also proposition 4.2 in section 7). Land

[9] See https://www.woodmac.com/market-insights/topics/hydrogen-guide/

[10] See https://auroraer.com/category/sector/hydrogen/ for an overview of the findings.

area is required for electrolysers and related equipment such as transformers, rectifiers, water supply, cooling water towers, separators, dryers and compressors. The overseas import of hydrogen carriers (such as ammonia), requires berths and conversion infrastructure for liquid hydrogen, ammonia and LOHCs (liquid organic hydrogen carriers). You also need room for energy supply infrastructure for the cracking of ammonia (conversion to hydrogen) and the recovery of hydrogen from LOHCs. Furthermore, you need storage space for hydrogen carriers and compressor stations to be able to inject hydrogen in the pipeline system.

h) **Competition for use of renewable energy**: The production and storage of green hydrogen requires **a considerable volume of renewable energy**. First, there is a limited amount of green energy (wind, solar) in Europe. Therefore, some argue that green energy should first and foremost be used for green electricity, i.e. to make current electricity consumption greener (electric cars, water pumps, etc.), not as a source for the production of green hydrogen or the transformation of imported green hydrogen to electricity. Second, hydrogen loses a fair amount of energy when produced through electrolysis of wind or solar energy or when converting back into electricity. Some sources point to losses of up to 60% of the initial wind energy in the 'wind energy to hydrogen back to electricity' cycle[11]. Third, there are rising concerns in the energy transition about the capacity of the electricity grid. For example, in the Summer of 2022, high-voltage grid operator Elia in Belgium reported it can no longer guarantee in West Flanders that new wind turbines, solar parks or power stations can put their power on the grid at all times. Some companies can only get a flexible connection, not a permanent connection. Elia can then disconnect them without them being eligible for financial compensation. The reason is the lack of the Ventilus high-voltage line through the province. This serves not only to bring power from future offshore wind farms to land, but also to strengthen the inland grid in West Flanders. Ventilus would not come in operation until 2030. Also in the Netherlands, there have been reports of mounting capacity issues in the high-voltage grid in two Dutch provinces. Complex planning and permitting procedures result in lengthy trajectories from inception to realization. This can hamper the energy transition trajectory. Moreover, the ESG requirements (Environmental, Social and Governance) applicable in sustainable finance imply no shortcuts can be considered in dealing with stakeholders and the social aspects of large infrastructure projects in the energy sector (see proposition 6.2 for an in-depth discussion). As a result, large infrastructure in electric grid networks typically take to 10 to 15 years to realize while the actual construction time only covers a few years.

i) **Use of green hydrogen**: Discussions can arise of the exact **use of green hydrogen** produced locally or imported. Renewable power generation, mainly by means of solar and wind, requires the availability of a back-up system of conventional power plants. Seasonal energy storage in the form of hydrogen could help to decarbonize dispatchable power through gas turbines or fuel cells. However, the next decade will also see more focus on the use of hydrogen as an industrial feedstock and the decarbonization of high-temperature heat. For example, steelmakers are working on fossil-free steel production methods and hydrogen could play a role in this transition.

[11] The International Council on Clean Transportation (ICCT) reports that hydrogen and e-fuels made from 100% renewable electricity are zero-carbon, but when made from grid electricity, these fuels are only a little better or in some cases even worse than natural gas. ICCT reports that about a quarter of the energy in the electricity is lost when it is converted to hydrogen, and around half of the energy is lost for e-fuels (Searle and Zhou, 2021).

j) **Long-distance transport and choice of hydrogen carrier**: As local green hydrogen production in the low countries will not be sufficient to cover demand, **hydrogen transport over long distances** will be necessary. This requires the conversion of wind or solar energy to hydrogen carriers in or near the exporting ports. At present there is still quite some uncertainty on the preferred hydrogen carrier, on rules and regulations, safety standards and certification, and the impact these will have on hydrogen supply chains (for example, safety issues related to ammonia transport near urban areas). While quite a few initiatives for hydrogen export and import facilities have been announced, we are still in the early days of the creation of a global hydrogen carrier shipping and port network. A recent report of the Oxford Institute for Energy Studies (2022b) demonstrates that choosing the most appropriate hydrogen carrier will be extremely important as it will help to make the entire H2 value chain more economical and efficient. The potential hydrogen carriers for maritime transport which receive most attention include liquid ammonia (so-called ‘liquid organic hydrogen carriers’ in general) and methanol. Although each of these fuels has its own advantages and offers a special set of benefits, none of them is flawless or possess the characteristics of a perfect hydrogen shipping solution. Technological progress in other decarbonization applications and, most importantly, full commercialization of CCUS solutions, is likely to dramatically change the approach towards long-distance hydrogen transportation.

8.1.7. Structured summary on proposition 5.1

Proposition 5.1. "In the medium term, any large-scale hydrogen adoption will rely on blue hydrogen and less on green hydrogen."

Overall evaluation: Refute (if medium term refers to the 2030s)

Arguments & observations in support of the proposition	Arguments & observations going against the proposition
1. Hydrogen accounts for less than 2% of Europe's present energy consumption and is primarily used to produce chemical products, such as plastics and fertilizers. 96% of this hydrogen production is through natural gas.	1. The current green hydrogen wave is very massive with large investment budgets and countless projects being released. 2022-2030 is a key period for upscaling of green hydrogen production.
2. Demand for green hydrogen is expected to only take off in the mid-2030s. Hydrogen is set to cover up to 12% of global energy use by 2050.	2. There is strong regulatory and political support within the EU and other countries for green hydrogen. Direct financial support and fiscal incentives for R&D and production are key at the first stages of market entry and scale-up.
3. For the start-up phase of large-scale hydrogen, it is expected that blue hydrogen combined with CCS will play a major part. CCS has seen major advances in recent years.	4. Hydrogen valleys are being developed, which are regional ecosystems that link hydrogen production, transportation, and various end uses such as mobility or industrial feedstock.
4. There still is a large production cost difference between green and blue/grey hydrogen. Only by the mid-2030s, green hydrogen would be cost competitve with fossil-fuel hydrogen, although the timing of cost parity differs between countries and is very much influenced by the cost evolution in fossil fuels and wind/solar energy production.	5. The Rhine-Scheldt Delta is taking up an important pioneering role and is positioning itself as a hydrogen import, transit and production hub.
5. Project finance for green hydrogen currently makes most economic sense where it can replace grey hydrogen that is already in use in industrial processes, and where there is already a hydrogen customer in place.	6. While scalability is still a challenge, we see strong advances in the upscaling of hydrogen production, electrolyser technology and transport network concepts for green hydrogen.
6. The production and storage of green hydrogen requires large surfaces. This challenges ports to make enough land available for production and storage activities, which is not an easy task in case land availability is very restricted.	7. The greenhouse gas footprint of blue hydrogen is not neutral, mainly due to associated fugitive methane emissions.
7. At present there is still quite some uncertainty on the preferred hydrogen carrier, on rules and regulations, safety standards and certification, and the impact these will have on hydrogen supply chains.	

8.2. Proposition 5.2

Proposition 5.2. Sustainable finance is becoming an important lever for making ports more sustainable.

8.2.1. The drivers of sustainability

There is a growing need for sustainability integration into supply chain management. Customers want companies to consider the environment when pursuing a more profitable supply chain (demand pull), while government regulation increasingly forces companies to become more environment friendly (regulatory push). Thus, companies might initiate the implementation of environmental practices due to motivational drivers such as sales to customers, and legislative and stakeholder institutional pressures. Thus, next to environmental motivations, regulatory, competitive and economic pressures also play roles in its adoption across the port ecosystem.

When focusing on the corporate context, there are clear signs that not opting for sustainability can negatively affect companies' cost base and profitability, and that a focus on GSCM is needed to secure revenue growth, achieve cost reductions, develop brand value and mitigate risks. Furthermore, a focus on the environment has a positive impact on brand value. The basic idea is that companies work to achieve profitability through measures that benefit society and the environment at the same time.

Financial incentives and penalties are one way for governments and public entities to support a further greening of supply chains. Whatever governments and public entities do in terms of environmental policy development, the business world is very sensitive to coherence and continuity in the developed policy, the legal (un)certainty of implemented policies, and the enforcement of policies through inspection and control. As many investment decisions have a medium to long-term payback time, any changes in government policy (for example, the abolishment of a subsidy scheme for certain green investments) can have large ramifications on the soundness of the initial corporate decision related to a green initiative. Thus, government policies and regulation typically have a significant impact on green strategies, investments and GSCM initiatives pursued by companies, but should provide legal and investment certainty to the affected companies.

Overall, companies cannot blindly roll out green initiatives. Logistics and supply chain managers have to balance efforts to reduce costs, improve service quality, increase flexibility and innovate while maintaining good environmental (ecological) performance. When deciding on green initiatives, companies take into account strategic performance requirements, which may not be environmentally based, such as cost, return on investment (ROI), service quality and flexibility. In other words, green initiatives should not only best support the green supply chain, but also result in a positive business case. Otherwise, the competitive and financial position of the company might be negatively affected.

Investment recovery is often cited as a critical aspect of any green investment. Investment recovery typically occurs at the back end of the supply chain cycle. Financial incentives or penalties given by public authorities (such as subsidies, tax breaks, etc. for green investments or penalties for non-compliance) or by private service providers (such as a commercial bank providing favorable loan conditions for green investments) are often very important in investment or divestment decisions and to achieve investment recovery. Sustainable finance is part of this spectrum of instruments to reach a more sustainable future.

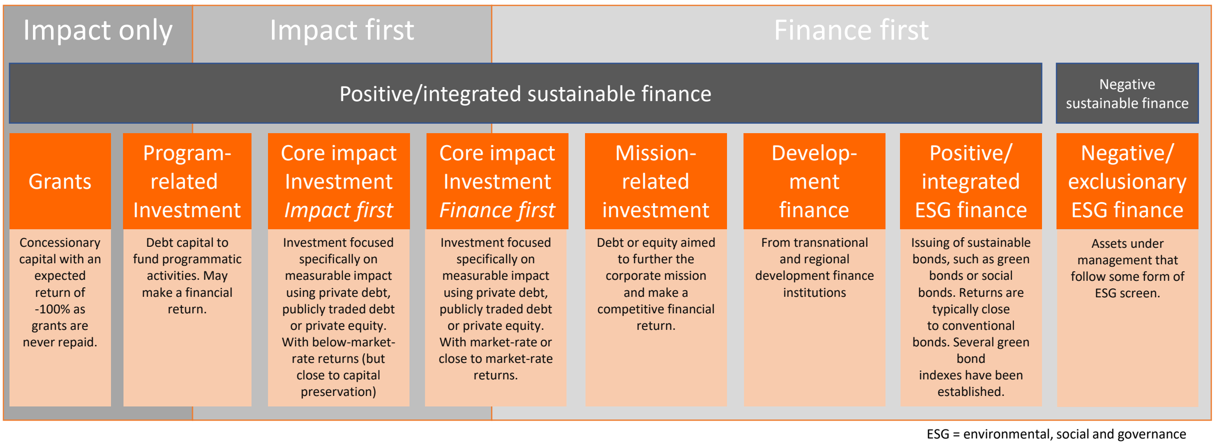
8.2.2. Overview of sustainable finance

Sustainable finance can be defined as '*the process of taking due account of environmental, social, and governance (ESG) considerations when making investment decisions in the financial sector, leading to increased longer-term investments into sustainable economic activities and projects'* [12]. In this report , we mainly focus on environmental sustainability referring to climate change mitigation and adaptation, the preservation of biodiversity, pollution prevention and the circular economy. In the latter context, the term **green finance** is also often used.

Figure 8.3 provides an overview of sustainable finance. A distinction can be made between **negative sustainable finance** and **positive sustainable finance** (Nicholls, 2021). The former relies on the screening of investments based on their environmental harm/risk profile, while the latter focuses on the potential contribution of investments in reaching specific environmental goals or, in a broader sense, the UN's Sustainable Development Goals (SDGs). Thus in a context of environmental sustainability, positive green finance is about providing start-up or growth capital to companies that address climate related issues (positive). Negative green finance implies divesting from companies negatively impacting the climate and allocating capital to companies that are aiming to reduce their overall carbon footprint.

A further distinction can be made based on the main focus of sustainable finance. 'Impact only' sustainable finance includes grants and program-related investment where there is no financial return or extremely low financial return. 'Impact first' sustainable finance includes investment with below market rate returns, while 'finance first' sustainable finance offers the investor a market rate return.

Figure 8.3. Spectrum of sustainable finance



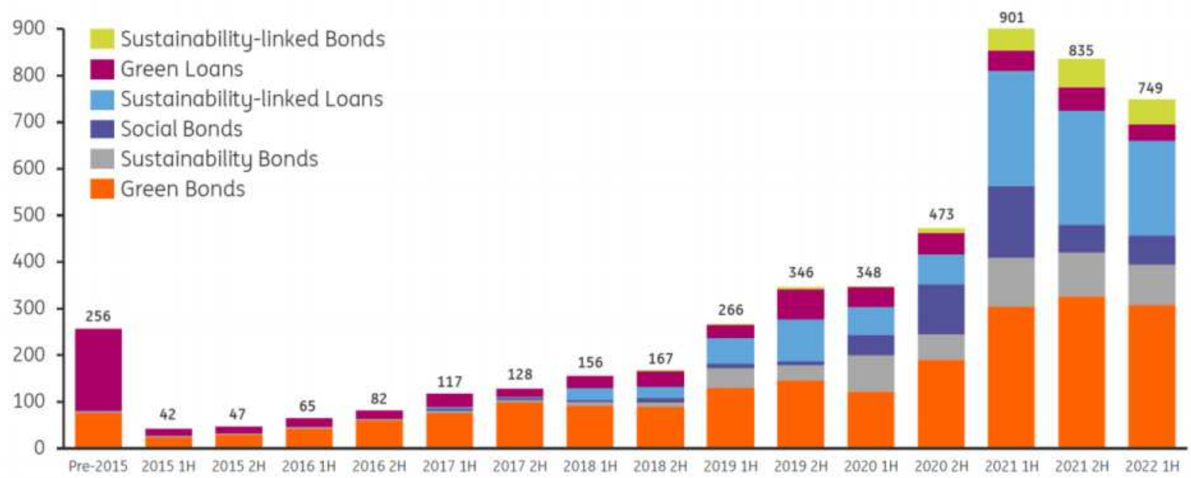
Source: own compilation based on Nicholls (2021)

The positive green finance market is dominated by **debt products**. Figure 8.4 shows the issuance of sustainable debt instruments reached about USD 750 billion in the first half of 2022. The sustainable debt market has seen strong growth in recent years and now totals about USD 5 trillion, of which USD 1.7 billion was issued in 2021. The EMEA region represents about 48% of the world' sustainable debt. The biggest category includes various forms of **green bonds** with some form of ESG screening (OECD, 2015), such as corporate bonds issued by a corporate entity to finance asset acquisitions; finance sector bonds issued by a financial institution to raise capital to finance lending (such as loans) to green activities; project bonds backed by single or multiple projects; and, supranational, sovereign, or agency

[12] https://finance.ec.europa.eu/sustainable-finance/overview-sustainable-finance_en

bonds issued by international financial institutions such as the World Bank or the European Investment Bank (EIB). Like any other bond, a green bond is a fixed-income financial instrument for raising capital from investors through the debt capital market. However, a green bond is different from a regular bond by its label, which signifies a commitment to exclusively use the funds raised to finance or re-finance green projects, assets or business activities (ICMA, 2015; 2021). Green bonds help investors to balance risk-adjusted financial returns with environmental benefits, to meet ESG requirements and to actively hedge against climate policy risks in a portfolio that includes emissions intensive assets.

Figure 8.4. Sustainable debt instrument issuance activity in billion USD (half-year figures)



Source: ING based on Bloomberg NEF's Sustainable Finance dataset, July 2022; Bloomberg NEF's Sustainable Finance Market Outlook, January 2022

Next to green bonds, **sustainability-linked loans** form another important category among the sustainable debt instruments (light blue bars in Figure 8.4). Unlike typical use-of-proceeds loans that are earmarked for specific assets, sustainability-linked loans are connected to key performance indicators and targets agreed with the customer to step up their climate efforts. For instance, the borrower may enjoy lower margins if the set sustainability targets are met.

Green loans are loans where the use of proceeds is linked specifically to green projects, green product development or a green project portfolio of the client. **Social bonds** are any type of bond where the proceeds will be used exclusively to finance (or refinance) projects focused on water infrastructure, health or education sectors, affordable housing, work integration, food security, and access to services.

A recent variation on the green bond theme is the **blue bond** whereby funds raised are earmarked exclusively for projects deemed ocean-friendly and part of the blue economy development such as sustainable marine and fisheries projects. The World Bank[13] defines blue bonds as 'a debt instrument issued by governments, development banks or others to raise capital from impact investors to finance marine and ocean-based projects that have positive environmental, economic and climate benefits'. While green bonds have been around since 2008 as instruments to finance climate-friendly projects, the first blue bond was launched in October 2018 by the Republic of Seychelles.

[13] https://www.worldbank.org/en/news/feature/2018/10/29/sovereign-blue-bond-issuance-frequently-asked-questions

8.2.3. Specific initiatives in the banking sector

Service providers such as banks take up a role in order to enhance the transition to more sustainable finance. For example, ING Bank launched the sustainability equity fund in 2000. Twelve years later a dedicated sustainable lending team was set-up. In 2015, ING launched its first green bond followed by the first sustainability improvement loan in 2017. These are loans that can be used for general corporate purposes, which link the interest margin to the improvement of the client's external ESG score or tailored KPIs. The bank doubled its so-called **Climate Finance portfolio** between 2017 and 2022. In late 2021, ING joined the Net-Zero Banking Alliance during the COP26 in Glasgow. Another key development was the **'Terra' approach** launched in September 2018. It is a holistic program of ING Bank co-created with the 2˚ Investing Initiative (a global think-tank for climate-related metrics in financial markets), to achieve a greener and more sustainable world. In a first phase, the approach is primarily focused on the sectors in the loan portfolio that are responsible for most greenhouse gas emissions: energy (oil and gas, renewables and conventional power), automotive, shipping and aviation, steel, cement, residential mortgages and commercial real estate. The overall lending portfolio of the banks is configured in such a way that it supports closing the gap between the current energy mix and the Paris Agreement climate targets. For example, the lending portfolio in the automotive industry is more directed towards R&D and the production of electric cars. The approach entered a new stage in December 2018 when ING, BBVA, BNP Paribas, Société Générale and Standard Chartered signed the **Katowice Commitment,** the first ever banking agreement aimed at steering the banks' portfolios toward the well-below two degrees goal of the Paris Climate Agreement and to work together to further refine the metrics and tools needed to do this.

Tools and instruments developed by ING bank to promote sustainable and green supply chains include:

- **Green loans** follow the Green Loan Principles, a set of voluntary guidelines issued by the Loan Market Association to aid the development of a market-standard approach to green lending.
- Concerning **green bonds**, ING Bank designed a Green Bond Framework that meets the highest standards on transparency and disclosure, and aligns with the ICMA Green Bond Principles (GBP), see ING (2022b) for more details. The net proceeds of the green bonds issued under its Green Bond Framework are allocated to an Eligible Green Loan Portfolio of new and existing loans including renewable energy projects and green buildings. Other categories are clean transportation, pollution prevention and control, and sustainable water management.
- The **'sustainability loan initiative'** enables ING to support customers who are making progress in sustainability and to encourage corporate sustainability performance further. This can be done by linking the terms of a loan package provided to a client to the company's performance in terms of sustainability, i.e. **Sustainability Improvement Loans (SIL)**. The performance can for instance be based on the company's sustainability rating by Ecovadis or other rating agencies. The company AB InBev is one of the companies in ING's portfolio that has signed up for this solution. ING acts as Joint Sustainability Coordinator for AB InBev's 10.1 billion USD corporate revolving credit facility, supporting the company in pursuing its CSR strategy. The facility incorporates a mechanism that incentivizes improvement in four key performance areas (i.e., water efficiency, PET recycling, renewable energy and GHG emissions reduction) that are aligned with and contribute to the company's 2025 Sustainability Goals[14].

[14] https://www.ab-inbev.com/content/dam/abinbev/news-media/press-releases/2021/02/ABI%20Sustainability-Linked%20Loan%20Announcement_EN_vfinal.pdf

- **Sustainable Supply Chain Finance (SSCF)** links supply chain finance (SCF) discount rates or payment terms to sustainability performance of suppliers to strengthen the supplier base of ING's clients.
- **Sustainable Improvement Derivatives (SID)** are financial market derivatives, such as an interest rate swap, where a part of the pricing is linked to the company's (existing) sustainable finance KPIs.
- **Sustainable structured finance** includes structured lending for new business models, technologies and sectors such as the circular economy, water and energy transition. ING Bank has developed **'Orange Circle', a circular economy program**, which has the ultimate ambition to help clients to transition to circular business models. It is based on the five pillars: knowledge (analyze the financial benefits of going circular), operations, deals (circular deals and relationships with circular clients), ecosystem (funding for circular business models) and innovation (work together with clients to develop circular propositions). Some circular deals include the merger of Shanks and Van Gansewinkel Groep to create Renewi, one of Europe's leading circular economy companies and the IPO of sustainable bio-plastics company Avantium.

Banks are also providing sustainability investment services. For example, ING Bank has developed a methodology to assess all asset classes including fixed income, equity and investment funds based on a diverse set of **environmental, social and governance (ESG) criteria**. The company-level analysis combines positive and negative ESG screening. As ING chooses to invest in companies with high ESG profiles, the positive screening covers over 100 ESG criteria assessing the risk, reputation and opportunities profile of each company. The negative screen excludes companies with a track record of negative corporate conduct or whose products and services have negative impacts on environment or society. Furthermore, ING Bank identifies **ESG leaders** as clients that ING considers 'best-in-class' based on a strong management score (50 or higher) by ESG rating provider Sustainalytics. The scoring methodology assesses the robustness of a company's ESG programs, practices and policies. Also, a stepwise process is followed during the **selection process of investment funds**. First, a quantitative screen is conducted to understand the ESG profile of the asset and the fund manager. This is followed by a qualitative screen based on an interview with the fund manager focused on their conviction and ESG approach. In a final step, ING Bank validates the fund's investments against its sustainable investing universe.

8.2.4. Advances in sustainable finance

The sustainable finance market is rather young. For many years, there was a lack of unified standards and a limited scope for legal enforcement of green integrity in for example the green bond market. This raised confusion and possibility for reputational risk if green integrity of the bond or other debt instrument would be questioned (OECD, 2015). The infrastructure still lacked many of the components of a fully functioning financial market, such as agreed impact performance metrics, listings on debt or equity public markets, and retail investment instruments. At present, frameworks and regulations have created widely-accepted but often voluntary market standards.

Despite a clear surge in the sustainable finance market, it remains a complex field affected by a wide array of sometimes competing reporting standards and principles (for example, the UN Principles for Responsible Investment or PRI[15], the Global Reporting Initiative or GRI[16] and corporate sustainability reporting). At EU level, the EU Taxonomy Regulation was adopted on 18 June 2020 bringing forward a

[15] See https://www.unpri.org/pri/what-are-the-principles-for-responsible-investment
[16] See https://www.globalreporting.org

common classification of economic activities substantially contributing to environmental objectives, using science-based criteria[17]. While the EU taxonomy leaves some room for interpretation, it supports market players in shaping their green transition. Furthermore, several EU policy initiatives deal with the promotion of a comprehensive disclosure regime for both non-financial and financial institutions to provide investors with the information necessary to make sustainable investment choices[18].

The EU policy makers are also working on a broad toolbox for companies and financial institutions to develop sustainable investment solutions, such as the development of a standard for European green bonds (EuGB) to facilitate the further development of the European market for green bonds while minimizing disruption to existing green bond markets. Historically, benchmarks incorporating constraints or objectives related to GHG emissions have lacked consistency and have not been tailored to investor needs and constraints. Since 2020, the EU Climate Benchmarks Regulation is in force. A climate benchmark is defined as an investment benchmark that incorporates specific objectives related to GHG emission reductions and the transition to a low-carbon economy based on the scientific evidence of the Intergovernmental Panel on Climate Change (IPCC). Two examples include the EU Climate Transition Benchmark (EU CTB) and the EU Paris-Aligned Benchmark (EU PAB). The EU CTBs are suitable mainly for institutional investors such as pension funds and (re)insurance companies, whose objective is to protect assets against investment risks related to climate change and the transition to a low-carbon economy. The EU PABs have primarily been designed for institutional investors that want to be at the forefront of the immediate transition towards a +1.5°C scenario.

In the past few years, a lot has been achieved in the promotion of greater transparency and disclosure from financials and corporations on financially material indicators of environmental, social and governance (or ESG) performance. Also, many new financial products stamped with ESG labels have been introduced. The spectrum of sustainable finance now includes blended structures that bring together multiple forms of impact investing, with different impact-return appetites, to leverage the capital of each individual investor.

Advances have also been made when it comes to deploying capital around impact milestones, for example in loans that are linked to outcomes, such as releasing capital in tranches. If impact milestones are not achieved, disincentives can be built into to the deal structure, including investor exit or loan default.

Port operators and investors in port-related projects can benefit from the strong development of the sustainable finance market by incorporating their sustainability strategy and targets in corporate finance decisions, and by exploring and implementing sustainable finance instruments to shape their sustainable transition in close cooperation with their financial partners. Many market players in the port industry are operating assets such as equipment and real estate which can be made more

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[17] The EU Taxonomy includes a list of economic activities which can make a substantial contribution toward at least one of six EU environmental objectives: climate change mitigation; climate change adaptation; sustainable use and protection of water and marine resources; transition to a circular economy, waste prevention and recycling; pollution prevention and control; and, protection of healthy ecosystems. The activities should not do significant harm to all other environmental objectives, meet minimum (social) safeguard compliance and should meet technical screening criteria to be established by the EC. There are three main groups of organizations that will eventually need to comply with the EU Taxonomy related regulation: financial market participants, large companies and the EU and Member States. See https://finance.ec.europa.eu/sustainable-finance/tools-and-standards/eu-taxonomy-sustainable-activities_en for further info.

[18] Think of the Sustainable Finance Disclosure Regulation (SFDR) applicable since March 2021 and the sustainability preferences adopted by the European Commission in April 2021.

sustainable (electrification, improve energy-efficiency, shift to renewables, water treatment, etc.) while also being part of supply chains that need to become greener. In the future, every new investment or finance file is going to be assessed in depth from a sustainability angle. At the same time, ESG ratings are more and more fully integrated in more traditional project and company ratings. The rise of sustainable finance implies green/sustainable investment, projects and overall company strategies are becoming the norm. From a finance perspective, opting for a non-sustainable or less sustainable path will more and more come at a cost premium for the company.

Sustainable finance will need a further upscaling to deal with specific challenges in port areas, such as the implementation and financing of large energy transition projects (think of investment in green hydrogen infrastructure as discussed in proposition 5.1). Some of these projects demand massive funding of many billions of euros. The financing of these huge projects in new energy sources or carriers typically involves a high risk profile. Existing regulation and banking rules might set exposure limits to commercial banks in terms of massive green loans in view of funding such large energy transition projects, and provide opportunities for green bonds, blue bonds or sustainable-linked bonds.

8.2.5. Structured summary on proposition 5.2

Proposition 5.2. "Sustainable finance is becoming an important lever for making ports more sustainable."	
Overall evaluation: Accept	
Arguments & observations in support of the proposition	**Arguments & observations going against the proposition**
1. Sustainable finance is part of the spectrum of instruments to reach a more sustainable future as it provides financial incentives (or penalties) for investment or divestment decisions. 2. Sustainable finance has seen a massive growth in the past decade with the introduction of a wide range products and instruments (green bonds, green loans, sustainability-linked loans, etc.) 3. Over the past decade, sustainability has become part of the DNA of quite a few commercial banks. From a finance perspective, green/sustainable is becoming the norm, while opting for a non-sustainable or less sustainable path comes at a cost premium for the client. 3. A lot has been achieved in the promotion of greater transparency and disclosure from financials and corporations on financially material indicators of environmental, social and governance (or ESG) performance, and deploying capital around impact milestones. 4. Policymakers are advancing the establishment of a comprehensive disclosure regime for both non-financial and financial institutions which provides investors with the information necessary to make sustainable investment choices.	1. While there are already quite a few examples of sustainable finance in the port industry, there is still a lot of room for port-related companies to embrace sustainable finance in partnership with their financial service providers. 2. The sustainable finance market will need a further upscaling to deal with the specific challenges linked to the implementation and financing of large energy transition projects such as green hydrogen infrastructure.

9. Overall summary and concluding remarks

The industrial-economic complex in the Rhine-Scheldt Delta is one the largest port systems in the world. This study examined the future of seaports in the Rhine-Scheldt Delta by critically analyzing a range of important developments. By adopting a kaleidoscopic approach, the report elaborated on trends and developments about which there is still a lot of uncertainty, or about which visions and opinions differ greatly.

Table 9.1. Themes and propositions

Themes and propositions	Overall evaluation
Theme 1: Ports and international trade	
Proposition 1.1. The worldwide trade relations of the Rhine-Scheldt Delta ports will fundamentally change due to geopolitical changes, the energy transition and sustainability goals.	Accept
Proposition 1.2. Trends in nearshoring do not necessarily undermine the market position of the Rhine-Scheldt Delta ports.	**Accept conditionally**
Theme 2. Port competition in a European perspective	
Proposition 2.1. The rise of Mediterranean seaports will only lead to a limited maritime cargo shift from north to south.	**Accept conditionally**
Proposition 2.2. The battle for the European hinterland will increasingly be shaped by the role of rail, barge transport and shortsea/coastal shipping as part of ports' modal split.	**Accept conditionally**
Proposition **2.3.** Centralized European distribution with XXL warehouses and liquid bulk storage hubs is the dominant model for the future favoring the competitive position of the Rhine-Scheldt Delta ports	Accept
Theme 3. Ports and the organization of (maritime) supply chains	
Proposition 3.1. Vertical integration in (maritime) supply chains will increase further, resulting in increased competition for the orchestration of these chains.	Accept
Proposition 3.2. The era of alliances between container shipping companies is gradually coming to an end.	**Accept (*)**
Proposition 3.3. Small and medium-sized freight forwarders without a strong digital backbone will struggle to survive.	**Accept**
Proposition 3.4. Conventional general cargo will remain an important market for the Rhine-Scheldt Delta ports.	**Accept conditionally**
Theme 4. The role and operation of managing bodies of ports	
Proposition 4.1. The role adopted by managing bodies of ports in the Rhine-Scheldt Delta should not go beyond the role of 'facilitator'.	**Refute conditionally**
Proposition 4.2. Concession policy in ports should focus more on sustainability while guaranteeing flexible business development for new and existing concessionaires.	Accept
Theme 5. Sustainable ports	
Proposition 5.1. In the medium term, any large-scale hydrogen adoption will rely on blue hydrogen and less on green hydrogen.	**Refute (**)**
Proposition 5.2. Sustainable finance is becoming an important lever for making ports more sustainable.	Accept

(*) If we talk about alliances in their present form ; (**) If medium term refers to the 2030s

Possible trends and developments were divided into five interconnected themes, i.e. ports and international trade; port competition in a European perspective; ports and the organization of (maritime) supply chains; the role and functioning of managing bodies of ports; and sustainable ports. Two to four propositions have been formulated to go with each of the themes. The propositions were accepted or refuted based on an analysis that considered the different visions and perspectives that exist in that area, the arguments and data that support the proposition and possible arguments that undermine it. These arguments for and against were supported as much as possible by findings in the existing literature, but also supplemented with own insights. The report therefore mainly looked for future trends about which the various experts and sources are much less unequivocal. Table 9.1 summarizes the main findings per theme and proposition. The findings are primarily focused on the Rhine-Scheldt Delta ports, but the discussions and conclusions presented for each of the propositions can also be of relevance to other seaports around the world.

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ABOUT THE PUBLICATION

The industrial-economic complex in the Rhine-Scheldt Delta is one the largest port systems in the world. This study examines the future of seaports in the Rhine-Scheldt Delta by critically analyzing a range of important developments. By adopting a kaleidoscopic approach, the report elaborates on trends and developments about which there is still a lot of uncertainty, or about which visions and opinions differ greatly. These possible trends and developments were divided into five interconnected themes, i.e. ports and international trade; port competition in a European perspective; ports and the organization of (maritime) supply chains; the role and functioning of managing bodies of ports; and sustainable ports. Two to four propositions are formulated to go with each of the themes. The propositions are accepted or refuted based on an analysis that considered the different visions and perspectives that exist in that area, the arguments and data that support the proposition and possible arguments that undermine it. The report is primarily focused on the Rhine-Scheldt Delta ports, but the discussions and conclusions can also be of relevance to other seaports around the world.

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FURTHER INFORMATION

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