DOCKSTHEFUTURE
defining the concept of "Port of the Future"

Maritime Traffic Analysis and Forecast Review – Key Results

Deliverable 1.3

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1. Introduction

In order to identify future trends and set priorities with regard to port development, it is necessary to appraise the structure of the European port landscape and the diversity among ports. This concerns the traffic volume in terms of tonnes or ship calls, but also the cargo structure. Based on data regularly collected by Eurostat, a database has been set up that helps filtering out ports that fulfill certain criteria, i.e. container ports, cruise ports, traffic density of, e.g., at least 50 ship calls per day, etc. These filtering possibilities will help identifying the number of ports to which a certain measure could be applied. This will form the basis for the Transferability Index to be developed in Work Package 3. The first part of the present report – Maritime traffic analysis – gives an overview of the major results of this analysis.

Part 1 on Maritime Transport Flows according to Outline:

The detailed data-based analysis of EU ports will help to classify them

- not only by size in terms of tonnes,
- but also by traffic type,
- major commodities,
- ship types,
- ship sizes,
- density of ship traffic (number of ship calls),
- surrounding population density (greenfield vs. city ports),
- hinterland connections (distance to highway, distance to TEN-T network),
- outreach area (population within 150 km)

The database will cover all TEN-T core and comprehensive network ports, but also various non-TEN-T ports. The base year of the analysis will be 2017. For cargo traffic and ship traffic, a time series analysis will be performed to identify relevant structural trends.

Deliverable 1.3 will include a descriptive report with tables and graphs on the different criteria. It will help understanding the diversity of the European port landscape. The database will help to estimate the transferability score (Work Package 3) of different measures.

The second part of the report indicates current trends in major maritime market segments such as dry bulks, liquid bulks, containers and the like. These trends must be considered when approaching the "Ports of the Future" concept. Most notably, some segments will face growing trade volumes and hence capacity issues while others may actually see a decline of volumes, leading to issues such as reconversion of existing terminals and areas.

Part 2 on Forecast according to Outline:

Building upon the status-quo analysis and the trends discerned therein, the forecast review identifies foreseeable structural changes in the port landscape. The aim is an adjustment of the database with regard to the different criteria. This will include:

- Growth trends for specific cargo segments (e.g. oil, coal, containers)
- Regional growth trends, incl. other structural changes

The different growth trends generally do not change the number of ports that could benefit from a certain measure (if the cargo segments and operator strategies stay the same). The aim of the analysis are hence not forecasts for single ports, but rather an adjustment of the number of ports in the different categories based on a focus on disruptions.

Explanatory note on sources used:

For deliverable 1.3 the studies mentioned in the proposal have been considered and analyzed with regard to relevant information for D1.3. A general issue with these sources however was that they either did not provide forecast volumes or trends or have been published in 2015 when the radical paradigm changes in one of the largest maritime traded commodities has simply not been foreseeable. In addition, especially with regard to fossil fuels, these studies (e.g. Study on the Analysis and Evolution of International and EU Shipping) are often vague or contain no guidance on trends for volumes. This gap has been filled with the help of the industry expertise from BP (biased as they might be, BP's statistical publications are considered as some of the most relevant industry assessments by shipping community experts within Europe). The scenarios outlined have been reduced to a combination of items which seems most plausible. Hence, chapter 1.3 is mainly based on

- Various issues of Drewrys „Dry Bulk Forecaster" from 2014 until 2018 (this is relevant because only the very last issues – according to ISLs assessment – fully reflect the fundamental paradigm change that the energy markets and here in particular the commodity "steam coal" (or to be more specific: the seaborne trade growth assessments for steam coal) have undergone. Drewry's Bulk studies also offer an up to date insight into the development potentials of other bulk commodities, which are reflected against the development stage of the European economies as well as the seaborne trade development model by Stopford/Rostow (Maritime Economics, 2009), which effectively also has been a source of the findings

- The most recent edition of Drewry's Annual Container Forecast and Market Review has been used to comment on the growth potentials of container handling in Europe's port ranges (instead of Drewry's Container Terminal Operators Review)
- BP's latest long-term forecast of fossil fuel production & consumption within Europe (has been used to run a supply/demand-balance analysis for the major fossil fuels consumed in Europe and to deduct infrastructure specific needs)
- The long-lasting experience of the ISL in analyzing port handling developments, traffic structures and future handling potentials of containerized, roro and bulk/neo bulk commodities.
- An ISL discussion paper which is about to be released shortly, forecasting the structure of the fully cellular container fleet

2. Maritime Traffic Analysis

2. Maritime traffic analysis

2.1 Total traffic by ports and maritime regions 2017

In 2016, Eurostat listed 1,382 seaports,[1] of which

- 956 ports reported cargo traffic (3.9 billion tonnes total);
- 427 ports were considered "main ports" (3.7 billion tonnes total);
- 957 ports reported passenger traffic (396 million passengers total)

The size distribution and classification of cargo handling ports and passenger ports is analysed below. About two thirds of the total cargo handled had origin or destination in short sea origins or destinations while only one third was direct deep-sea traffic. The majority of trade is within basins or between neighbouring basins such as the North Sea and Baltic Sea area.

2.1.1. Cargo-handling ports

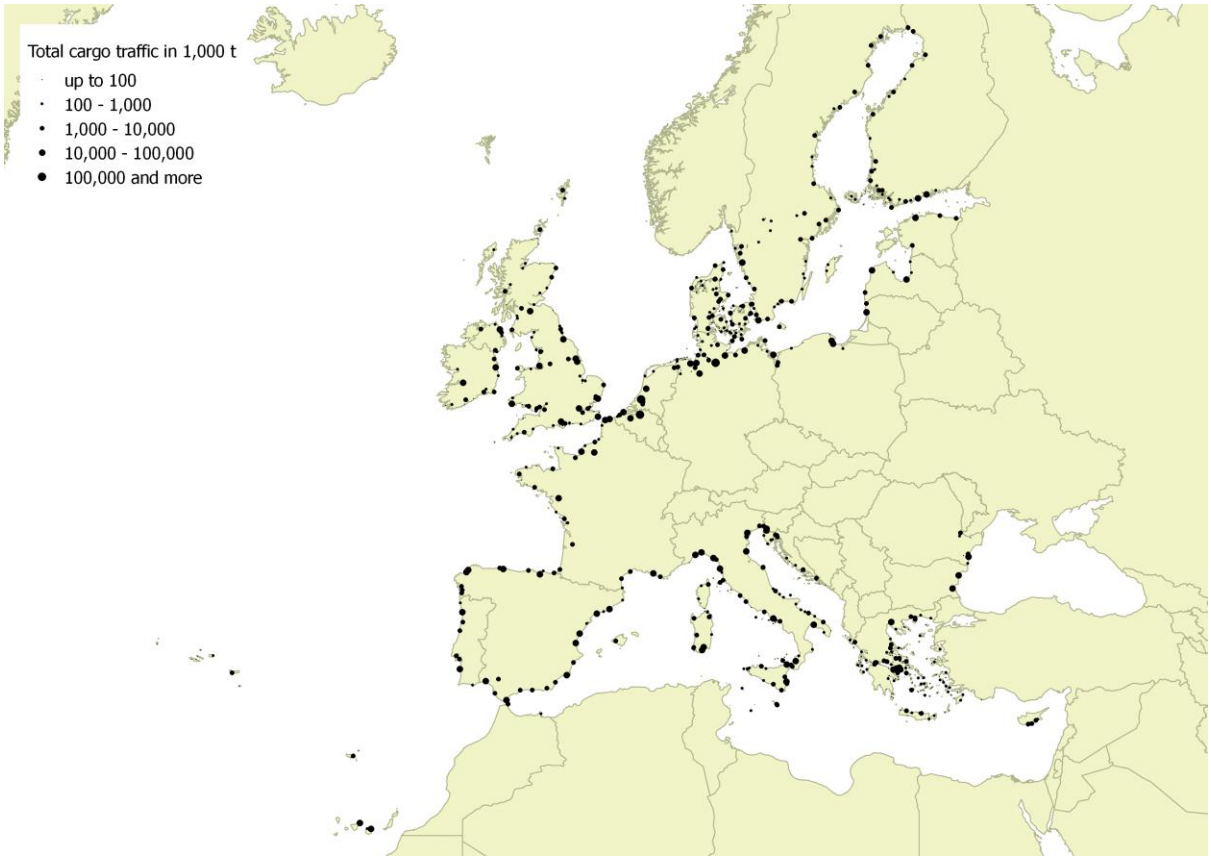

Figure 1: European ports by size class (cargo traffic)

There are only three ports having handled more than 100 million tonnes in 2016 (Rotterdam, Antwerp, and Hamburg), but already 80 ports with a traffic volume between 10 and 100 million

[1] As of 29 July 2018, data for 2017 is not yet complete.

tonnes. The categories below count more than 200 ports each, indicating a rather balanced distribution of port sizes.

Detailed cargo data is given for 427 so-called 'main ports' only, which includes all TEN-T core and comprehensive network ports except Ullapool (UK, 280,000 tonnes handled in 2016). With 3.7 billion tonnes, the main ports accounted for 97% of the total EU maritime traffic in 2016.

The largest traffic volume passes through the main ports in the North Sea area (1.8 billion tonnes in 2017), followed by the Mediterranean (1.1 billion tonnes) and the Baltic Sea area (0.6 million tonnes.

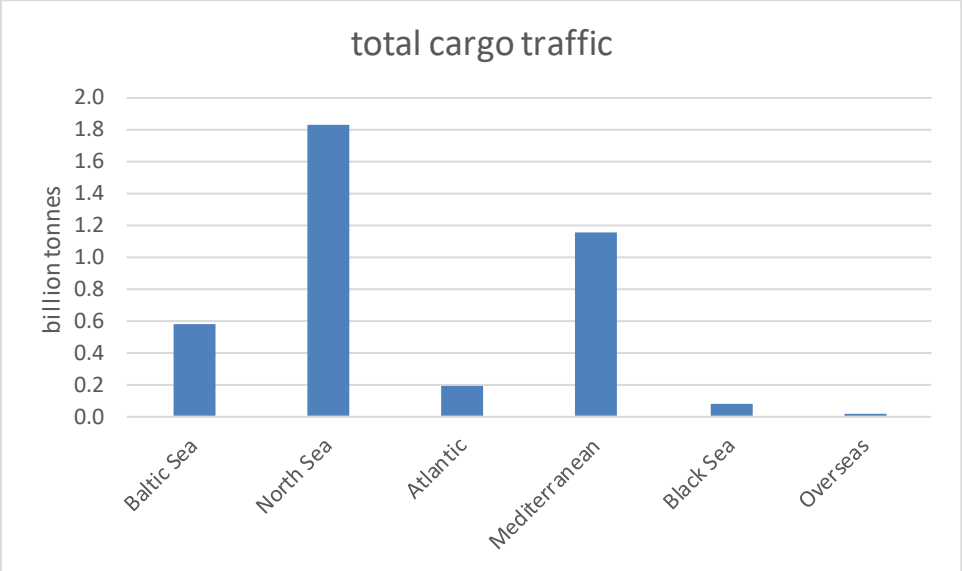

Figure 2: Cargo traffic in major European port ranges

Over the past 10 years (i.e. between 2017 and the pre-crisis year 2007), traffic was least dynamic in the North Range (-0.2% per year), while the Atlantic Coast, the Baltic Sea and the Black grew above average.

In terms of tonnes, the most important cargo type is liquid bulk (1.4 billion tonnes), followed by dry bulk and container traffic (0.9 billion each). The gap between dry bulk traffic and container traffic has narrowed considerably during the past 10 years. In 2007, the total dry bulk volume was 40% higher than the container volume. In 2017, the difference was less than one per cent and it is likely that container traffic will soon surpass dry bulk traffic in EU ports due to the higher growth expectations (see Forecast Review).

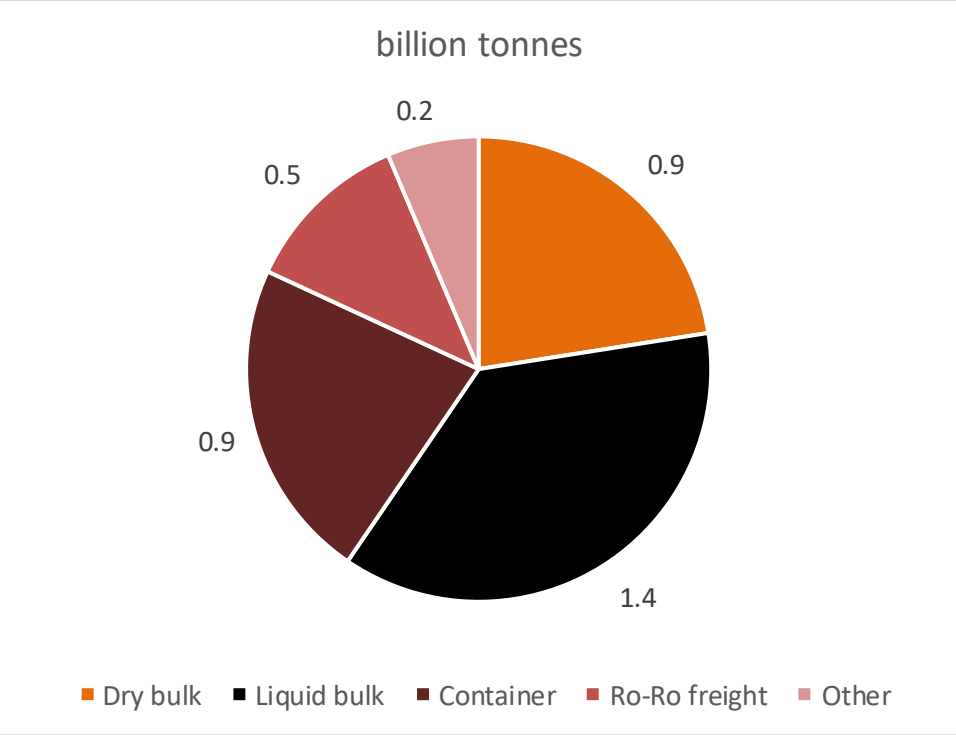

Figure 3: Cargo traffic in major European port ranges

2.1.2. Passenger ports

While cargo handling ports can be found all along the European coasts, maritime passenger traffic concentrates on short distances (except cruise shipping) and is hence particularly dense in major straits such as the Channel, the Fehmarn belt or the Strait of Gibraltar. In addition, passenger ferries connect islands with the mainland and is hence particularly dense in Greece, Croatia or Denmark, for example.

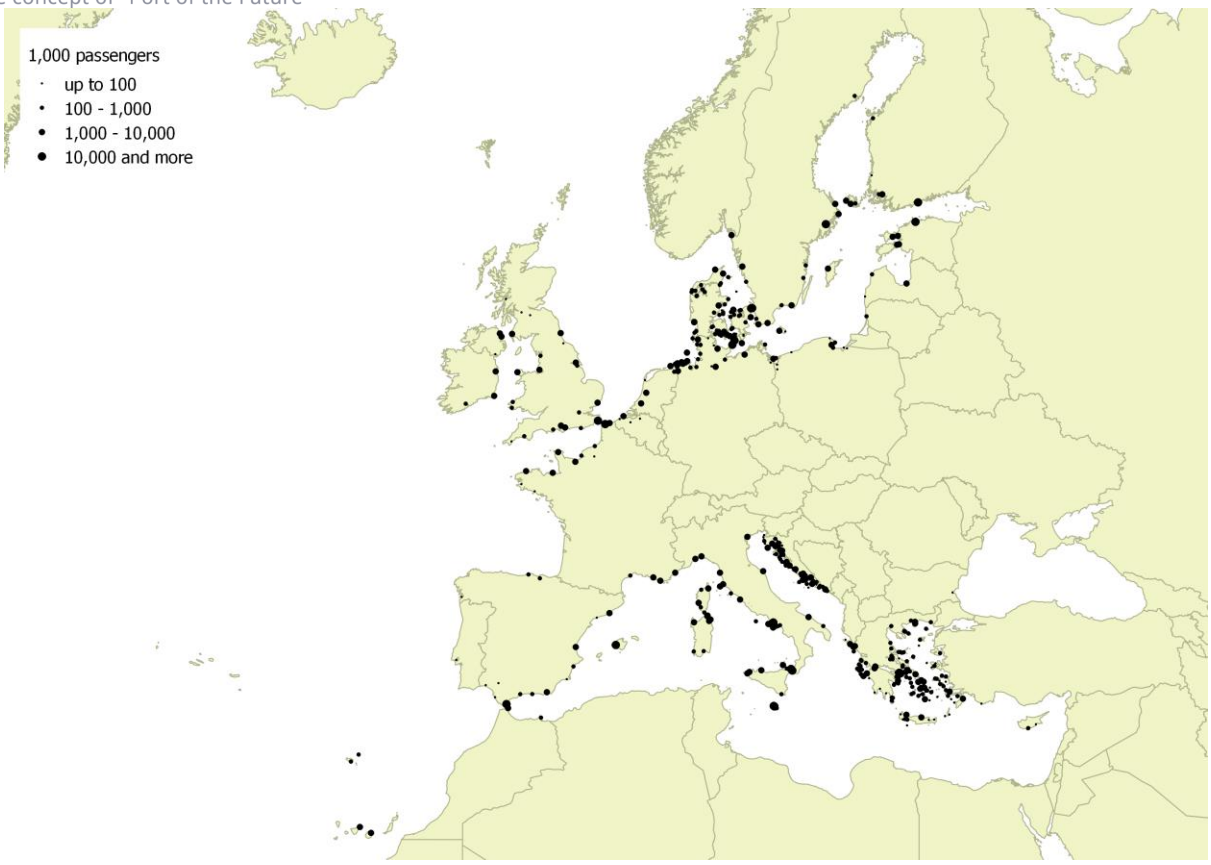

Figure 4: European ports by size class (passenger traffic)

Around half of the ports (480) having reported passenger traffic registered 1,000 passengers or less in 2016. The second-largest group is composed of 225 ports with a passenger volume between 100,000 and one million passengers. Another 105 ports had more than 1,000,000 passengers, two out of which (Dover and Helsinki) counted more than 10,000,000. In total, almost 400 million passengers passed through EU ports, including 12.9 million cruise passengers.[2]

2.2 Structural port characteristics

Besides cargo and passenger volume, ports are characterised by their geographical position and the surrounding area. Measures concerning the port-city relationships are most relevant for ports in populated areas. On the other hand, some measures may be specific for ports in sparsely-populated areas with low outreach. Another important factor is the distance to the European Core Network Corridors. These characteristics have been identified for the sample ports in order to provide additional filtering options for the Transferability Index.

2.2.1 Population density and outreach area

Among the 1,256 ports for which a unique geographical location could be identified,[3] 548 ports (44% of the ports) counted less than 10,000 inhabitants in a radius of 5 kilometres. In total, 1074 ports (roughly 85%) count less than 100,000 inhabitants. For these ports, measures targeted to

[2] Passengers travelling between two EU ports are counted twice.
[3] i.e. excluding ports grouped by Eurostat for statistical reasons such as "Zeekanaal Brussel-Schelde ports"

densely populated areas may be less relevant. The remaining 15%, however, account for two thirds of the population in port vicinities.[4]

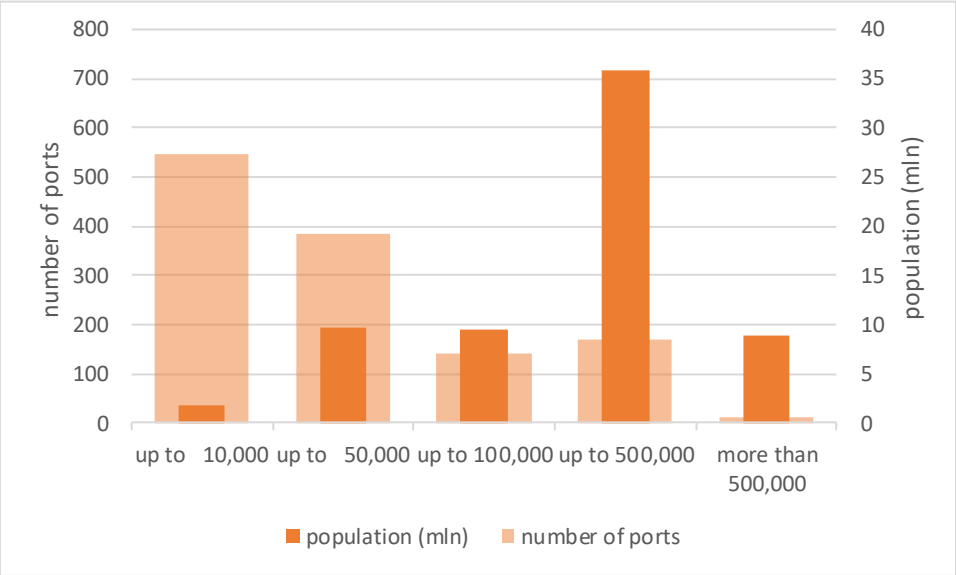

Figure 5: European ports: population within a radius of 5 km[5]

Some measures are specific to ports in large cities with large local traffic volumes (e.g. dynamic traffic lights and real-time traffic information). These measures would be transferable to around 200 ports. Other port-city relations measures like protection against noise are relevant also for ports in smaller cities, particularly if the measures are not very costly to implement. Additional filtering will be possible with different distances.

In addition to the direct vicinity, ports can also be characterised by their outreach areas. Ports with a large population in the short-distance range (typically a radius of 150km) have a high potential for 'local consumption' traffic. High shares of this local and regional traffic will be transported by truck. Other ports may have a stronger focus on long-distance traffic with intermodal hinterland chains.

2.2.2 Integration into Core Network Corridors

As of spring 2018, there are 106 TEN-T Core Network ports, of which 84 are situated on one of the nine Core Network Corridors. The TEN-T Comprehensive Network comprises another 225 seaports. The remaining 1,000+ seaports are not part of the TEN-T network. Some of them have a high share of domestic traffic (i.e. inter-island traffic), others fill a regional gap or market niche. The 'Port of the future' per se is not limited to TEN-T ports, so all ports will be included in the Transferability Index unless measures are explicitly targeted towards the Corridors.

[4] double counting of inhabitants in closeby ports
[5] Source: ISL based on Eurostat population grid

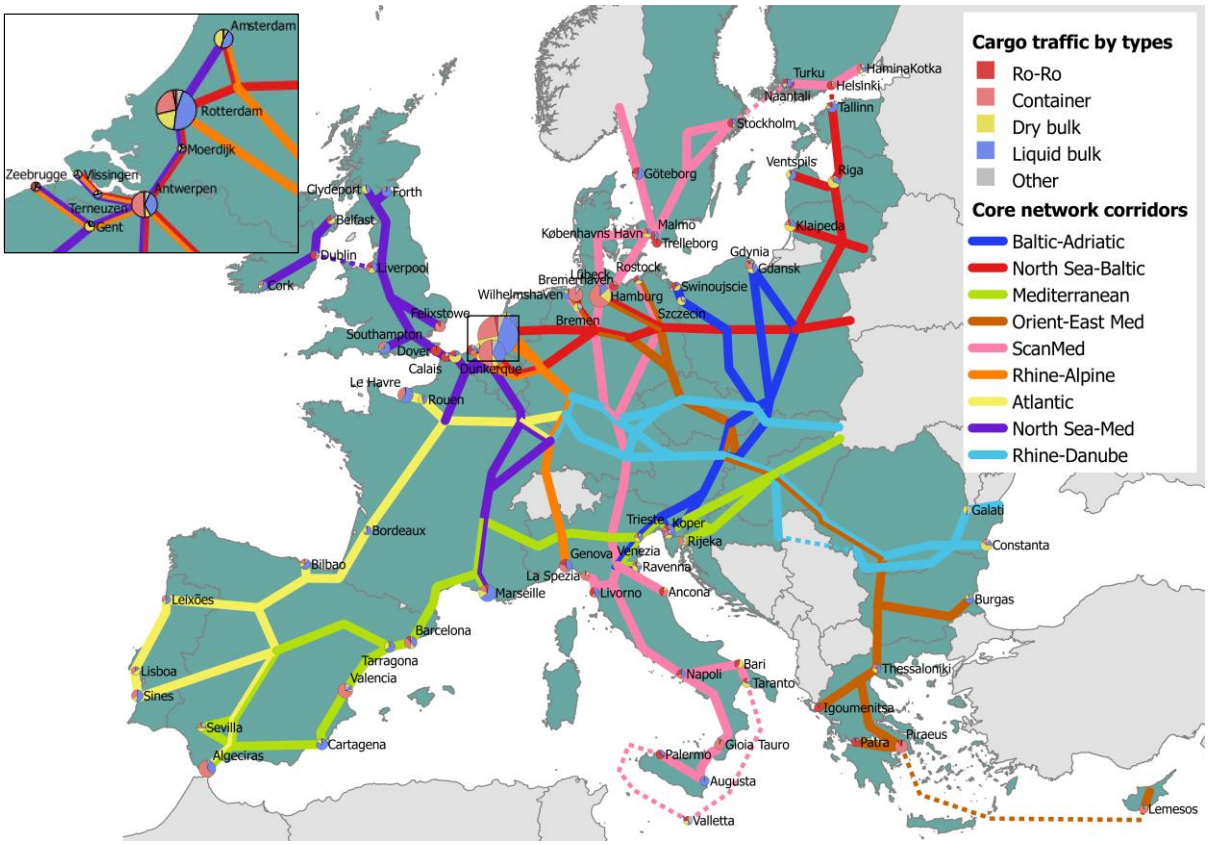

Figure 6: Core Network Corridors and Core Network Corridor seaports[6]

Many of the ports that are not included in the Core or Comprehensive Network are situated close to one of the Corridors. The distance to the next Core Network Corridor will be determined for each port so the possibility of linking the non-CNC ports to the core network can be assessed.

[6] Source: ISL based on Eurostat maritime traffic statistics

3. Forecast Review

3. Forecast review

3.1. Container Trade

Until the global financial crisis struck hard in 2008, shipping of commodities in standardised steel boxes presented itself to be the most pressuring issue for port development with volumes doubling roughly every 7 to 10 years and growth rates even accelerating sharply after Chinas WTO ascension in 2001. This has induced a significant amount of expansion projects, particularly within the Major North Range ports. Today as the growth has slowed markedly and terminal overcapacities are a reality, capacity concerns are muted especially in light of changing transport strategies i.e. the implementation of more direct calls as emerging markets have matured and volumes justified the switch from hub and spoke strategies to direct calls or the expected revival of the rail connection to China.

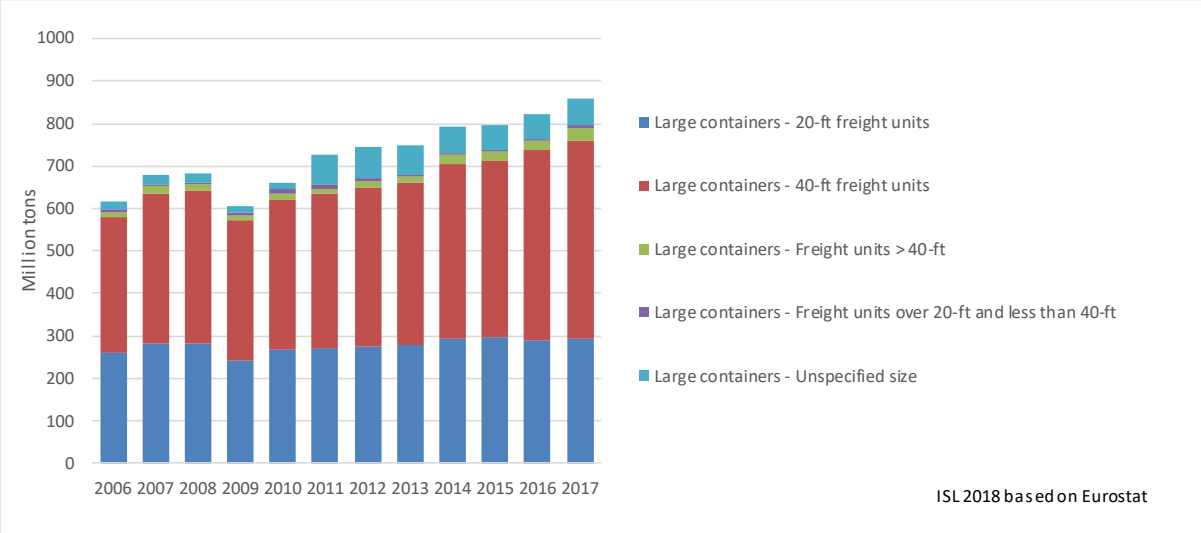

Figure 7: Container Handling in European Ports 2006-2017

After the crisis, it took two years for the European container handling segment as a whole to recover but growth has recently been anemic (compared to the years before 2008) as the relocation of manufacturing jobs to other countries (predominantly China) has reached saturation levels, transshipment demand from Russia has been hit by falling oil prices and imposed sanctions on a global level, and de-globalization became more pronounced with more trade barriers installed than have been removed during the last 10 years on a global level.

Looking forward, it is easy to attest that, in a world in which most trade barriers have been removed already and initiatives to remove additional trade barriers are met with greater skepticism, additional trade volumes would need to be generated from additional economic activity. This however comes with the issues that the already mature economies of Western Europe are set to grow at low rates and also that Consumers nowadays are being offered a multitude of options to spend additional income – none of which are all that prone to fuel containerised trade. When the following points are taken into consideration, it becomes clear that long-run growth prospects for container handling in North Sea container ports are subdued:

- cargo owners will benefit from additional hub and transshipment activities in the Baltic Sea, and
- the new interpretation of the silk road will also provide – particularly Chinese exporters – with a fast and competitive access to the Eurozone economic heavy weights

A forecast from Drewry Shipping Consultants looks at total port handling volumes and differentiates into individual sub markets. Drewry believes that the container handling demand will grow between 2.7 and 3.1 % in the years 2018-2021 with the Eastern Med/Black Sea market and the Scandinavia/Baltic market slightly outperforming this growth in terms of dynamic.

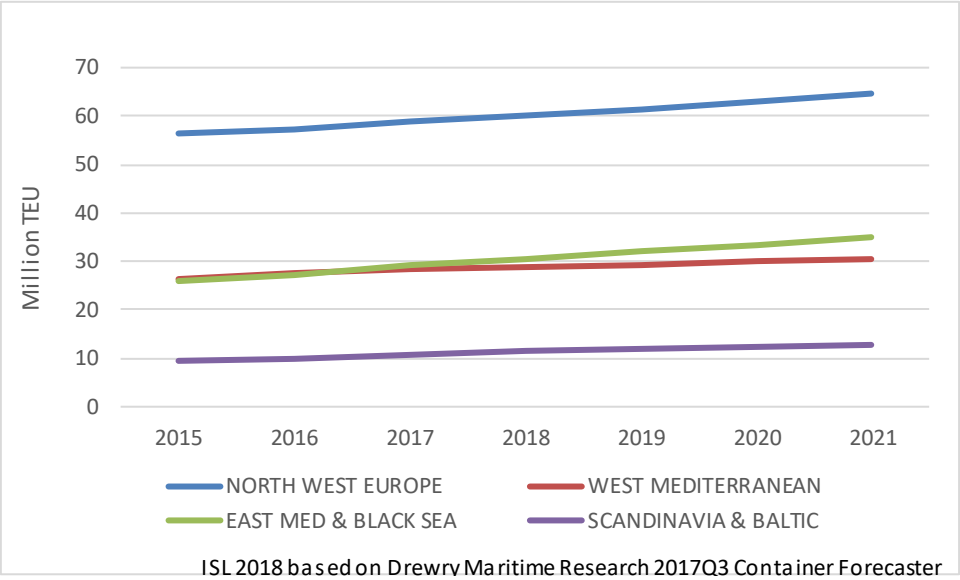

Figure 8: Forecast of Container Growth by European Regions 2017-2021

When it comes to ship sizes, the fully cellular container fleet during the last decades has behaved fundamentally different from the already matured dry- and liquid bulk fleets. For the latter two, a clear segmentation into size classes has been observable for years now. Thereby the individual segments recorded a minimal and very gradual expansion of dwt capacity over time as engineers have been finding clever ways to optimize how many tons of cargo any vessel could hold at given beam, draught and width.

The fully cellular containership fleet has behaved different in this regard insofar as it has brought entirely new size classes every 7-11 years, each time outperforming previously seen dimension by far. The current upper limit if this are vessels with a length of 400m, a beam of close to 60m an draughts between 16m and 16.5m, listed with a nominal capacity of up to 22,000 TEU. A subset of ordered vessels is believed by industry experts from Alphaliner to potentially achieve a beam of as much as 62.5m. ISL believes that in the last 30 years – give or take – it has been a combination of the regular double-digit demand growth of trade lanes and the constant introduction of ever larger ships that has led to the fully cellular fleet being – until today – a somewhat homogenous pulpy mass with vessels of all sizes and little recognizable segmentation. However, studying recent order behaviour, ISL has concluded that as the liner shipping markets are maturing and the growth is slowing down this fleet is to become more segmented into precise segments. The effects of which will not be seen for a couple of years to come though. This results from the fact that the

ordering activity of recent years shows a clear focus on selected segments while the existing fleet is still relatively young and distributed from the smallest to the very largest ships.

The following table includes ISL's most recent fully cellular fleet forecast and the colouring indicates the expected segmentation by nominal TEU capacities, which will become more clear around the year 2030 as the older and wildly distributed vessels are being "combed" out gradually. This phenomenon is something that is – according to ISLs assessment – unique for the fully cellular containership fleet. The dry bulk and liquid bulk fleets are already very clearly segmented and have already tested and accepted their individual commercial upper limits to dwt capacity.

	Fully Cellular Container Ship Fleet Forecast *in million TEU*			Average annual growth of capacity (rounded)		
	Start 2020	Start 2025	Start 2030	2018-2020	2020-2025	2025-2030
01: 0 - 999 TEU	**0.6**	**0.5**	**0.5**	-1%	-2%	-2%
02: 1000 - 1999 TEU	**1.8**	**2.1**	**2.3**	2%	3%	2%
03: 2000 - 2999 TEU	**1.8**	**2.2**	**2.5**	6%	5%	3%
04: 3000 - 3999 TEU	**0.9**	**1.0**	**1.1**	4%	3%	2%
05: 4000 - 4999 TEU	**2.5**	**2.4**	**2.2**	0%	-1%	-2%
06: 5000 - 5999 TEU	**1.6**	**1.5**	**1.4**	0%	-1%	-1%
07: 6000 - 6999 TEU	**1.5**	**1.4**	**1.3**	0%	-1%	-3%
08: 7000 - 7999 TEU	**0.3**	**0.3**	**0.3**	0%	-1%	-2%
09: 8000 - 8999 TEU	**2.6**	**2.0**	**1.9**	0%	-6%	0%
10: 9000 - 9999 TEU	**1.6**	**2.0**	**2.4**	0%	5%	4%
11: 10000 - 10999 TEU	**0.9**	**1.1**	**1.3**	4%	5%	3%
12: 11000 - 11999 TEU	**0.7**	**1.0**	**1.3**	20%	8%	5%
13: 12000 - 12999 TEU	**0.1**	**0.2**	**0.3**	0%	8%	5%
14: 13000 - 13999 TEU	**2.1**	**2.8**	**3.4**	5%	6%	4%
15: 14000 - 14999 TEU	**1.2**	**1.7**	**1.8**	17%	6%	2%
16: 15000 - 15999 TEU	**0.3**	**0.4**	**0.6**	17%	9%	8%
17: 16000 - 16999 TEU	**0.0**	**0.0**	**0.0**	0%	0%	0%
18: 17000 - 17999 TEU	**0.2**	**0.2**	**0.2**	0%	0%	0%
19: 18000 - 18999 TEU	**0.5**	**0.7**	**0.7**	4%	6%	0%
20: 19000 - 19999 TEU	**0.6**	**0.9**	**0.9**	11%	8%	0%
21: 20000 - 20999 TEU	**0.7**	**1.4**	**1.4**	95%	15%	0%
22: 21000 - 21999 TEU	**0.1**	**0.4**	**0.4**	10%	23%	0%
23: 22000 TEU +	**0.2**	**1.1**	**4.2**	n.v.	45%	30%
Total (million TEU)	**22.83**	**27.34**	**32.49**	**5%**	**4%**	**4%**

Source: ISL Forecast May 2018

Figure 9: Forecast of Fully Cellular Container Fleet until 2030

The container market is somewhat special in that it regularly enjoys the detailed medium-term attention of analysts, trying to understand the medium outlook in relatively detailed regional aggregates (as above). When it comes to other commodities, forecasts of industry observers will often aggregate stronger. This is the reason, why the following discussions will need to consider more broadly based global outlooks and demand drivers.

3.2. Dry Bulk Cargoes

According to Eurostat information, European ports handle more than one billion tons of dry bulk commodities (including general cargoes, which are not containerized or ro-ro cargoes) annually. During the time of the industrialization, these commodity flows grew almost hand in hand with economic activity but ever since the economies matured and additional growth took place in the less resource demanding service sector, traffic growth stalled. Thereby the commodities do possess a fundamentally different outlook which warrants for individual discussion.

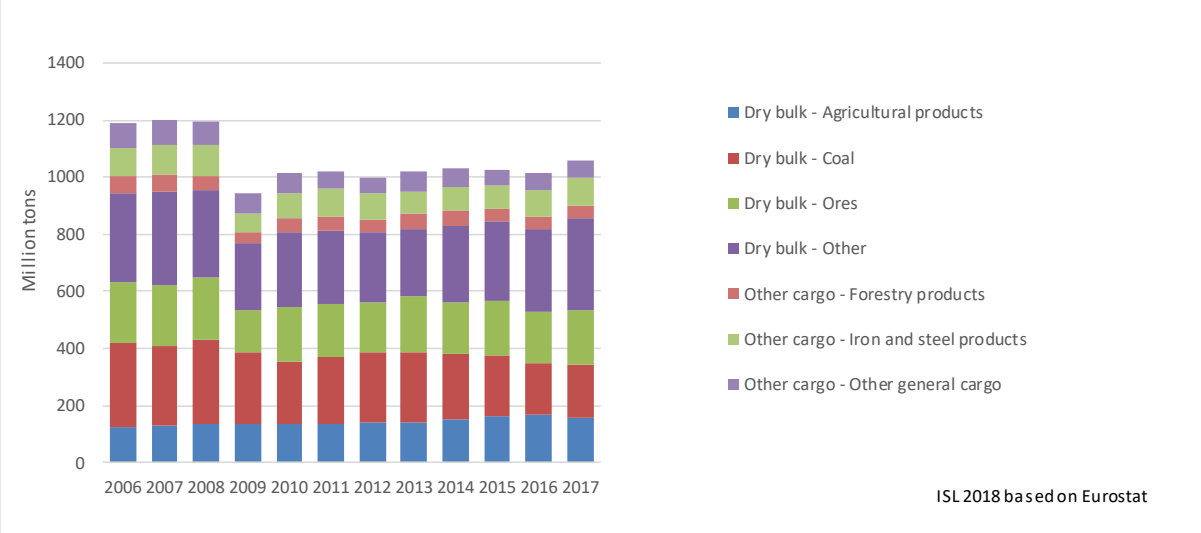

Figure 10: Dry Bulks and Non Ro-Ro/Container- other Dry Cargoes in European ports 2006-2017

3.2.1. Ores

The trade in ores – which except for Sweden is regularly a net import – stagnated long ago. However, the European steel industry has so far been able to tackle competition from low wage countries and is expected to continue to do so for the foreseeable future. Yet it seems unlikely, that additional sites will be set up in the high wage/environmental standard European countries. So, the most realistic outlook for the trade of iron ore is a constant development at given levels. As far as the (much smaller) bauxite import is concerned, the same reasoning applies.

3.2.2. Coal

Coal imported via European ports consists of steam coal and coking coal – both have different demand drivers. Until 2008, the imports of steam coal actually showed a regular growth as domestic production of coal was abandoned to rely on cheaper (and often better quality - i.e. higher caloric value) maritime imports. On a global level, it seems that this commodity has peaked due to global warming concerns (or at least on a global average) with even China and India mothballing some of their initially planned coal fired power plants projects. On a European average, it is to be expected that some coal fired power plants will shut down ahead of their effective life expectancy as methane-based electricity generation is starting to take over as the fossil fuel du jour in electricity generation, while energy produced from renewables is enjoying a steady year-on-year growth. The 2018 BP Energy Outlook assumes that EU coal consumption will decline by 4.2% on

average during 2016 to 2040, cutting consumption effectively by two thirds. The impact on ports will be partially offset since coal is currently still being mined within the EU but the net impact will be a noticeable drop in the import of hard coal during the next decades.

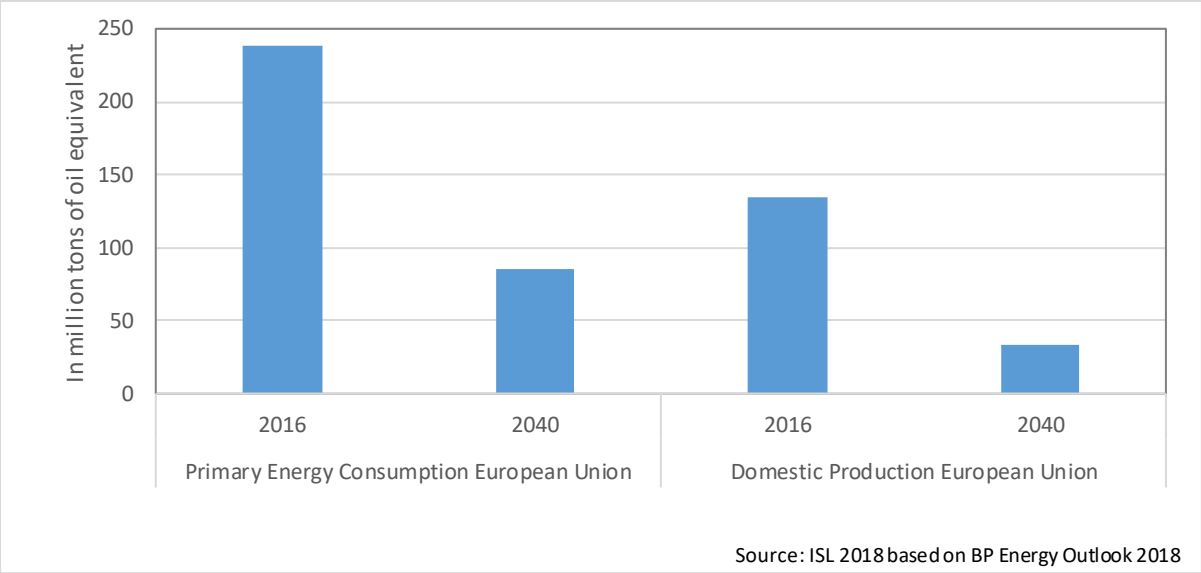

Figure 11: coal consumption and domestic production, European Union 2016 / 2040

The second (much smaller) segment of coal that is handled in European ports is coking coal, which is used in blast furnace operations of the steel industry. Since it is expected that the steel industry will persist, this smaller segment of cargo handling is expected to remain constant as well. However, the end of coal as a fuel for power plants seems to be agreed upon for the time being and some ports have already discussed (behind closed doors to the expert knowledge of the ISL) how to put the vast spaces of soon to be freed up land to a good and productive use, once the need to handle coal in previously seen amounts will be gone. It would be entirely speculative to specify a time frame for this development. Erratic climate developments could spark political initiatives and disruptive developments in terms of reduced costs for renewables or LNG (methane) becoming more and more of a global commodity could advance the decline of coal in European ports.

3.2.3. Grain

Grain handled in European ports is one of the commodities where a long run growth trend is visible and plausible. Whilst during the years around 2000, many industry observers chose to ignore grain as a topic since the Chinese import of Iron ore and the entire Asian import demand growth for steam coal have been the dominant topics, the trade of grain has two growth drivers which remain intact even as economies mature. First of all, a growing world population is expected to consume more staple foods than a smaller population would have – at any given point, which works as a growth driver for grain used in the bread industry. Second of all, the income increases in developing economies bring about changing diets and consumers tend to increase their consumption of meat, which has a superproportionate impact on the demand for animal fodder. Whilst the world population and the GDP per capita continue to grow, there is a superproportional impact on the demand for grains. European ports are suited to benefit from this impact as they are located close to fertile and often unused land. At the same time, countries where the population is expanding

rapidly are suffering from poor agricultural conditions and the trade of grains – at the end of the day – is effectively a trade in fresh water. Since the trade in agricultural products is notoriously volatile there have always been reasons to not escalate investments in suitable infrastructure in ports too far. As a result, the grain trade volume of European ports is spread over numerous smaller ports in significantly smaller amounts compared to e.g. the trade in ores and coal. In the long run, the silo capacities in European ports could turn out to be bottlenecks of a trade with – as of now – very much intact growth drivers.

3.2.4. Other dry bulk commodities and dry cargoes

Next to the major bulks, iron ore, coal and grain, there exists a noticeable amount of industry raw materials, industry products and agricultural raw materials or products. These prove to be particularly hard to analyse as they are in fact a very broad mixture of commodities with fundamentally different origin-destination patters, sometimes linked and sometimes independent demand drivers and will sometimes chose to travel in containers without that meaning that they will remain containerized forever. In the following, sub categories will be introduced and discussed.

In those instances, where « metals and minerals » are imported to Europe, the reasoning is that growth is likely to remain at or around zero % - similar to the reasoning for the « ores » as discussed above. It is unlikely that Europe will see some sort of core industry expansion so there also seems to be no plausible case for the development of maritime imports of these raw materials. Similarly, an unchanging or potentially declining population in mature European economies does typically not give rise to additional imports of steel coils, which may be reported as general cargoes or “other bulk” depending on the individual understanding of the ports. This also explains why sometime project cargoes may be listed as “other bulk” if they are for example steel products like pipes and shipped in huge amounts.

Somewhere hidden within the « other dry cargoes » are typically the non-containerized and non-RoRo cargoes which fall under the heading of project cargoes. There fortune will to a large extent depend on the development of the world economy and political interactions with energy markets. This sector – which went by almost unnoticed while the liner shipping markets have been booming. It is assumed that there should be always a bit of spare capacity available allowing Europe to remain competitive and able to import and export key project machinery/components. However unfortunately, until this very day there exists no comprehensive assessment of the global or even regional project cargo shipment industry.

The trade in fertilizers could benefit slightly from the overall intact demand for grain which could imply a 1-2% annual growth of the demand for storing and handling fertilizers in European ports. Similarly, the remaining agricultural products (including forest products) are likely to grow at rates of or around 1 %.

3.3. Liquid bulks

Combined, all European ports regularly handle around 1.4 billion tons in liquefied bulk cargoes which warrant a specific discussion each.

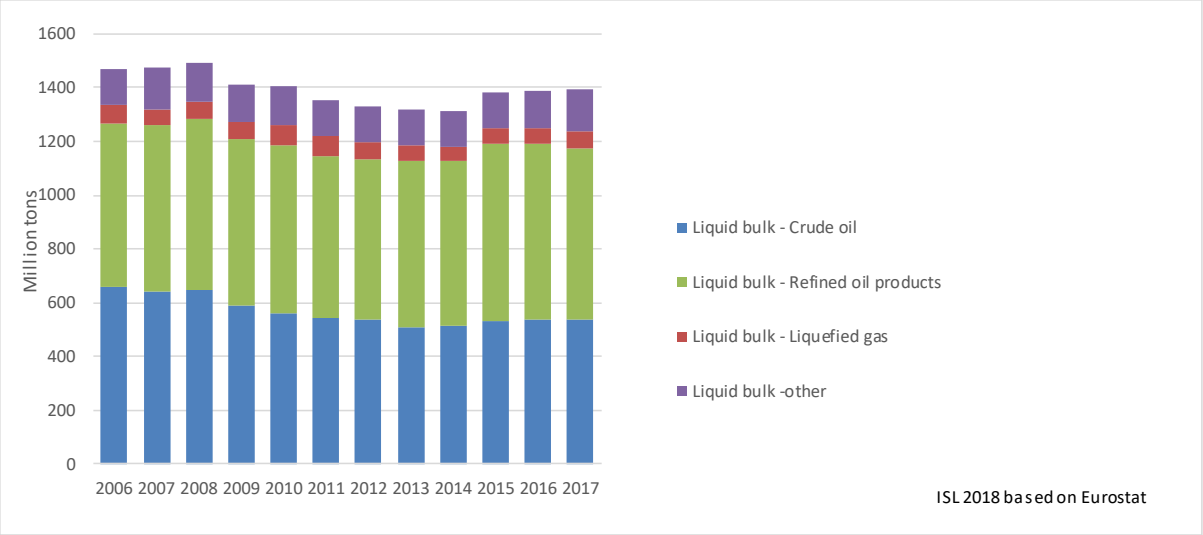

Figure 12: Liquid Bulk Handling in European Ports 2006-2017

3.3.1. Oil & oil products

European ports regularly handle 570 million tons of crude oil on average. This breaks down into mostly (around 500 million tons) of imports to continental Europe and around 70 million tons of exports which mainly originate from British ports or – in rare occasion relate to transshipment or storage moves. As it once was coined that « the stone age did not end for a lack of stones, much the same as the oil age will not end for a lack of oil », oil is expected to lose relevance with a growing share of electric propulsion of cars and new mobility concepts. The BP Energy outlook 2018 expects that the primary energy consumption in oil (including e.g. shale oil and naturals gas liquids but excluding biofuels) within the European Union will decline by 1.9 % on average annually during the years from 2016 to 2040. This implies a drop in consumption from 13 million barrels per day in 2016 to 8 million barrels per day in 2040. Domestic production is expected to decline from 2 million barrels per day to 1 million barrels per day still leaving import terminals with a considerably reduced amount of work.

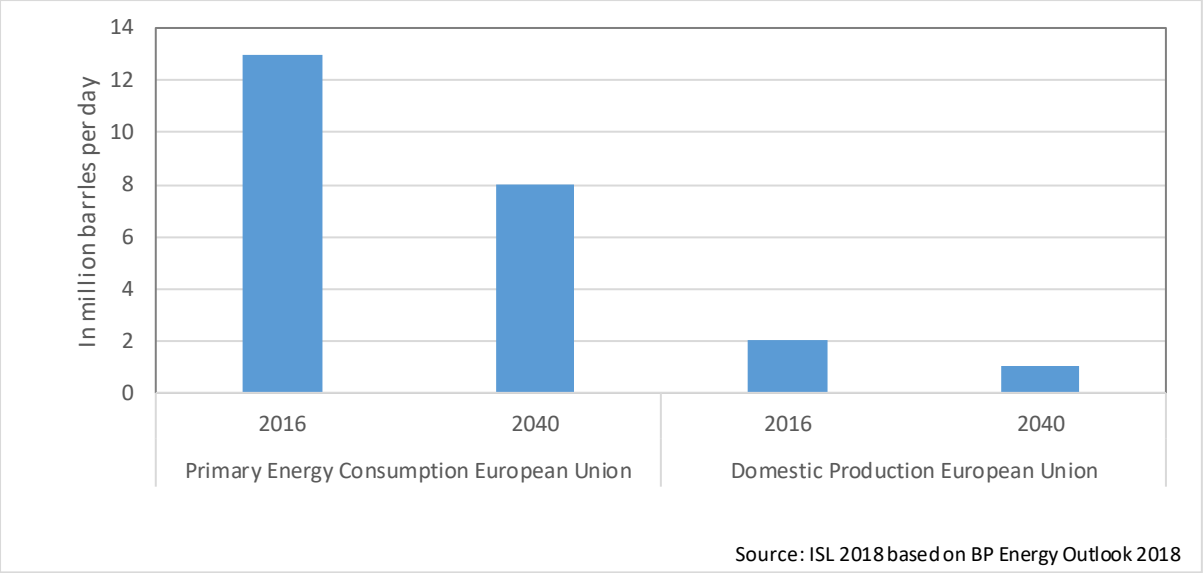

Figure 13: oil consumption and domestic production, European Union 2016 / 2040

For several years already, there is a decline of refinery capacity observable and the most realistic assumption is that this trend will continue. As a result, there is no evident shortage of capacity for the import of crude oil. Unlike coal, this commodity is not expected to decline as aggressively but rather gradually as refineries are likely to close one by one as investments to replace the plants are deemed uneconomical in face of a declining consumption.

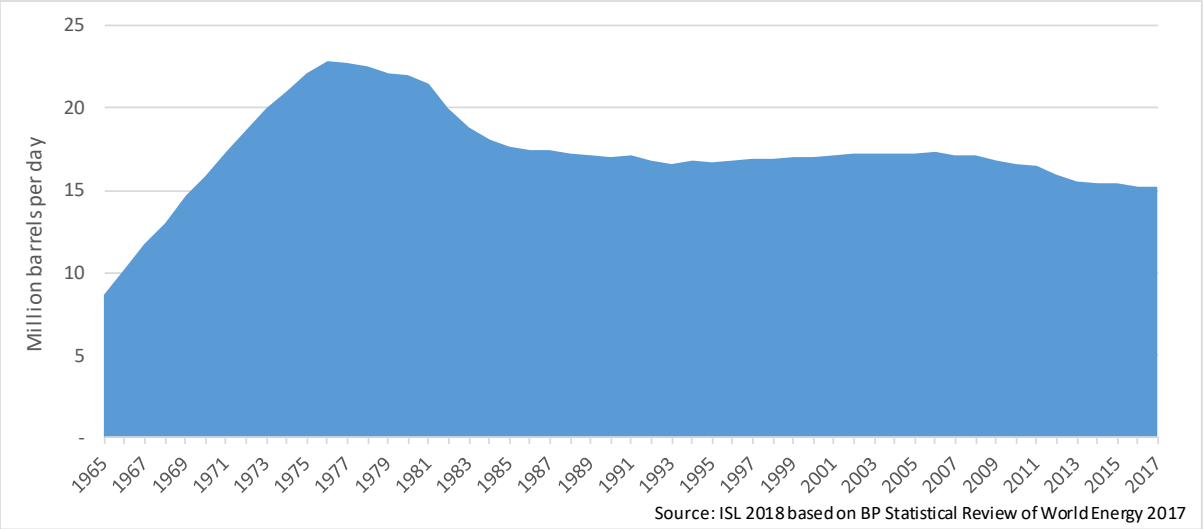

Figure 14: development of refinery capacity in Europe 1965-2017

When it comes to the handling of oil products, the picture is more complex and while a long run decline of crude oil consumption will equal a long run decline of domestic oil product production, the demand assessment is rather difficult here and depending on a lot of individual factors. Normally, Western Europe has shortage of diesel fuel and a surplus of gasolines. This imbalance is met by imports and exports from Russia / to the U.S. or via the « world market » in general. With the ongoing decline of oil in heating and recent dispraise of diesel fueled cars by insecure

consumers, this general trade demand could also falter. However, these trend towards gasoline fueled cars could prove to be short-lived and it is by no means clear which propulsion technology will ultimately win over the consumers. Additionally, jet fuel consumption is expected to increase and shipping as a whole might have to resort to distillate fuels in larger amounts in the future – e.g. with regard to the Sulphur cap by IMO in 2020. The implication is that wherever possible, tank storage facilities with licenses to store clean and dirty products should at least be maintained to have a reasonable amount of buffer storage available for sudden demand swings, which may no longer be met by the decommissioned domestic refineries in the future.

The « other liquid » cargoes could and will likely comprise the occasional petroleum product considered by some of the reporting ports to be a chemical substance or vegetable oils as well as chemical acids. There is a niche market for the transport of juice and wine but the lion's share of these volumes are likely to be vegetable oils and acids, produced or consumed in local European industries. Here, similarly to the iron ore trade it is reasonable to assume that these chemicals have reached a mature volume, reflecting the demand of the mature economies of Europe as a whole. Capacities should be maintained at the given levels hence.

3.3.2. Chemicals

While the oil market is relatively easy to asses based on assumptions about the future demand and supply, the oil products market is already harder to analyse as it is to some extent supply driven and much of the trade is depending on the location of the refineries. Still, as both markets are reasonably large and the demand for standardized petroleum products is large in volume and by number of customers. Compared to this, the market for liquid chemicals transported in tankers is a much more delicate issue as these trade flows originate from a wide range of industrial plants from e.g. ore processing plants via food processing plants and refineries to straight forward chemical companies.

The list of possible destinations for European chemical trade is equally diverse. Furthermore, there are effectively two trading patterns. In the first pattern, the import or export of chemicals will often be a key aspect of the respective trading partners' business model. Here it will be quite normal to find suitable import/export-storage facilities adjacent if not directly on site of the industrial plants producing or consuming the commodities. This is different for oil products, where it makes sense to run large independent tank storages, as there is a well-developed market with few products in large quantities with a large number of multinational buyers. With chemicals however, the parcels will regularly be very small and the list of potential customers is rather narrow (for any one of the transported substances). Hence, it is quite normal for the enterprises to comprise the landside elements of the maritime logistics chain. These enterprises normally will discuss their respective needs for e.g. quay-maintenance with local authorities and will very likely fly well below the radar of any EU port governance. Very similar to ores, it is argued here that the demand has effectively peaked with the maturing of the industries in Europe. In addition, that the occasional additional import or export demand resulting from a new producing/consuming industrial plant will be rather the exception than the norm.

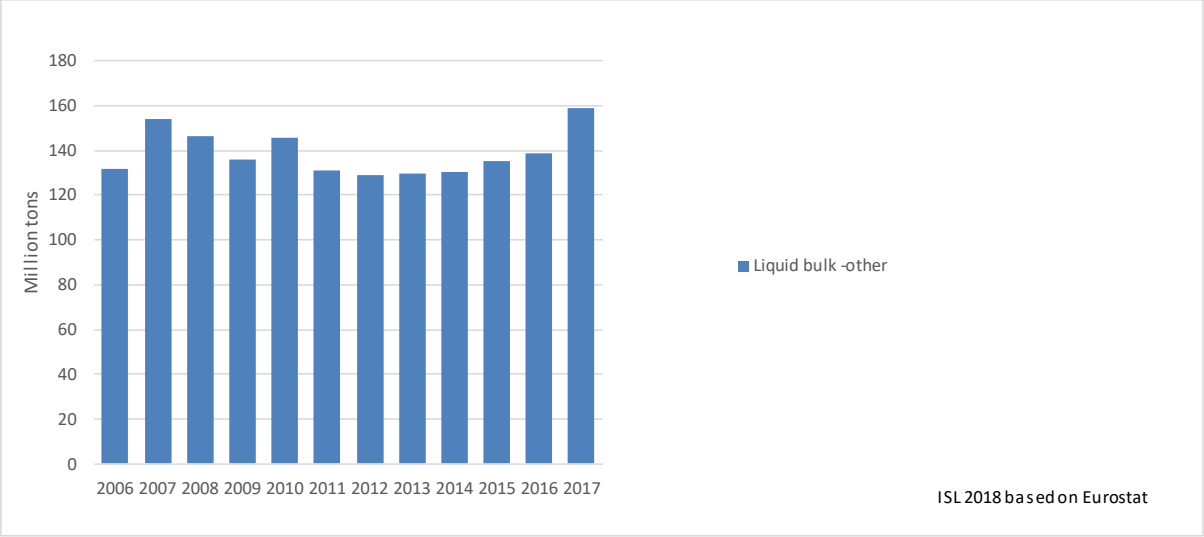

Figure 15: Handling of "other" liquid bulk cargoes in European Ports 2006-2017

Next to the small-scale chemical cargo imports and exports of companies with access to the ocean, there exist large scale chemical clusters e.g. in Rotterdam, where the maintenance of tank storage even for "un-easy" (= hazardous) chemicals would be an option for independent operators as the sheer size of the surrounding industries could make for a viable business case based on regular import and export demand. While the European market as a whole is matured and it is not expected that these clusters expand in size, the tank storages may on occasion be sought after rather feverishly if interests from outside Europe show an increasing demand to aggregate transshipment cargoes while expanding their own terminals. This kind of transshipment could also make sense during the winter season when ice-class vessels could shuttle chemicals from Baltic Sea countries to ice-free North Sea ports for aggregation/transshipment.

The known unknown in this sector is the future of energy used in transportation. If for example, at any time in the future the offshore wind energy will be used to produce synthetic organic fuels or if bio-fuels will at some point appear to be the right solution going forward, tank storages could become scarce abruptly. In these cases, however, it seems likely that decommissioned oil refineries will see an upgrade of their own tank storages wherever the persisting cargo restrictions seem unfit for the then required cargoes (e.g. ethanol instead of heating oil).

3.3.3. LNG, LPGs and chemical gases

The market for liquefied gas consists of several segments with sometimes strict and sometimes weak borders. By far the most important market of the next decades to come will be the market for the import of liquefied methane commonly referred to as « LNG » (liquefied natural gas). This is effectively the only fossil fuel where demand within the European Union is expected to increase in the future, as it will replace coal in electricity generation due to its cleaner combustion, and relatively better CO^2 emissions per unit of energy produced.

However, methane (or CH4) remains a fossil fuel and will most likely be a bridge technology towards the more intense use of renewables, which is expected to show significant growth in the long run. Along the entire European coast, port authorities and administrations as well as energy companies

are eying potential sites for the import and regasification LNG. The huge import potential however does not so much originate from a significant increase in demand but more from a decline of domestic production. Whilst some large import terminals already exist and are in operation on Europe's coasts, it is still not entirely clear where the industry is headed as a whole and which type of supply chain will ultimately be dominant (shore-based storage and regasification or floating storage and regasification units). Whilst the LNG trade is expanding rapidly on a global level, it remains an intransparent industry in terms of supply chain costs or let alone a global pricing mechanism. When the oil price collapsed in 2014/2015, this has somewhat dampened the industry's enthusiasm to go ahead and push for the implementation of new terminals. In terms of volumes however, LNG imports will very likely show the highest absolute and relative growth performance as shortfalls in domestic production will have to be met with increasing imports in the long run. The dynamic is hard to gauge and will depend effectively on the competition by renewables and political pressure to abandon coal and partially oil.

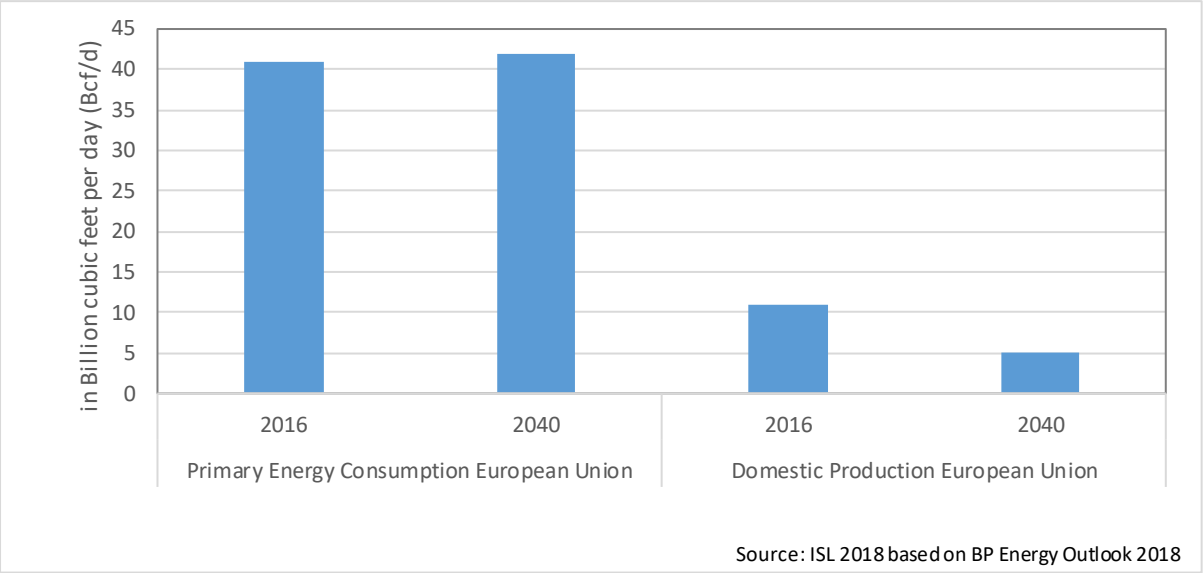

Figure 16: Gas consumption and domestic production, European Union 2016 / 2040

LPGs are a by-product of the oil refining process as well as of the production of crude oil or methane from conventional sources (i.e. underground deposits which are available without the application of hydraulic fracturing). They are used in industrial processes, for heating and transportation purposes (e.g.: cars regularly rely on propane/butane rather than methane for propulsion). With the expected ongoing decline of the European refinery capacity, fewer of these products will be produced domestically, which could create an additional import demand in the long run. As a result, where possible, LPG import facilities should be maintained and where handling shortages are reported by operators already, theses facilities should be upgraded.

The last and smallest group are « chemical gases ». These are produced/consumed in selected industries where it seems reasonable that there will not be any additional demand yet but also no noticeable decline.

3.4. Noncontainerised Cargoes

3.4.1. RoRo

Accompanied and unaccompanied trailers account for the lion's share of the «RoRo» traffic. This segment still possesses some growth potentials, which are occasionally realized with the help of EU funding. With ship emissions becoming smaller through slow steaming and cleaner through stricter emissions regulations, while the truck fuel emission optimization potentials are wearing thin, we could reasonably see additional growth of around 1-2% p.a. for this particular market. Where the mature European economies are already reasonably well connected and fixed links (e.g. the Fehmarn Belt fixed link) might have a detrimental impact on local volumes, markets are likely to grow slower, particularly as trailers are in constant competition with European shortsea container shipping. However, where the economies are not equivalently mature or where connections lead to less developed economies within (or without the EU), growth of RoRo cargoes could potentially outperform the above-mentioned range of 1-2% p.a.

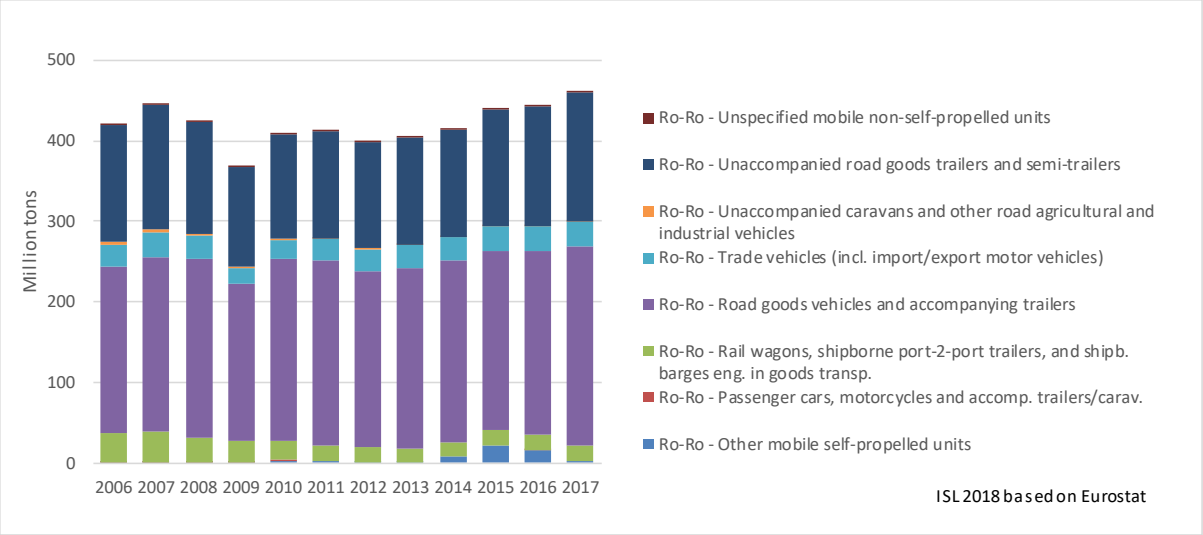

Figure 17: RoRo Cargo Handling in European Ports 2006-2017

A persistent challenge of the analysis of the project cargo markets is that the goods are well hidden in multinational port statistics (as is already discussed above under "other dry bulk cargoes"). The RoRo cargo section for example will often comprise cargoes that effectively rolled onto the vessel by itself (e.g. large machinery used in agriculture) or which potentially could "roll on" by itself but have been loaded with a crane instead. In lack of any hard data and given the notoriously mercurial nature of these trade flows, it is close to impossible to identify these trade flows or asses their growth correctly (as will be discussed in the next section on "general cargoes" as well.

3.4.2. General Cargoes

"General cargo" was once the standard way of transporting anything that was not a bulk commodity. Since the container captured or rather conquered these markets, even captivating

some bulk commodities, the amount of general cargoes handled in European ports has become almost negligible in volume. The three remaining types of "general cargoes" normally fall into either one of the three following categories:

3.4.3. Reefer cargoes

Despite the impressive expansion of global trade flows during the last 20 years, the reefer fleet has been stagnating during the same time as more and more reefer cargoes previously thought to be "un-containerizable" ended up in containers. With a few rare exemptions, this industry is declining and the facilities in Europe have often turned partially or entirely from unloading refrigerated cargoes from reefer vessels to importing reefer containers and managing the inland distribution. This decline is expected to continue.

3.4.4. Neo-bulk or "break-bulk"-cargoes

These will often be forest products, effectively handled individually but transported in bulk carriers. Additionally, large homogenous shipments of e.g. pipes (effectively project cargoes) as well will often be referred to as either general or "break-bulk" cargoes. These are either not feasible for container transport or may actually employ specialized ships (e.g. forest product carriers). Where these trade flows belong to the "project cargo"-spectrum, the trade flows are generally hard to predict. Unfortunately, there are no binding definitions and one ports' break-bulk-cargoes may be another ports' project cargoes or general cargoes. Likewise it seems plausible that a share of the "iron and steel" products listed in Eurostat's database are not merely standardized steel coils but are effectively very sophisticated project cargoes instead.

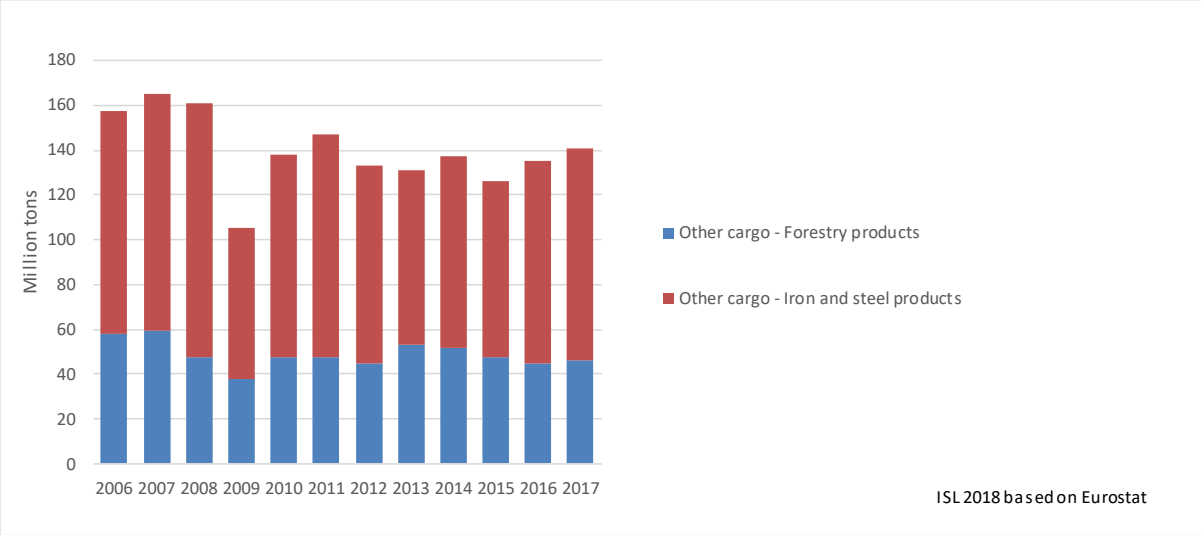

Figure 18: Handling of Forestry and Iron and Steel products in European Ports 2006-2017

Project cargoes

With the exception of the abovementioned standard steel products or agricultural products and refrigerated goods, the remaining cargoes handled in European ports _should_ all belong to the project cargo sector, which is notoriously light in volume but heavy in workload/added value.

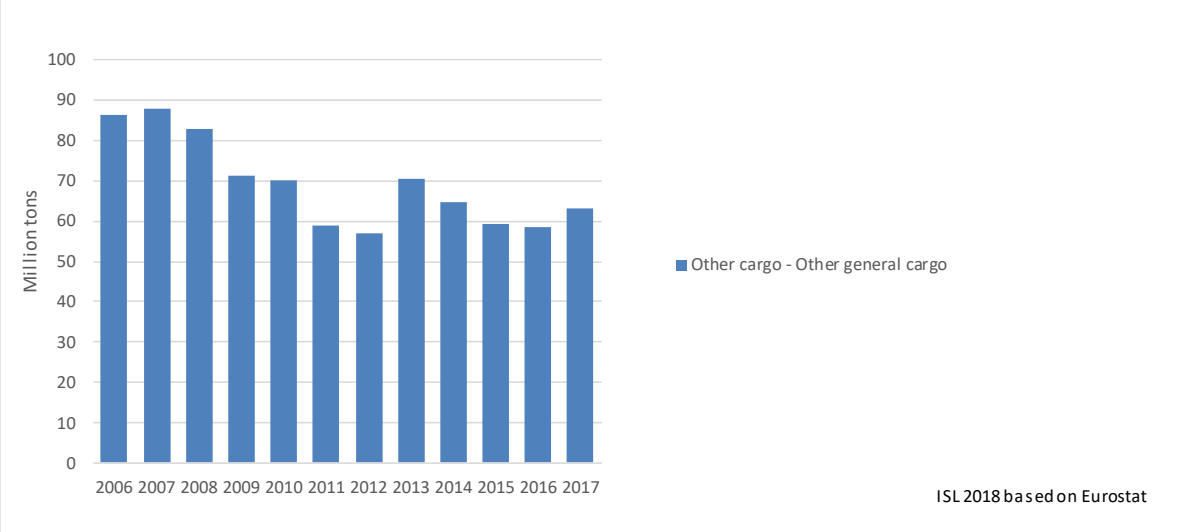

Figure 19: Handling of Forestry and Iron and Steel products in European Ports 2006-2017

The chart above is likely to represent both the impact of the financial crisis on the project cargo market, which hit with somewhat of a delay, as well as the ongoing decline of (conventional) refrigerated cargoes, not represented anywhere else in Eurostat figures. The project cargo industry is particularly hard to gauge since there are no regular trade flows and importers and exporters are very diverse. Before the 2008/2009 economic downturn, it was argued that this market would benefit from the long run increase of economic activity in emerging markets. There, additional growth would lead to additional raw material consumption from ores to coal and this would in turn call for example for more investment in global mining facilities – and in turn generate more project cargo shipping demand. With the demise of the coal industry and China's appetite for iron ore turning out to be somewhat overestimated, these growth prospects have vanished. In addition, new companies from said emerging economies have started to ramp up their own production of industry goods which would travel as "project" cargoes, effectively cutting the growth potential of European exporters. Currently the demand is likely going to be stable going forward with the future installation volumes of offshore wind energy being the known unknown.

3.5. The impact of Brexit

The most important change regarding the traffic volume will be induced by the end of the UK's EU membership. Among the 1,382 ports with maritime traffic (Eurostat), 144 are in the UK. In 2016, they handled close to 500 million tonnes, one eight of the EU in total. As regards passenger traffic, the weight of UK ports is less important (roughly 7 % of the EU total), but includes the largest passenger port in the EU, namely Dover.

The impact of Brexit will hence be asymmetrical in the different segments. Within cargo traffic, some segments will be more affected than others. The database will provide segment-specific filtering options and hence the adequate assessment of the impact on transferability.

4. Trends in Port-City Relation and in international Port Cooperations

4. Developments in port-city relations and international port cooperations

Chapter 4 is covering issues with regard to port-city relations and international port cooperations that are expected as essential for the future developments of ports. Concerning port-city relations, the relevant policies and related areas for future relations between ports and their cities are explained. The subchapter on international port cooperations refers to individual forms of cooperations and the reasons why horizontal and/or vertical cooperations are assumed to appear.

4.1 Developments in port-city relation

This topic on port-city relations has been an issue for a number of decades when ports and cities started to lose their mutual interdependence and their developments since then has influenced each other.

The maritime transport sector, i.e. shipping and ports evolved like e.g. in terms of vessel developments, transport and ICT technologies, required terminal infrastructures and stacking areas, increasing volumes in port handling and pre- and oncarriages, sea-side access, hinterland infrastructures, and port adjacent logistic services. The developments have been necessary to maintain ports' competitiveness in a fast-changing environment which has been heavily influenced by the demand side for port services, i.e. ship operators. In addition to these factors which have driven ports' development in the recent past, a consequence of advanced ship and port technologies has been a decline in jobs for port workers.

In the meantime, urbanisation in port cities advanced. Populations in cities have grown and thus more living space has been required. Here, revitalisation of non-used older port areas has been only a part-solution to create new modern living quarters but also leisure facilities and commercial services, which only partly have links to the port business.

Hence, port-city developments can be characterised as an increasing rivalry for limited land resources and in parallel by a decrease in benefits from ports for their port cities (e.g. in terms of employment) and an increase in negative consequences from port operations like environmental impacts and traffic congestions.

This picture on the development from the recent past and the related conflict potentials can be also assumed as a reflection of the prevailing future trends in port-city relations.

Particularly environmental impacts from port operations on cities have become essential issues in the past which will even enhance in the future. The reduction of exposures from emissions and noise is a key issue here - particularly the reduction of emissions like SO_x, NO_x and PM as these emissions have strong local impacts on health, well-being and thus on quality of life of populations in and around port cities. Relocations of port areas or terminals and settling of new terminals outside from urban areas is one ongoing trend to relieve port cities from pollutions caused by port operations. The relocation of the intermodal terminal from the inner city in Gothenburg to the outsided port area in 2018 is one example here that serves for both purposes, i.e. reduction of air and noise emissions from 200 trucks and twelve block trains daily and provisions of space for urban development of the inner city.

Contrary to the newbuilding of a port, relocations of existing ports or terminals require certain framework conditions like available space in these more remoted port areas, accessibility from the sea side as well as from the land side - particularly hinterland infrastructures in terms of

efficient rail and road connections as hinterland transport is a decisive competition factor for ports , e.g. not only among ports along the North range between Antwerp and Hamburg but also between the North range port and ports in Southern European for Europe-Asia trades. Thus, further promoting a modal shift by inceasing the share of environmental friendlier rail and inland waterway transports will remain a trend to lessen environmental conflics in port-city relations. However, as road transport will have also in the future significant shares in the modal split, it will remain an essential challenge for ports and port cities to improve road transport's environmental performance by increasing its efficiency – in addition to new technologies from the truck industries like autonomous vehicles. Here, technology solutions togther with spatial plannings are to be used, like e.g. truck-appointment-systems and pre-gate-systems which are joint issues of port authotities and urban development departments.

Since 2010 vessels are required already to use only fuels with less than 0,1% sulphur content in ports and port access which has lowered already SOx emissions from vessels operating in ports. Additional measures will be required here to reduce local emissions in port areas affecting also port city populations. Provision of facilities to use alternative fuels is and remains a future issue in port cities to achieve further emission reductions. Here, provision of LNG bunker facilities and the extension of shore-side electricity ('cold-ironing') have to be achieved as an increased suppply of these infrastructures on the port side are expected to trigger also a higher demand from the shipping side (i.e. through rising newbuildings eqipped for these alternatives or through retrofitting of vessels). Besides the aim to tackle the issue of local emissions, port-city relations will have to cope also in the future with challenges deriving from climate change. Predicted increasing number of natural disasters like e.g. extreme rainfalls, high floods, winds and a rising sea level will affect also ports and port cities and needs joint measures to develop required port infrastructures. Hence, developments to reduce environmental impacts from ports will be also crucial drivers for port-city relations.

Spatial planning is closely related to environmental challenges for port-city relations and mutual benefits and rivalry are immanent here. Linking to burdens that port cities have to bear from port operations, transport and traffic planning is an essential issue for spatial planning in order to optimise port-related traffic with regard to competitive hinterland structures but also considering impacts of port-related traffic for cities. An essential challenge for spatial planning in port cities is the use of port areas that are not fully used for port business activities and offer opportunities for urban developments like housing. However, often there are legal obstacles that do not allow having port service companies and living spaces at close quarters. Here, regulations are to be adapted in a way that interests and rights of both sides, i.e. port companies and residents are sufficiently considered and former purely port areas can be used commonly.

Relocations of port areas remain therefore also a task in spatial planning in order to provide revitalised space exclusively available for urban developments. The above-mentioned relocation of a terminal of the Port of Gothenburg is a good example here but there are many. Taking an example from Asia, the Port of Singapore Authority announced in 2013 that port activities at the Tanjong Pagar Terminal will be relocated to a new location in Tuas. This process is expected to be finalised by 2027 and shall provide required land for the further spatial development of urban area in Singapore. Therefore, spatial planning against the background of port-city relations will have to tackle the challenge to balance out interests and requirements from the port and the urban city in order to achieve a required efficient functioning of the port and the city.

Taking the changes in the port-city relation into account, i.e. alterations in port operations mainly caused by external factors and the requirement that urbanisation entails, there are opportunities

that offer benefits for port and cities as well. The development of economic clusters taking advantage not only of the ports but of the overall adjacent maritime business provide the chance to create mutual benefits between ports and cities and will essential for port-city relations. Tourist activities like event tourism, leisure sailing, historical museums and gastronomy or new marine business like offshore wind farms with production site and adjacent logistic services using benefits that port areas provide are two examples for economic clusters benefiting ports and cities.

As environmental impacts from port operations, the provision of efficient port infrastructures and traffic systems, revitalisation of port areas or the development of new economic clusters and the balancing of interest and needs of ports and cities are complex issues and often interfering each other, governance involving port authorities and port stakeholders and the concerned is a key for sustainable port-city relations.

4.2 Developments in international port cooperation

The development of port volumes in 2017 was positive in terms of container and bulk volumes and based on the positive trends in global trade and thus maritime transport. However, the global port sector has experienced an increasing competition among ports in recent years. Growing market power by alliances, pressure on infrastructure developments to accommodate increasing vessel sizes, the need to follow technological advances (e.g. autonomous vehicles), and stricter environmental framework conditions has put the pressure on ports to re-define their roles within global logistic chains. Ports have to react by improving their services through adapted strategies and corresponding port development plans in order to comply with benchmarks and with aims stipulated by international organisations as well as by the demand side for port services. Therefore, port stakeholders like port authorities, terminal operators, governments, bunker operators, logistic service providers, are challenged to identify appropriate measures to enhance operational, economic and environmental service performances. In the following different forms of cooperations will be outlined that are also expected to take place in the maritime sector with regard to the future.

4.2.1 Forms of international port cooperations

International port cooperations have been an issue for a long time in the port sector but with an ever-growing importance in recent years. There are different reasons triggering port cooperations like e.g. the need for financial means for investments in port infrastructures and superstructures, enhancing complying with environmental regulations and setting standards for environmental protections, improved hinterland transports or provision of capacity extensions. Hence, as orts are immobile nodes in global supply chains, international port cooperations provide the potentials to contribute to strengthening port performances within these global supply chains and their changing requirements. Envisaged synergy effects through port cooperations can achieved through on two different levels, i.e. through horizontal cooperation and vertical cooperation. Horizontal port cooperation is understood as cooperation on the level of ports, i.e. between two or more ports – subject to different reasons and with forms of cooperations. Whereas vertical cooperations refer to a cooperation between ports and other stakeholders within the supply chains – either seaside or landside-related.

The range of actors participating in port cooperations refer to public entities and private companies – either involved together in types of cooperation or involved individually. Public entities comprise

port authorities presenting generally local or regional governments. Private actors as potential partners in cooperations cover terminal operators as well as shipping companies, forwarders, barge and train operators, logistic providers as well as cargo owners.

However, the organizational port landscape is not that homogeneous. Different organisational forms of port governance exists whereby the landlord from is the prevailing form in Europe, i.e. in general with a public owned and financed infrastructure, private owned superstructures and also private port operations. Other port organization forms, i.e. tool ports, public service ports, corporate ports and private services ports are declining, inter alia as the strategy behind EU ports policy has been supporting a move towards the landlord form. As ownerships, organisation and administration of ports have been different in the EU applying different forms of port organisations, the EU port policy has been aiming at the harmonisation of financial flows between the public purse and private industry, i.e. between port authorities, port operators and the users of the port infrastructures, superstructures and related services. The aim is to avoid distortion of competition among ports by subsidizing port services with public investments. Hence, a level the playing field for the port sector has to be implemented allowing transparent and efficient investments in ports. As a result, financing of port infrastructures has been done with an increasing share of participation by the private sector resulting from the fact that relevant port authorities – either on a local, regional or national level - have been more focused on their landlord role and the financing and operation of port facilities that are relevant for services of public interest. These services refer inter alia to development and construction of port infrastructures, organization of nautical services, planning of port developments, organization and administration of safety and security in ports. Hence, despite the fact that the roles and tasks of port authorities are subject to the organizational form determined by the responsible local, regional or national government, a number of characteristics are in common for port authorities.

While port authorities are the main actors in port cooperations on the public side, terminal operators take the prevailing role for the private side. Core business of terminal operators is the handling and storage of cargo including operations of hinterland transports and complemented by value-added logistic services. In principle, terminal infrastructures are leased out by the responsible port authority while the terminal operator is responsible for the investment and operation of port superstructures.

In the following, the different forms of horizontal and vertical cooperations relevant for future trends in the port sector are outlined.

Cooperation agreements, e.g. through a 'Memorandum of Understanding' as horizontal cooperation refer in principle to information exchanges aiming at increases in port handling volumes. However, growing handling volumes are here not directly achieved but indirectly through a number of different measures that foster trade links between the ports and the port countries concerned. Possible measures comprise information exchanges on hinterland, strategic marketing, environmental protection measures or exchanges and training of staff for mutual learning benefits (e.g. application of new technologies). Additional measures included in a 'Memorandum of Understanding' as administrative issues like custom clearance procedures and safety and security standards have to be considered within the framework of international agreements or organisations like the EU, e.g. common custom clearance procedures in the EU need to be considered in case of bilateral port cooperation agreements

A more on operational focused form of horizontal port cooperation is the coopetition as one of upcoming cooperation strategies in order to comply with market requirements. The term consists

of cooperation and competition as ports do both in this cooperation form, i.e. they compete and cooperate – and driven by common aims. Hence, through coopetition the involved ports concentrate on the advances while trying to minimize drawbacks from their weak points in order to develop joint assets allowing to enhance their competitiveness towards other ports.

Measures have a stronger binding character than in the form by 'Memorandum of Understandings' and comprise also financial implications like joint marketing initiatives, qualification and employment of staff, buildup and use of equipment pools or investment in port facilities or services.

Next level of horizontal port cooperation is the port merging leading to the full integration of the concerned ports which may refer also to ownerships. The operational business and thus revenues from port operations are divided according to the contractual agreements as base for the port cooperation. The Copenhagen Malmö Port is a well-known example here, which was established by a merger of Copenhagen Port and Malmö Port in 2001 as response to operational and economic challenges following the completion of the Öresund Bridge between Copenhagen and Malmö.

Port cooperation forms on a vertical level involve actors along the supply chain and thus have in general a more business or operational character. Existing cooperations are between seaports and inland ports with the strategic aim to expand the hinterland and to improve the existing hinterland connections increasing or maintaining port handling volumes for the benefit of both cooperation partner. Land-side related vertical cooperations refer also to terminal operators on one hand and rail and barge operators on the other hand - either based on common business contracts in order to ensure efficient and reliable hinterland services or on the basis of joint ventures which gives terminal, operators also the ownership in hinterland transport services. Vertical cooperations between terminal operators and ship operators are seaside related and are based on business contracts (e.g. dedicated terminals) or joint ventures.

4.2.2 Reasons for future port cooperations

The described forms of international port cooperations will further on play an essential role for the future development of the EU ports in a globally changing market environment. The portfolio of port cooperation forms vary from low-binding agreements to joint ventures but within and at both ends the strategic goal is the increase of port handling volumes as the basis for core as well as value-added port services in order to enhance the overall competitiveness of a port.

Joint marketing activities show the lowest barrier for ports to cooperate. Normally, driven by port authorities, marketing cooperations offer all relevant port actors the opportunity to participate, including hinterland transport operators and other logistic providers linked to port operations. As benefits are obvious in terms of optimising resources and cost savings (e.g. shared fair costs), joint marketing will remain a future option for port cooperations in order to present and sell services of ports having similar interests but intend to cooperate on a competition-neutral level without any uncertainties in terms of problems in financing or operation.

Given the increasing market power of the shipping side, 'coopetition' as horizontal cooperation form is assumed as a remaining option for ports to react on bargaining power. A number of essential drivers for coopetition are to be considered. The distance between ports is important as the closer cooperating ports are, the higher the competition between them is to be assumed. In this respect, the relevant hinterland and its characteristics of the concerned ports is important.

The scopes of natural port hinterlands have been decreased as constructions of efficient hinterland transport connections and port infrastructures and facilities allow competing ports to attract volumes as well. An example is the upcoming importance of South European ports for Europe-Asia container trades with destinations e.g. in Austria and Eastern European countries – and which have been belonging clearly to the hinterland of the North range. Other drivers for coopetition are the organisational form of port governance, the technology level applied in the port and the level of correlation of the port services (e.g. are similar commodities handled in ports).

Provided that drivers allow to go for a coopetition, there are a number of reasons for ports which could bring benefits from cooperation on a horizontal level. Strategic reasons are very essential in this respect as they refer to the business strategy of ports and long-term benefits. In an increasing competitive environment, coopetition offers port the opportunity to build up supply-driven market power. Currently, container ship operators are driving port investments in infrastructures and superstructures through increasing vessels sizes to gain economics of scale. Discussion have been initiated whether ports have to play the game according to ship operators' rules or if port can oppose these developments through cooperation. Financial reasons are also essential as ports as profit-oriented industries have to reduce costs where appropriated. Hence, cost sharing for new investments, lower need for investment capital and faster rate of return are clear benefits for ports. Economical reasons derive from aiming at economics of scale or benefits from knowledge sharing. Knowledge sharing and feasible technology investments (e.g. through cost sharing) provide opportunities for operational improvements or for remove of existing operational problems and capacity constraints.

With regard to cooperation trends in the EU ports sector, horizontal coopetition is assumed to provide benefits for ports but this is subject to individual situations of potential ports and has to be decided on a case-by-case basis.

The latest approach by the port authorities of Hamburg, Barcelona, Antwerp, Los Angeles, Long Beach, Vancouver and Rotterdam to work jointly on challenges from climate change presents a good example for a future trend with regard to coopetition. Although there is a strong competition among the ports of Rotterdam, Antwerp and Hamburg, common goals facilitated a cooperation among these ports. Here, a number of issues that will be addressed jointly were agreed:

- increasing efficiency of supply chains using digital tools;
- accelerating development of in-port renewable power-2-ship solutions and other zero emission solutions;
- accelerating the development of commercially viable sustainable low-carbon fuels for maritime transport and infrastructure for electrification of ship propulsion systems;
- accelerating efforts to fully decarbonize cargo-handling port facilities.

All efforts are planned to lead to reduce emissions from maritime transport in order to limit global warming to well below 2°C as cooperating ports are concerned that ports can perform significant contribution. For such a purpose, the coopetition aims to work together with stakeholders in the maritime sector and beyond. Considering the relevance of environmental protection measures, particularly this area is suitable for port to cooperate through 'coopetition' by addressing challenges here.

Environmental challenges may also support cooperation between ports using joint ventures. So called 'wider benefits' could trigger joint ventures in order to achieve essential environmental related aims. A possible example might be the operation of a LNG vessel offering bunkering to

vessels. As there is still a lot of discussion about the shipping fuel of the future within the maritime community, it is not clear yet whether LNG will be the final solution. As fixed LNG bunker terminals in ports are highly cost–intensive, joint operations of LNG bunker vessels serving ships calling the cooperating ports might be a future option. However, if joint ventures like the Copenhagen Malmö Port will occur in the future – e.g. following the Fehmarn-Belt-Link - is not foreseeable.

Vertical port cooperations will be seen also in the future. Vertical cooperation between ship operators and port operators has been a trend since decades – particularly in the container shipping sector. Cooperation has taken place either by joint ventures, i.e. joint financing of terminals by ship and terminal operators or by contractual assignments of dedicated terminals and semi-dedicated terminals. Reasons for ship operators were and still are inter alia to ensure handling of vessel at the time the vessel is calling, reduction of port costs and controlling of supply chain. On the other hand, main benefits of terminal operators refers to reduced costs and a guarantee of the terminal capacity use to the contractual agreed extent.

Also, land-side related vertical cooperation will be a future issue in port cooperation. As given the immobility of ports and their assets, it is of vital importance for ports to gather control about hinterland transports to the extent possible by operating own rail and barge services or alternatively, cooperating closely with rail and barge operators – as well as with inland barge and rail terminals.

Likewise the International Transport Forum of the OECD stated in its latest report 'Container Port Strategy' from October 2018 that it is necessary to enhance and trigger cooperation between stakeholders in the maritime logistics chain. The performance of maritime supply chains are clearly depending on nodes between the different stakeholders. Here, inefficiencies occur due to lack of effective communication, coordination and alignment. In order to remove these problems, it is essential to enhance the cooperation of actors along the supply chain.

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