OECD Regional Development Working Papers 2013/13

The Competitiveness of Global Port-Cities: Synthesis Report

Olaf Merk

https://dx.doi.org/10.1787/5k40hdhp6t8s-en

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Edited by Olaf Merk

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FOREWORD

This report provides a synthesis of main findings from the *OECD Port-Cities Programme*, created in 2010 in order to assess the impact of ports on their cities and provide policy recommendations to increase the positive impacts of ports on their cities. This Programme was directed by Olaf Merk, Administrator Port-Cities within the OECD Public Governance and Territorial Development Directorate.

This synthesis report was directed and written by Olaf Merk; it draws on the work of a number of other contributors: César Ducruet, Jasper Cooper, Jing Li, Ihnji Jon, Maren Larsen and Lucie Billaud. The report has benefited from comments from Bill Tompson, Nils-Axel Braathen, Jane Korinek, Nicolas Mat and Juliette Cerceau.

The synthesis report is based on findings from a series of OECD Port-Cities case studies. Such case studies were conducted for Le Havre/Rouen/Paris/Caen (France), Hamburg (Germany), Helsinki (Finland), Marseille (France), Mersin (Turkey), Rotterdam/Amsterdam (the Netherlands), Antofagasta (Chile), Bratislava/Komárno/Štúrova (Slovak Republic), Durban (South Africa) and Shanghai (China). Within the framework of these studies, study visits to these port-cities were conducted, which included a series of interviews with the port-city related actors and stakeholders in these places.

The OECD Port-Cities Programme also benefited from visits to the following ports and port-cities and discussion with port-related actors in the following port-cities: Hong Kong, Shenzhen, Singapore, Casablanca, Venice, Trieste, Genoa, Valparaíso, Varna, Gdansk, Koper, Vienna, Antwerp, Felixstowe, Los Angeles, Long Beach, Sydney and Newcastle (Australia).

Contributions and inputs into the OECD Port-Cities case studies and related working papers were provided by César Ducruet, Elvira Haezendonck, Michael Dooms, Patrick Dubarle, Markus Hesse, Géraldine Planque, Theo Notteboom, José Tongzon, Jörg Jocker, Oguz Bagis, Angela Bergantino, Claude Comtois, Nicolas Winicki, Thai Thanh Dang, Claudio Ferrari, Alessio Tei, Anna Bottasso, Maurizio Conti, Salvador Saz, Leandro Garcia-Menéndez, Zhen Hong, Zhao Nan, Angela Xu Mingying, Xie Wenqing, Du Xufeng, Wang Jinggai, Jing Li, Matthieu Bordes, Rachel Silberstein, Xiao Wang, Jean-Paul Rodrigue, Jasper Cooper, Marten van den Bossche, Carla Jong, Christelle Larsonneur, Walter Manshanden, Martijn Dröes, Evgueny Poliakov, Olli-Pekka Hilmola, Charlotte Lafitte, Caroline Guillet, Léonie Claeyman, Suzanne Chatelier. The Programme has been enriched through the interaction with these experts.

Within the framework of the Programme, three different workshops in Paris were organised and benefited from presentations by: César Ducruet, Markus Hesse, Elvira Haezendonck, Claudio Ferrari, Jan Egbertsen, Ingo Fehrs, Stijn Effting, Michael Vanderbeek, Alessio Tei, Philippe Deiss, Birgit Liodden, Johan Woxenius, Hyong Mo Jeon, Dimitrios Theologitis, Carla Jong, Lorene Grandidier, Dominique Lebreton, Claude Comtois, Marten van den Bossche, Matt Bogdan, Alice Liu, Jan Green Rebstock.

Within the framework of the Programme, the Administrator has provided presentations and interventions in conferences organised by: European Committee of the Regions (COTER), European Seaport Organisation (ESPO), Moroccan Association for Logistics (Amlog), International Association of Ports and Harbors (IAPH), Port of Long Beach Board of Harbor Commissioners, City of Shenzhen,

Korean Transport Institute (KOTI), Korean Maritime Institute (KMI), French Association of Town Planners (FNAU), Italian Association of Transport Economists (SIET), World Conference of Transport Research Society (WCTRS-SIG2), Maersk, Port Finance International, BSR Clean Cargo Working Group, Infrastructure Australia, International Association Cities Ports (AIVP), Inter American Committee for Ports, International Transport Forum (ITF), Florence School of Regulation, Cargo Edições Lda, Logistics Portugal, International Forum on Shipping, Ports and Airports (IFSPA), Port of Amsterdam, Port of Rotterdam, Port of Hamburg, Université du Sud Toulon-Var, Colloque Axe Seine Acte II.

The Programme has benefited from the support of: the Netherlands Ministry of Economy, City of Rotterdam, City of Amsterdam, Port of Amsterdam, Çukurova Development Agency, City of Helsinki, Port of Marseille, Slovak Ministry of Transport, Construction and Regional Development, Slovak Ministry of Foreign Affairs, City of Hamburg, Transnet South Africa, Provence-Alpes-Côte d'Azur Region, Bouches du Rhône Department, Syndicat mixte du Schéma de Cohérence Territoriale Ouest Étang de Berre, Communauté d'agglomération Marseille Provence Métropole, City of Marseille, Chamber of Commerce and Industry Marseille Provence, the Agence d'Urbanisme de Marseille, the Union Maritime et Fluviale, l'Agence d'Urbanisme de la Région du Havre et de l'Estuaire de la Seine (AURH), l'Agence d'Études d'Urbanisme de Caen Métropole (AUCAME), l'Atelier Parisien d'Urbanisme (APUR), l'Institut d'Aménagement et d'Urbanisme de la région d'Île de France (IAU IDF), l'Agence d'Urbanisme et de Développement de la Seine Aval (AUDAS), la Ville du Havre, la Communauté d'Agglomération Havraise (CODAH), la Communauté de l'Agglomération Rouen Elbeuf Austreberthe (CREA), le Grand Port Maritime du Havre (GPMH), le Grand Port Maritime de Rouen (GPMR), Ports de Paris.

The report, as well as the Port-City case studies and related thematic papers can be downloaded from the OECD website: www.oecd.org/regional/portcities

Further enquiries about this work in this area should be addressed to:

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EXECUTIVE SUMMARY

Ports and cities are historically strongly linked, but the link between port and city growth has become weaker. Economic benefits often spill over to other regions, whereas negative impacts are localised in the port-city. How can ports become the drivers again of urban economic growth; and how can negative port impacts be mitigated? Those are the questions that this report aims to answer.

Many economic benefits are associated with well-functioning ports. They lower the costs of trade, generate value added and employment and attract certain economic sectors. Doubling port efficiency of two countries is found to increase their bilateral trade volume with 32% as indicated by an earlier study. One tonne of port throughput is on average associated with USD 100 of economic value added, and an increase of one million tonnes of port throughput is associated with an increase in employment in the port region of 300 jobs in the short term. Moreover, ports are associated with innovation in port-related sectors. Nine out of the 10 world regions with the largest amount of patent applications in shipping are home to one or more large global ports, including Houston, Los Angeles/Long Beach, Tokyo, Oakland and Rotterdam.

However, a lot of these benefits from ports spill over to other regions. Firms in other regions also benefit from efficient ports when exporting and importing, and links with other sectors mostly take place outside the port region. Less than 5% of the economic linkages with suppliers take place in the port or the port-region, with a larger share in the main economic centre of the country, which could be relatively far away from the port, e.g. Ile-de France for the ports of Le Havre and Marseille; and Bavaria and Baden-Württemberg for the port of Hamburg.

Ports also have negative port impacts, mostly related to the environment, land use and traffic congestion. These impacts can be very substantial; e.g. more than half of the SO_2-emissions in Hong Kong are related to shipping, and a third of the land surface of the city of Antwerp consists of its port. In addition, port truck traffic accounts for more than 85 % of total truck traffic on some sections of the highways in Los Angeles. Most of these negative impacts are localised, taking place close to the port area (in terms of noise and dust) and in the metropolis (for air emissions, water quality, congestion and land use). This represents what can be called the port-city mismatch: the combination of benefits spilling over to other regions and localised negative impacts. How to solve this mismatch?

Evidently, the port needs to be competitive if cities want to benefit from it. Port-related value added and employment is strongly related to urban wealth. Ports can be made more competitive by strengthening their maritime links, port operations and hinterland connections. Local goodwill for port functions in cities is essential and can be earned. Environmental policies and incentive schemes have reduced a variety of environmental impacts, transport policies in and around ports have mitigated congestion and port relocations have freed up centrally located urban land for other functions. However, the key issue is how to get more local value for money out of ports.

Three main models exist for cities to reap additional benefits from their ports: maritime services clusters, industrial development and port-related waterfront development. Maritime services clusters try to attracted high value added services related to the maritime industry, such as maritime finance, consulting, law and engineering services. Industrial development related to ports has traditionally

taken place because many industries are interested in being close to imported resources and consumer markets. Finally, waterfront development has frequently managed to capitalise on port and maritime heritage and transform this into a source of urban growth.

A range of policy instruments is applied to support these strategic orientations. These include incentive schemes, training and education, platform organisations and knowledge transfer schemes to attract high value added companies that could make the city an international maritime services centre; Singapore is a clear example of pro-active policies in this regard. With respect to industrial development on port sites many initiatives have emerged that position the port as a site for industrial ecology (Rotterdam) and renewable energy (Bremerhaven). Master planning and financial mechanisms for redevelopment have been applied to waterfronts in order to create areas with interesting mixes of functions, and somehow still connected to port functions, such as Port Vell in Barcelona.

Public policies can be effective in increasing port-city performance. In terms of overall policy packages, there are clear indications, based on our research, of the effectiveness of port policies, transport policies and policies stimulating university-business cooperation: more active policies in these fields have a positive influence on performance. In terms of specific instruments, relatively much is known on the most important factors for competitive ports, even if policy design and implementation relies in most cases on common sense of port authorities rather than established academic insights. There is some evidence on the effectiveness of certain transport policy instruments, such as the Clean Truck Program and terminal gate strategies both applied in the ports of Los Angeles and Long Beach. Several ports have also started to track environmental impacts, the reduction of which can sometimes be linked to policies. However, the impact of specific policy instruments in many areas remains to be clarified.

1. INTRODUCTION

Ports and cities are historically strongly linked. However, the link between port and city growth has become weaker. There are various sorts of port-cities, with their own particular challenges; so much depends on local circumstances. However, the main question remains: are ports still drivers of urban growth, and how can this effectively be achieved?

Ports and cities: historically a strong link

Ports are at the origin of many cities. Many cities started as trading posts, with the port as natural interface of land and maritime connections. They allowed small towns to become cities, and fuelled urban development thanks to the prosperity related to trade. Observation of old city maps shows the strong interlinkages of port and urban development, and economic historians such as Fernand Braudel have stressed the importance of port-cities in the birth and development of the global, capitalist market economy. Ports are often still closely connected to the city. Even if they have disappeared from a city, they can continue to influence the city, because their heritage lives on, e.g. in urban form. This link has been strong in history and continues to be strong in many emerging economies. A striking example in recent history is the case of Shenzhen, a small fishing village turned into one of the world's largest metropolises and ports within a few decades, thanks to export-driven growth triggered by a free trade zone and extensive port development.

Many of the largest cities have the largest ports. This is particularly the case of many Asian cities, such as Shanghai and Osaka-Kobe, which are among the twenty largest metropolitan areas and also home to the twenty largest ports in the world. Other examples of very large Asian metropolises with very large ports are Guangzhou, Shenzhen, Tianjin and Hong Kong. The link between metropolitan size and port size is also visible in North America, with New York and Los Angeles as prime examples, and to a lesser extent in Europe that has a more limited number of very large metropolises, but where some of these including London and Barcelona also have large ports (Table 1). At the same time, not all of the largest metropolitan areas have large ports. Buenos Aires and Rio de Janeiro are examples of very large metropolitan areas with relatively small ports. Some of the world largest metro-areas have river ports, such as Chicago and Paris, and there are also examples of large metropolises without port, such as Delhi and Mexico City. The cities with the largest ports are not only the largest cities in the world, but they are also the largest global cities.

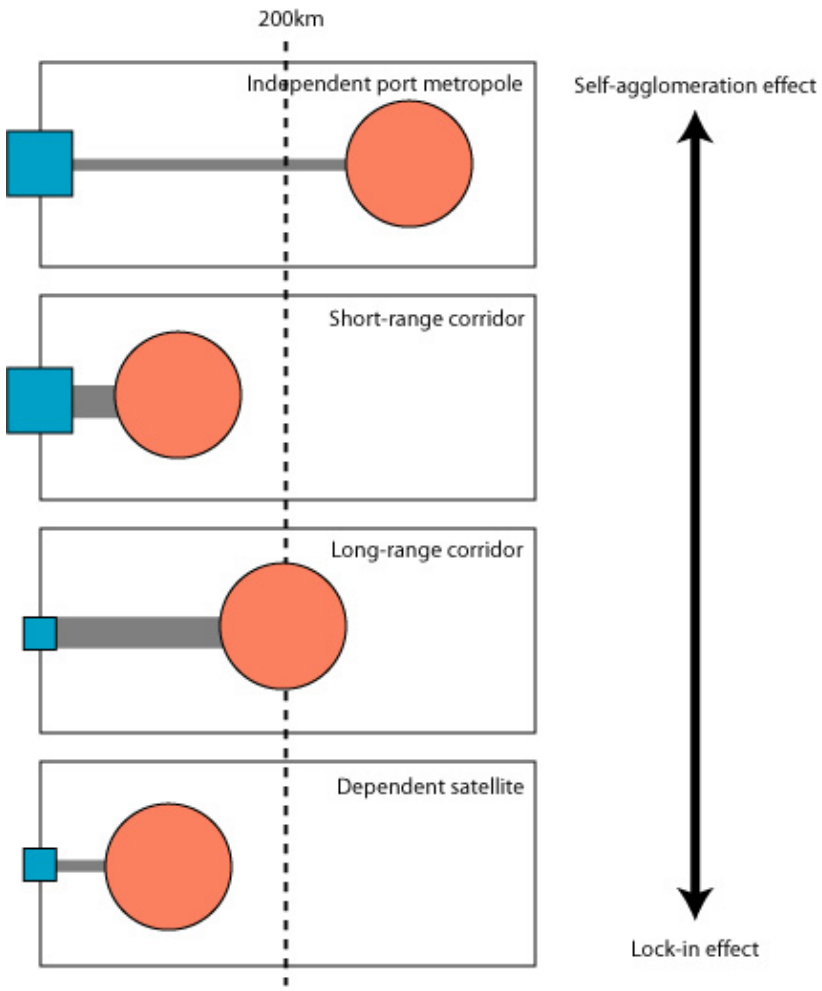
Table 1.Overlap world's largest metropolises and ports

	Top 20 metro-areas	Top 40 metro-areas	Top 60 metro-areas
Top 20 ports	Shanghai, Osaka-Kobe	Guangzhou, Shenzhen, Tianjin, Hong Kong	
Top 40 ports	Sao Paulo-Santos, New York, Los Angeles/Long Beach	Madras	
Top 60 ports	Tokyo	Bangkok	
Top 80 ports	Mumbai		
Top 100 ports	Kolkata, Karachi	London, Jakarta	Barcelona
Top 125 ports	Manila, Istanbul		Ho Chi Minh City, Chittagong, Miami/Tampa, Philadelphia

Source: Own elaborations based on data from UN Habitat and American Association of Port Authorities

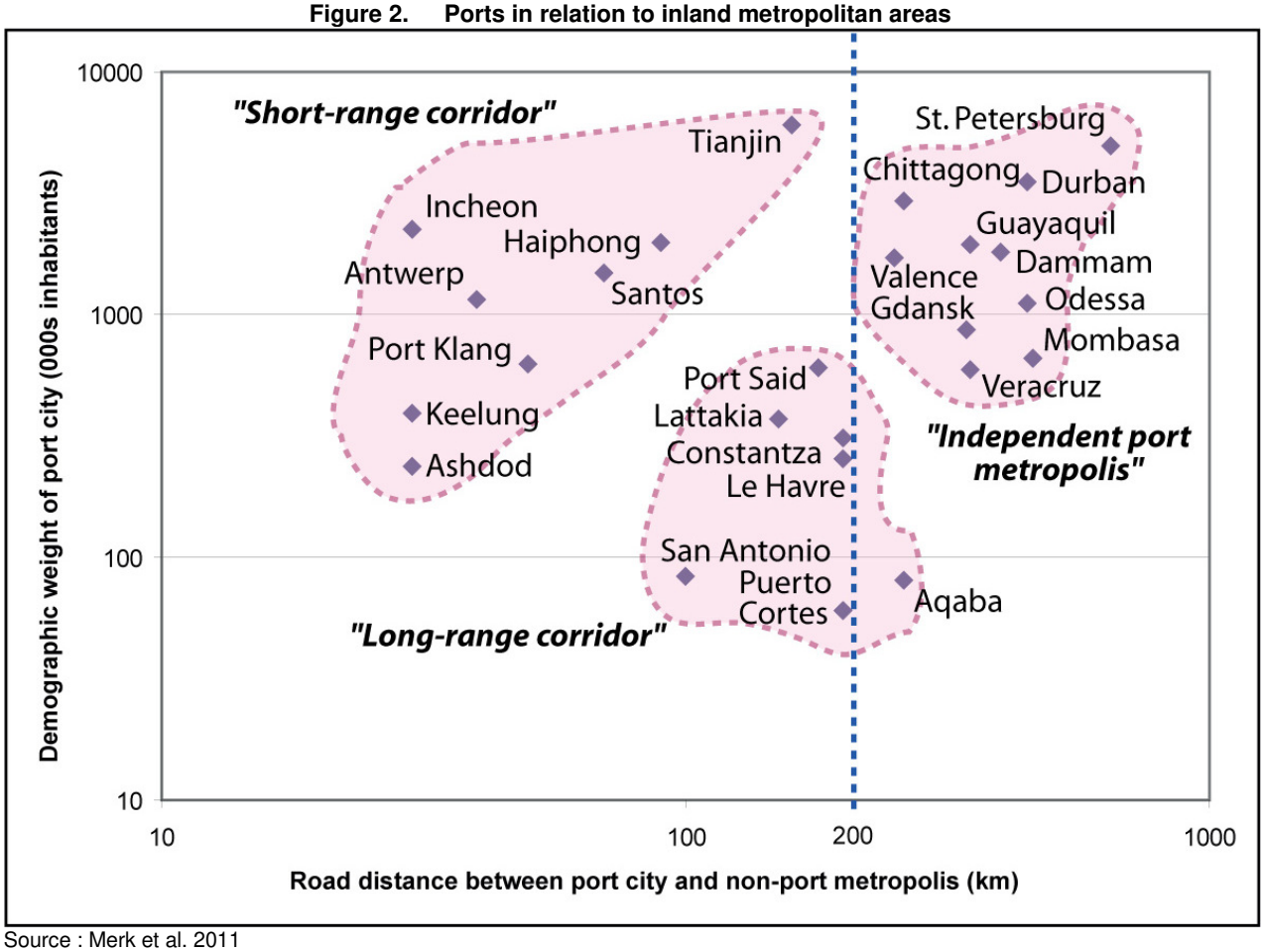
Although there are large metropolitan areas without a port, their fate is often strongly dependent on the quality of the connection with ports. The smaller and the closer the port-city in relation to the inland metropolis, the more it can be considered to form part of this metropolis. It could then be considered dependent satellites, short-range corridors or long-range corridors (Figure 1). Dependent satellites are small and close; these would for example be Civitavecchia in its relation to Rome, and San Antonio in relation to Santiago. Short-range corridor relations exist when an inland metropolis is closely located to a relatively large port-city, such as in Santos-Sao Paulo, Port Klang-Kuala Lumpur and Incheon-Seoul. Long-range corridors are observed when inland metropolises are further away from a relatively small port-city, e.g. Le Havre-Paris, Port Said-Cairo and Constantza-Budapest. Finally, there are also constellations in which the inland metropolis is really far away from a port (more than 200 km), in which cases the port-city has the room to develop itself into an independent port metropolis. This is the case for St. Petersburg (with Moscow as the inland metropolis), Durban (Johannesburg) and Odessa (Kiev) (Figure 2). Land-locked countries are dependent on other countries' ports, which might be problematic when this is a dependence on one port, but is much less challenging when it has links with many different ports. An example of such a country is Austria that exports and imports via at least six ports located in different coastal zones: Rotterdam, Antwerp, Hamburg, Koper, Trieste and Constantza (Merk and Hesse, 2012).

Figure 1. Typologies of inland metropolis-port relationships



Source : Merk et al. 2011

Figure 2. Ports in relation to inland metropolitan areas



Source : Merk et al. 2011

There are large ports that are not located in cities, but there are usually very specific reasons for this: because they are close to natural resources, to global shipping routes or because of a deliberate decision to de-congest urban ports. Ports located close to natural resources, such as coal, oil and ores, are Port Hedland (Australia), Richard Bay (South Africa), Corpus Christi (US) and Novorossiysk (Russia). Large transhipment hubs close to intercontinental shipping routes are Salalah (Oman), Freeport (Bahamas), as well as Gioia Tauro (Italy), Algeciras (Spain), Port Said (Egypt) and Marsaxlokk (Malta) all in the Mediterranean Sea. Finally, the non-urban gateway ports that were in many cases deliberately created away from large cities in order to de-congest the urban ports; these include Felixstowe (United Kingdom), Laem Chabang (Thailand) and Lianyungang (China).

However, the link between port and city growth has become weaker

Urban population growth is only one of the determinants of port growth. Port growth also depends on GDP per capita growth, the growth of external trade and the resource intensity of production. Various studies have observed that port volume growth is steeper than the GDP per capita growth and external trade growth, a ratio expressed in port to GDP growth-multipliers and port to external trade growth-multipliers. In addition, the container growth rate depends on the containerisation rate of cargo traffic, which has dramatically increased over the last decades with an increasing share of freight being transported by containers. E.g. the container port growth to GDP growth multiplier in the Hamburg-Le Havre range over the period 1990-2010 3.0: this means that an average annual GDP growth of 1% was associated with

average container port growth of 3% (McKinsey, 2011). Finally, port growth is dependent on how well it is linked to the hinterland: the most important ports for some countries are in fact not their own ports, but foreign ports well connected to their country, such as the Belgian port of Antwerp for France, hence the importance of hubs and regional networks.

Although port and urban growth often go hand in hand, there are metropolises in OECD countries where this is no longer the case. Port decline can go together with urban growth; and population decline can combine with port growth. This can be concluded from comparing population growth and port volume growth over the last decades, from 1970 to 2010 (Table 2). In the majority of cases population growth and port growth still go together, in particular in the Asian port-cities, where both population growth and port volume growth have been spectacularly high, and where a distinction between strong and moderate population growth would be more appropriate (Table 3), except for some Japanese cities that actually had population decline. Large North American cities, such as New York, Los Angeles, Houston, Seattle and Vancouver, have also witnessed simultaneous population and port growth, but several North American cities had population growth combined with port decline, including in Baltimore, Boston, Philadelphia and Montreal. Almost all of the North American cities with population decline were cities without a port. In European cities there are several examples for every category: growing cities with growing ports (Barcelona), growing cities with declining ports (Stockholm), stagnating cities with growing ports (Rotterdam) and stagnating cities with declining ports (London). All in all, there is a large variety of trajectories, with some of the leading OECD metropolises having lost most of their port functions and with some of the leading ports struggling to become successful metropolises.

Table 2. Port-cities and their population and port growth in Europe and North America (1970-2010)

	Population growth	Population decline/stagnation
Port growth	New York, Los Angeles, Houston, Seattle, Vancouver, Barcelona, Valencia, Dublin, Helsinki, Athens	Rotterdam, Hamburg, Antwerp, Amsterdam,
Port decline	Baltimore, Boston, Philadelphia, Montreal, Stockholm, Oslo, Lisbon, Bordeaux	London, Copenhagen, Naples, Liverpool, New Orleans
No port	Chicago, Paris, Madrid	Berlin, Rome, Milan, Budapest, Detroit, Buffalo, Cleveland

Source: Own elaborations based on data from UN Habitat and Journal de la Marine Marchande

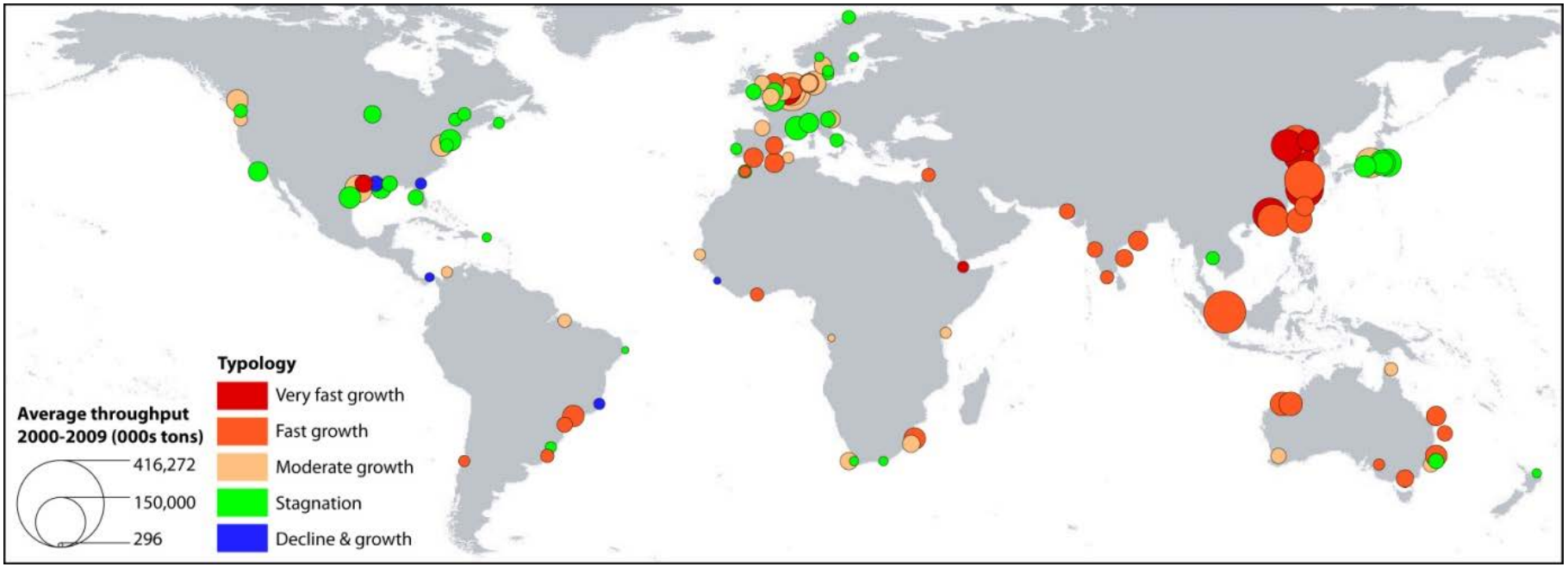
Table 3. Port-cities and their population and port growth in Asia (1970-2010)

	Strong population growth	Moderate population growth
Strong port growth	Shenzhen, Dubai, Shanghai, Singapore, Mumbai, Kolkata	Hong Kong, Busan, Nagoya
Moderate port growth		Kobe
No port	Delhi, Beijing	

Source: Own elaborations based on data from UN Habitat and Journal de la Marine Marchande

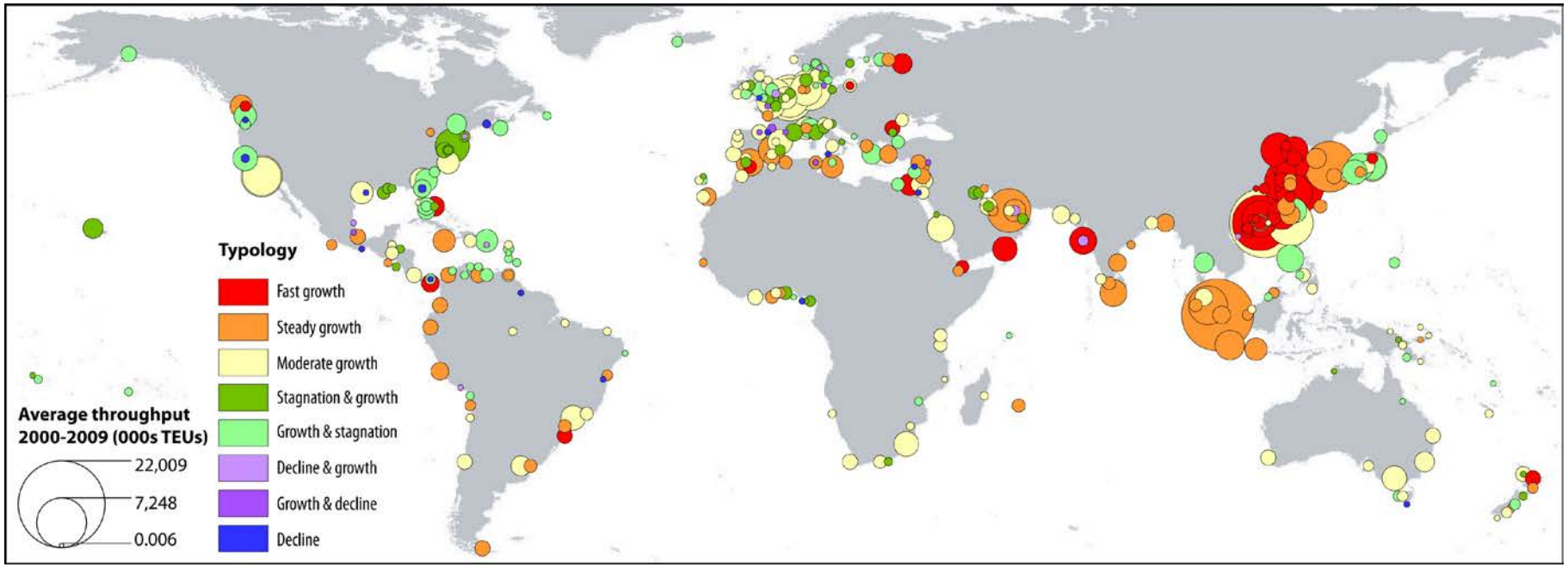
These trends also reflect the shifting economic balance across continents over the last decades. In 1972 approximately 40% of all world port activity took place in Europe, 20% in North America and 20% in Asia. These shares had dramatically changed by 2009, when more than half of world port activity took place in Asia, around a fifth in Europe, and a tenth in North America. Ports in Asia, in particular Chinese ports, have shown very fast growth rates over the last four decades, whereas ports in North America and Europe has shown more mixed growth patterns, characterised by stagnation or a combination of stagnation, decline and moderate growth (Figures 3 and 4).

Figure 3. Port trajectories 1970-2009



Source: Own elaborations based on data from Journal de la Marine Marchande

Figure 4. Container port trajectories 1970-2009

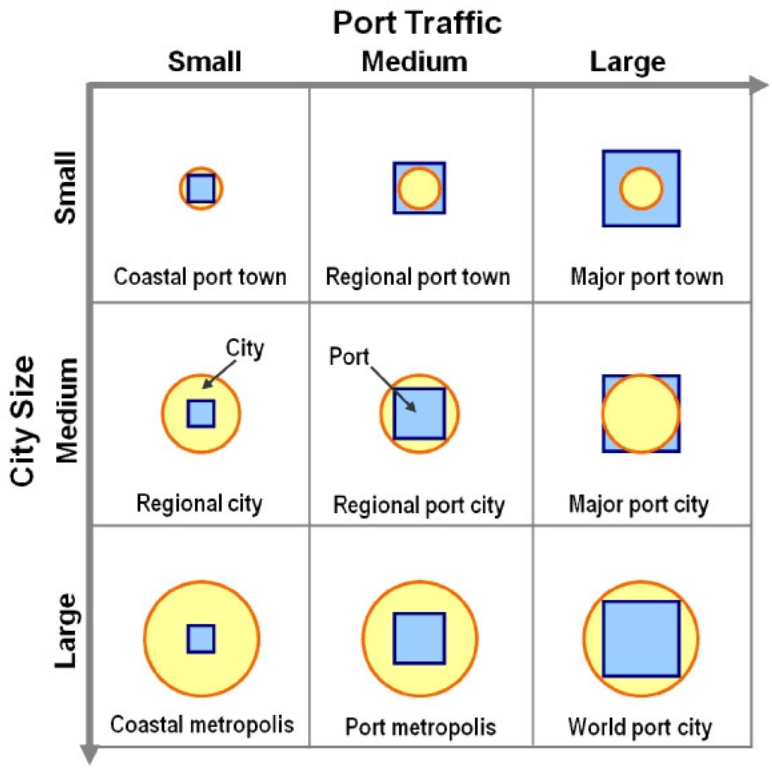


Source: Own elaborations based on data from Journal de la Marine Marchande

Hence, there is a diversity of port-city trajectories with their own particular challenges

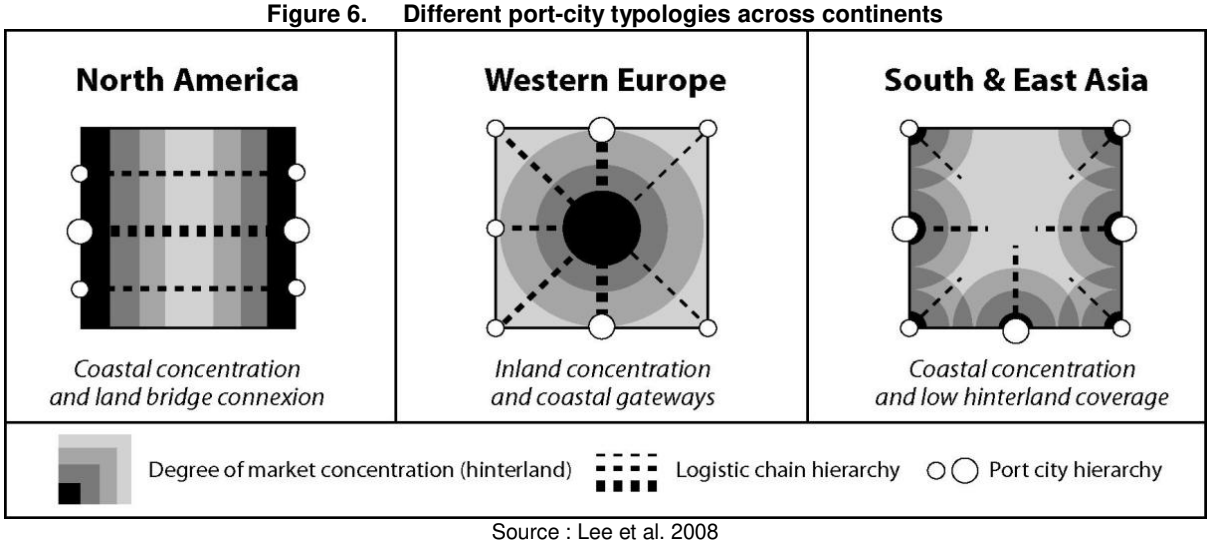
There are different types of port-cities, dependent on port size and city size, ranging from coastal port towns to world port-cities (Figure 5). World port-cities are large cities with large ports; examples of these are New York, Hong Kong, Tokyo and Singapore. In a port metropolis, the urban function is large, whereas the port function is smaller but still considerable, e.g. in Cape Town and Buenos Aires. When the port function is even smaller in a large metropolis, it could be considered a coastal metropolis (Stockholm, Baltimore and Tunis). However, opposite cases also exist; in these cases the port size is relatively larger than the urban size. These could be called major port-cities, such as Rotterdam, Le Havre and Genoa, and major port towns, e.g. Freeport, Gioia Tauro and Laem Chabang. This study is about port-cities in which either the city or the port is very large (a port metropolis or major port-city respectively), or both of them (world port cities). There are clear differences between continents in this respect, with North America having most of its cities at the coast connected by land bridges, with the largest European cities concentrated inland, but with many coastal gateways, and with Asia having a large coastal urban concentration with low hinterland coverage (Figure 6).

Figure 5. Typology of port-cities



Source : Ducruet and Lee (2006)

Figure 6. Different port-city typologies across continents



Source : Lee et al. 2008

Different port and urban growth patterns lead to distinctly different impacts and policy challenges (Table 4). The main challenge of port-cities with growing ports and growing population is the development of new port sites: they generally face space constraints, congestion and under-capacity of the port, with the need for infrastructure investments, relocation of port sites which then subsequently opens up the possibility of transforming port land into housing or mixed urban development. Growing cities with declining ports are mainly characterised by the need for urban waterfront development; so they can face similar transformation processes of port land as port-cities with growing ports and population, with the difference that ports do not re-locate, but simply need less space because of declining traffic volumes. The cities in which the population shrinks but the port grows have a different concern, which is to find port cargo elsewhere than in the metropolis, hence the need for better hinterland connections. And finally, the port-cities in which both ports and cities decline need economic transformation: these will have to find new sources of growth, so transformation of port areas there might take less the form of new housing development, but more of a leisure and business area, with attempts to attract new services and port niches.

Table 4.Policy challenges for different port-city types

	Growing city	Shrinking city
Port growth	New port sites (Singapore)	Extending hinterlands (Rotterdam)
Port decline	Urban waterfronts (Baltimore)	Economic transformation (Bilbao)

Source: Own elaborations

The following chapters will assess these various impacts and challenges, and analyse policies to deal with these. It will be shown that there are many commonly shared impacts and challenges, despite the variety of different port-cities. The core question is how ports can continue to add value to a metropolis: once at the source of its development, can it still foster the prosperity and well-being that current metropolises need? Port-city relations evolve over time and various authors have attempted to capture certain stages of port development and the dynamic relation of port-city interaction. Reality remains multi-faceted and not all port-cities follow the same trajectories over time. However, the variety of port-cities over time provides for a rich source of experiences and examples to compare and draw lessons from. The following chapters will make use of these sources to assess and interpret the impact of ports on their cities and possible ways to improve these.

2. PORT IMPACTS

Ports have various impacts on their cities, both positive and negative. Most of the positive impacts are related to economic benefits. Main negative impacts include environmental, land use and traffic impacts. This chapter provides an overview of these impacts of ports, their terminals, their related economic sectors and activities. It assesses where these impacts are localised, and will illustrate a mismatch between negative impacts that are mostly localised and benefits that spill over to other regions. This mismatch has intensified over the last decades due to technological, market and other developments. The concluding section of this chapter assesses future developments that could pose additional challenges to policies.

2.1 Benefits from ports

The economic benefits from ports are manifold; an overview of the main benefits will be presented below. First, ports play an essential role in global supply chains, and – as such – act as facilitators of trade between port-regions and countries (section 2.1.1). Ports also provide value added through the economic activities that they and the firms related to ports perform (2.1.2). This economic value translates into port-related employment (2.1.3). Finally, ports are also spatial clusters for innovation, research and development (2.1.4). Port-cities are at the source of these economic benefits, but by no means the only places that benefit from port activity; this section concludes with an assessment of where the main economic impacts take place (2.1.5).

2.1.1 Ports as facilitators of trade

Maritime transport costs form a substantial share of the value of traded goods. On average, 5.1% of the imported value of manufactures can be attributed to shipping, compared with 10.9% for agricultural goods and 24.1% for industrial raw materials (Table 5). However, transport costs vary widely between various products and countries of origin and destination. In general, goods shipped in containers have lower transport costs per tonne of merchandise shipped than non-containerised goods, as do goods shipped between major ports on well-travelled trade routes. The costs of shipping a container, for example, can vary with a factor 10; on some routes shipping costs are ten times higher than others. In the first half of 2008, the cost of shipping a container varied from USD 300 from Dubai to Singapore, to USD 2849 from Brazil to the United States, a variation that remains in place even when corrected for differences in distance (Korinek and Sourdin, 2009). Shipping into Africa is by far the most expensive, representing on average 25% of imported value. In some countries, mostly remote nations with very small markets, face such high maritime transport costs that they represent a significant drag on most exports; the maritime transport costs of exports can equal up to 43% in Christmas Islands (Korinek, 2008).

Table 5. Maritime transport costs for main economic sectors

	Maritime transport costs as % of import value	Maritime transport costs (USD/tonne)
Raw materials	24%	33
Agriculture	11%	81
Manufactures	5%	174
Crude oil	4%	18

Source: Korinek 2008

Higher maritime transport costs are related to lower external trade volumes. Doubling of maritime transport costs between a given country pair is associated with a decline of 66-80% in the value of imports and a decrease in trade volume of 26-28% (Korinek and Sourdin, 2009). A wider range of reductions in trade volume (from 1.5% to 38%) was found in a study of Spanish exports to Poland and Turkey (Marinez-Zarzoso and Nowak-Lehmann, 2007). Yet another study identified that a 10% increase in bilateral maritime transport costs (USD/tonne) is associated with an approximate 8% decrease in value of agricultural imports on average. However, there is a large variation in trade impacts of a decrease in transport costs between products, ranging from a 1.7% decrease for products of animal origin, to 11% decrease for cereals, given a decrease of 10% in transport costs (Korinek and Sourdin, 2010). Large trade-transport cost elasticities (2.3-2.5) have repeatedly been found in different studies (Limao and Venables, 2001; Martinez-Zarzoso et al. 2003; Martinez-Zarzoso and Suarez-Burguet, 2005). External trade between countries is not only dependent on maritime transport costs, but also related to the GDP of the two countries, whether or not they share a common language, membership in a major regional trading agreement and shipping distance.

In comparison, land-locked countries have higher costs of trade. A study on 97 developing countries (of which 17 were landlocked) estimated that transport and insurance costs are twice as high for landlocked countries as coastal countries (Radelet and Sachs, 1998). This is related to the larger share of land transportation, considering that it is seven times more expensive to transport goods by land than by sea (Limao and Venables, 2001). As a result, a landlocked country trades approximately 80% less than a non-landlocked country (Raballand, 2003; Martinez-Zarzoso and Suarez-Burguet, 2005), and median land-locked countries have only 30% of the trade volume of the median coastal economy (Limao and Venables, 2001). However, there are considerable differences among land-locked countries: the greater the number of options for a land-locked country, the more the land-locked country imports, because they have more bargaining power for reduced transit costs than land-locked countries that only have connections with one seaport (Raballand, 2003). Examples of land-locked countries with multiple port options are Switzerland, Austria and Czech Republic: these are highly contested hinterlands by ports as diverse as Rotterdam, Hamburg, Koper, Trieste and Constantza (Merk and Hesse, 2012).

An important determinant of the relation between transport and trade is time. Each additional day in transit reduces trade volumes by one percent, leads to an increase in freight rate of USD 56 and adds on average 0.8% to the value of a manufactured good (Djankov et al. 2006; Hoffmann and Wilmsmeier, 2007; Hummels, 2001). A 10% increase in time reduces bilateral trade volumes by 5-8% (Hausmann et al. 2005) and leads to a reduction in trade value of 5-25% (Nordas et al. 2006). In addition, uncertainty in the delays has a bigger impact on decreases in trade. Korinek and Sourdin (2011) found that the reason of the delay makes a difference in trade impacts – if the delay is due to administrative reasons, for example, the trade impact is greater than if it is due to distance. This could be attributed to greater uncertainty in the case of the former; in the latter case, the delay can be estimated and more easily allowed for. Delays matter more for time-sensitive perishable goods. Shipments of livestock are the most time-sensitive, whereas shipments of coal are the least time-sensitive. This can be concluded from a measure of industry sensitivity to shipping times developed by Hummels and Schaur (2012), reflecting the premium for air shipping that firms in an industry are willing to pay to avoid an additional day of ocean transport. Industries that are sensitive to shipping times are also sensitive to good logistics (Table 6). Moreover, firms tend to shift to more expensive air shipping when uncertainty in ocean shipping increases (Clark et al. 2012).

Port efficiency is one of the main determinants of international transport costs. It was found to be most important among six different port characteristics, including port infrastructure, private sector participation and inter-port connectivity (Wilmsmeier et al. 2006). Various studies have quantified the relation between increased port efficiency on the one hand, and decreased transport costs and increased trade volumes on the other hand, with substantial effects varying with the extent of port efficiency improvement (see Table 7).

The important role of port efficiency for reducing costs of trade is confirmed by other studies (Sanchez et al. 2003; Nordas and Piermartini, 2004).

Table 6. Time sensitivity of economic sectors

Industry sector	Time sensitivity index
Livestock and livestock products	2.590
Chemicals and allied products	1.659
Miscellaneous manufactured products	1.257
Stone, clay, glass, and concrete products	1.224
Scientific and professional instruments	1.171
Fabricated metal products	1.100
Non-metallic minerals	0.998
Machinery, except electrical	0.905
Rubber and plastics products	0.904
Paper and allied products	0.881
Electrical machinery	0.788
Primary metal products	0.743
Printing, publishing and allied products	0.703
Apparel	0.666
Crude petroleum and natural gas	0.665
Transportation equipment	0.654
Food and kindred products	0.591
Furniture	0.585
Fish, fresh or frozen and other marine products	0.577
Lumber and wood products	0.577
Textile	0.575
Agricultural products	0.433
Petroleum refining and related products	0.359
Tobacco	0.279
Forestry products	0.268
Metallic ores and concentrates	0.000
Coal and lignite	0.000

Source: Hummels and Schaur, 2012

Table 7. Link between port efficiency and trade/freight costs

Port efficiency measure	Impact on trade	Characteristics	Source
Double port efficiency	32% increase of trade volume	Top 100 non-US and top 50 US ports; 1991-2003	Blonigen & Wilson 2008
From 75th to 25th percentile	25% increase of trade volume	59 countries, 1996-2000	Clark et al. 2004
From lowest score to highest	Decrease of freight cost by 25.9%		Wilmsmeier et al. 2006
One point rise on WEF-index	4.3% reduction in ad valorem transport costs		Abe and Wilson 2009
All ports as most efficient port	82.5% increase in export volumes	14 Brazilian ports	Haddad et al. 2010

Source: Own compilation of the sources indicated in the table
Note: The WEF-index refers to the port quality index of the World Economic Forum, ranging from 1 to 7.

Other ports characteristics also determine maritime transport costs. Among the main characteristics identified are:

- **Port infrastructure**. Onshore infrastructure accounts for 40% of predicted transport costs for coastal countries, and various studies indicate a link between port infrastructure and maritime transport costs. Limao and Venables (2001) calculate that if a country with relatively poor infrastructure (around the 75th percentile) were to upgrade to the 25th percentile, it would reduce transport costs by between 30 and 50 %.

According to Martinez-Zarzoso et al. (2003) an improvement of 10% in the port infrastructure of a destination country lowers transport costs by 1.4%; and an increase of port infrastructure of one standard deviation reduces the freight rate by USD 225 following calculations of Wilmsmeier and Hoffmann (2008). It should be noted that the port infrastructure of exporters is more important for transport costs than the importers' (Nordas and Piermartini, 2004; Korinek and Sourdin, 2011).

- **Port centrality**. If a country doubles its centrality in liner shipping networks, meaning a significant increase in direct liner services to a wider range of countries, transport costs can decrease up to 15.4% (Wilmsmeier and Sanchez, 2009). An increase of connectivity of one standard deviation implies a potential reduction of the freight rate of 287 USD (Wilmsmeier and Hoffmann, 2008).
- **Port congestion**. 10% increase in port congestion leads to 0.7% increase in maritime transport costs (Abe and Wilson, 2009). This is related to the quality of logistics services in ports. Devlin and Yee (2005) document the wide variation in logistics costs in Middle Eastern and North African countries and how they can influence shipping costs, e.g. inefficient trucking services lead to longer stand time on the dockside and costly inventory accumulation as well as reducing export volumes so that there are infrequent shipping services.

The impact of port infrastructure and efficiency differs depending on industry and the stage of economic development. Marinez-Zarzoso et al. (2008) find that a 1% improvement of infrastructure in the destination country lowers transport costs by 0.20% on average, but that infrastructure variable are not significant for high value added sectors, such as household appliances and vehicle parts, generally sold to the most developed countries that already have the highest levels of infrastructure quality. In addition, infrastructure benefits middle-income countries more than lower income countries. A one-unit improvement in port infrastructure (on the World Economic Forum's Global Competitiveness Report index for port infrastructure ranging from 1 to 7) for a lower-middle income country is associated with an estimated increase in trade of 139%; this is 236% for upper-middle income countries and 171% for high-income countries. This may be due to their ability to reap the gains of trade that trade facilitating investments offer which lower income countries may be less able to do (Korinek and Sourdin, 2011).

Higher external trade can translate into higher economic growth. An overview of existing studies on the impacts of trade on economic output and growth indicates that the macroeconomic evidence provides dominant support for the positive and significant effects of trade on output and growth, although microeconomic evidence lends larger support to the exogenous effects of productivity on trade, as compared to the effects of trade on productivity (Singh, 2010). In any case, high trade costs inhibit a country from taking advantage of potential gains form specialisation and trade in order to promote economic development (Markusen and Venables, 2007).

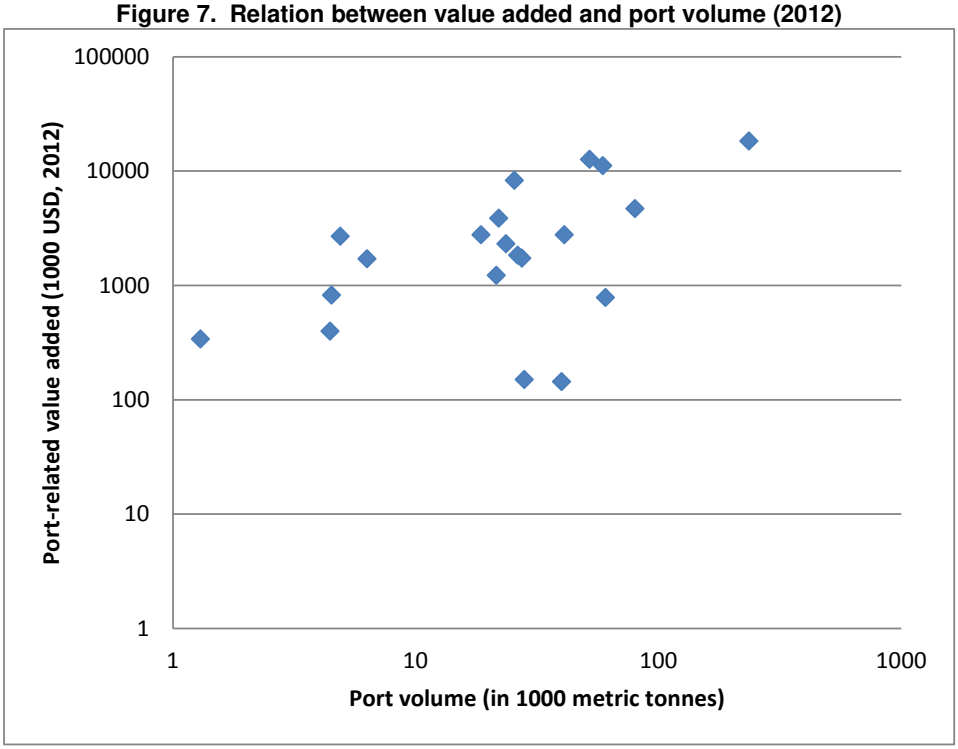
2.1.2 Value added

Value added creation by ports and port-related industries can be substantial. For example, the value added of the port cluster in Rotterdam in 2007 was calculated at EUR 12.8 billion, representing approximately 10% of regional GDP. Even higher shares of regional and national GDP are attained for the port cluster of Le Havre/Rouen, representing more than 21% of regional GDP in 2007, and the case of the port cluster of Antwerp that generates around 3% of national GDP (Merk et al. 2011). These numbers include direct and indirect value added, the categories most frequently covered in studies on the economic impact of ports. In general four different types of impact are distinguished: direct, indirect, induced and catalytic impact. Direct impacts are jobs and income generated by the construction and operation of the port. Indirect impacts are the employment and impact by the suppliers of goods and services, and the induced impact is the employment and income generated by the spending of incomes by employees created

by the direct and indirect effects. Catalytic impact is generated by the port as a driver of productivity growth and attractor of new firms (Ferrari et al. 2010).

The larger the port, the more value added is created by the port and port-related sectors. A meta-study of approximately 150 port impact studies, conducted for this report, indicates that on average one tonne of port throughput is associated with USD 100 of economic value added, with two thirds of the ports in the sample have between USD 50 and USD 250 value added per tonne port throughput (Merk, forthcoming). This number includes direct and indirect port value added. Our analysis shown in Figure 7, for reasons of comparability only showing US ports with port impact studies with similar methodology, indicate that larger ports have larger port related value added (direct and indirect). Much depends on the types of goods that are handled in the port. There are very large differences in direct value added associated with different categories of goods handled in ports. Dry bulk and liquid bulk generally generate more limited value added per tonne than project cargo, general cargo and containerised cargo. Analysis of value added per cargo types in US ports learns that these values can differ with a factor 10: one tonne of grain handled generates on average USD 20; this is USD 220 for automobiles and USD 90 for containerised cargo (Table 8).

Figure 7. Relation between value added and port volume (2012)



Source: Merk (forthcoming)

Table 8. Value added per cargo type (USD per metric tonne)

Cargo type	Average	Minimum	Maximum
Automobiles	220	116	331
Containers	90	40	149
Steel	60	23	118
Petroleum	45	11	183
Grain	20	9	37

Source: Merk (forthcoming)

Ports can have large indirect economic effects (backward linkages). Our series of case studies, in which a similar methodology was applied, found multipliers ranging from 1.13 to 2.47 (Table 9). A multiplier of 2.47 means that one more euro spent in the port leads to 1.47 euro additional demand for

suppliers to the port cluster. These multipliers measuring the backward linkages of the ports sector were calculated by integrating port clusters into national input output-tables and assessing the inputs and outputs from the port cluster economy. The indirect impact of the ports of Rotterdam and Antwerp on the national economy was smaller than those found for the other European ports, namely Hamburg, Le Havre and Marseille. This could be explained by the fact that Rotterdam and Antwerp are very large ports in relatively small country, so presumably a considerable part of the indirect economic effects of these ports is taking place in other countries than their own and not showing up in the multiplier. Overall, ports were found to have strong linkages with the sectors of transport, storage and communication; coke, refined petroleum and nuclear fuels; and chemicals.

Table 9. Overview of port multipliers (backward linkages)

	Leontieff multiplier
Le Havre/Rouen	2.47
Marseille	2.01
Mersin	1.79
Hamburg	1.71
Antwerp	1.18
Rotterdam	1.13

Source: OECD Port-City case studies

Port-related industries can be differentiated in firms providing services necessary to maritime trade (*port required industries*), firms attracted to the region because of the presence of a port (*port attracted industries*) and firms that have expanded markets by exporting through the port (*port induced industry*), based on Yochum and Agarwall (1987, 1988). Port-required industries include transportation services and port services (such as terminal operations, stevedoring, towage etc). Port-attracted industries are either firms that export commodities, or firms that import products or raw materials (e.g. refineries, steel factories). The port induced industries is a much wider category and generally more difficult to capture, as it is difficult to assess their dependence on the port. Generally, direct impacts of ports will include impacts on port-required industries, whereas indirect impacts will cover port-attracted and port-induced industries. Some studies differentiate port-related industries (required or attracted) into industries that need direct quay access and those that do not, such as the national port monitor published annually in the Netherlands. A related concept is the seaport cluster, which could be considered to consist of port-required and port-attracted industries.

Ports tend to attract firms in a variety of industries. These include in many ports transport and logistics, warehousing and storage. Several ports are also sites for resource intensive industries, such refineries, chemicals, steel and coal; aerospace and renewable energy production, including off shore wind energy and biomass production. However, a large variety of practices exist, which seem to be determined by available space, port strategies and also the structure of the economy of a region. Regional industrial specialisations correlate with and might in fact determine to some extent the types of cargo handled in the port: e.g. regions with strong specialisations in agriculture have ports specialised in handling of agricultural products etc (Ducruet et al. forthcoming).

Strong interlinkages can exist between ports and related industries. This can be concluded from our assessment of backward economic linkages of various port clusters; the main economic sectors linked to the port sector – and the intensity of these links – are indicated in table 10. Many of these links are also localised. Large chemical clusters, such as in Antwerp, Rotterdam and Tarragona, have developed in and around their respective ports. The port represents the principal access point to raw materials and competitive feedstock for the manufacturing of chemicals. The impact of the port on the economic success of the chemical clusters is considered fundamental for exports as well (EPCA, 2007). These industries could in turn also be interlinked. The planned implantation of heavy steel and metal industry in Dunkirk

went together with large energy poles needed to supply these industries with energy, followed by firms that wanted to benefit from the proximity of intermediate products, such as white iron, used for producing cans for drinks, produced by other firms on the territory, such as Coca Cola (Boutillier et al. 2011).

Table 10. Intensity of economic links between selected ports and other sectors

	Le Havre-Rouen	Marseille-Fos	Hamburg	Rotterdam	Antwerp
Transport equipment	3.28	2.83	2.47	1.04	1.18
Food, beverages and tobacco	n.a.	2.69	2.22	1.07	1.05
Coke, refined petroleum, nuclear fuel	2.76	2.67	2.15	1.24	1.20
Other manufacturing	2.47	2.57	1.90	n.a.	n.a.
Transport, storage and communication	2.02	1.92	1.79	1.25	1.39
Financial intermediation	1.96	1.96	1.64	n.a.	n.a.
Wholesale and trade	2.02	1.90	1.31	1.03	1.09
Non-market services	1.89	1.39	1.31	n.a.	n.a.
Chemical, rubber and plastics products	n.a.	n.a.	n.a.	1.34	1.36
Manufacturing metals/metal products	n.a.	n.a.	n.a.	1.06	1.07
Electricity, gas and water supply	n.a.	n.a.	n.a.	1.17	1.13
Electrical and optical instruments	n.a.	n.a.	n.a.	n.a.	1.03
Mining, quarrying and energy supply	2.31	2.45	n.a.	n.a.	n.a.
Construction	2.30	2.17	n.a.	n.a.	n.a.

Source: OECD Port-City case studies

Value added of industrial development within ports can be at a par or even higher than those of direct port value added. For example, the four largest European ports all have approximately half of their value added concentrated in non-transport related industrial sectors. In Antwerp, the chemical sector alone represents more than a quarter of the total direct and indirect value added of the port cluster. Moreover, in various large ports there are indications of synergetic cluster effects; these can be measured through the intensity of economic linkages between the sectors within the port area: the backward linkages multiplier. In the ports of Rotterdam and Antwerp substantial within-port economic interlinkages were found (Table 11).

Table 11. Economic linkages within the port area (Rotterdam, Antwerp)

	Rotterdam	Antwerp
Total	**1.03**	**1.05**
Chemical, rubber and plastic products	1.08	1.10
Transport, storage and communications	1.07	1.13
Coke, refined petroleum and nuclear fuel	1.05	1.05
Electricity gas and water supply	1.04	1.04
Manufacturing n.e.c.	1.02	1.02
Food, beverages and tobacco	1.04	1.02
Manufacture basic metals/metal products	1.02	1.02
Transport equipment	1.01	1.05
Wholesale and retail trade, auto repair	1.01	1.03

Source: Merk and Notteboom, 2013

The value added generated by cruise activities is relatively limited. Cruise port impact studies generally look at three categories of spending resulting from cruise tourism: cruise line spending, crew spending, and passenger spending. Some reports claim, that the “crew” category is often skewed and fails to measure crew members that actually come ashore (Scarfe 2011; Vaggelas 2011). Passenger spending,

nonetheless, generally accounts for the largest share of revenues from cruise tourism in ports of call, particularly in island economies (i.e. the Caribbean). The average spending per cruise passenger in a port amounts to USD 100, based on our meta-assessment of cruise port impact studies covering over 75 different ports. The average economic contribution per passenger in a cruise port is USD 200, although there is a large variation of values so it is difficult to generalise from these findings (Table 12). The largest absolute economic contribution of cruise shipping was identified in the port of Piraeus with a report economic turnover of USD 690 million. Although this is certainly a substantial amount, it does not come close to the economic value added generated by cargo and industrial functions in many ports. For most seaports, the share or cruise-related value added remains fairly small.

Table 12. Economic contribution of cruise shipping

	Average	Minimum	Maximum
Spending per cruise passenger (USD)	100	34	309
Turnover per passenger (USD)	200	20	1868

Source: Merk (forthcoming)

There are links between port activity and global firms, in particular maritime services, such as ship finance, maritime insurance, maritime law and maritime consultancy. The location and connectivity of multi-office firms in these sectors are more closely following global cities hierarchies than port hierarchies, as indicated for example by relatively strong positions of non-port-cities such as Paris and Madrid, although the high ranks of Rotterdam and Hamburg present the exceptions to the rule (Jacobs et al. 2010). For these economic activities urban attractiveness is a more important criterion than the presence or size of a port, as can be illustrated by the case of London, a city where most port functions have disappeared over the last decades but that has developed one the leading world cities in advanced maritime services, with the highest connectivity in terms of multi-office maritime services firms (Figure 8). Studies on the command centres in container shipping confirm that such high value added functions are often located in port-cities, but that being a port-city is in no way a guarantee for attracting such functions (Verhetsel and Sel, 2009). These kinds of services can provide large value added; the economic contribution of maritime business services to the British economy was estimated at approximately 1.5 billion UK pounds in 2011 (Oxford Economics, 2012).

Figure 8. Global maritime APS linkages of London

Source : Merk et al. 2011

In comparison with seaports, airports tend to attract more high value added activities, such as headquarter functions and high technology jobs. These are in many parts of the world related to hub airports that are able to offer a wide variety of inter-continental flights. E.g. it was estimated in the early 2000s that across all major US cities, the location of a hub airport in their region resulted in about 12 000 extra high-technology jobs locating in that region (Button et al, 1999). Headquarters are important for a regional economy because they could in turn attract high value-added business services. A study on the location of headquarters in the EU showed that a 10 % increase in the provision of intercontinental flights leads to a 4% increase in the number of headquarters located in the urban area (Bel and Fageda, 2008). Airports, in contrast to seaports, attract a large cluster of business services, commercial retail and hotels, headquarters. This can be explained by the fact that servicing business passengers is core business of most major airlines and airports, but not for seaports. Air cargo is mostly limited to high value cargo. The combination of sea- and airports can create synergies for certain businesses. O'Connor (2010) has observed that more diversified gateways (i.e. those possessing multiple airports and seaports within a radius of 70 km from the "core") generate bigger traffic and larger logistics sectors than more specialised gateways (i.e. those handling either air or sea freight). At the same time, the air and sea cargo sectors are in practice fairly disintegrated (e.g. for Europe: Ducruet and Van der Horst, 2009). Some port authorities, such as New York/New Jersey, Portland and Seattle, also administer airports, which can generate substantial shares of value added.

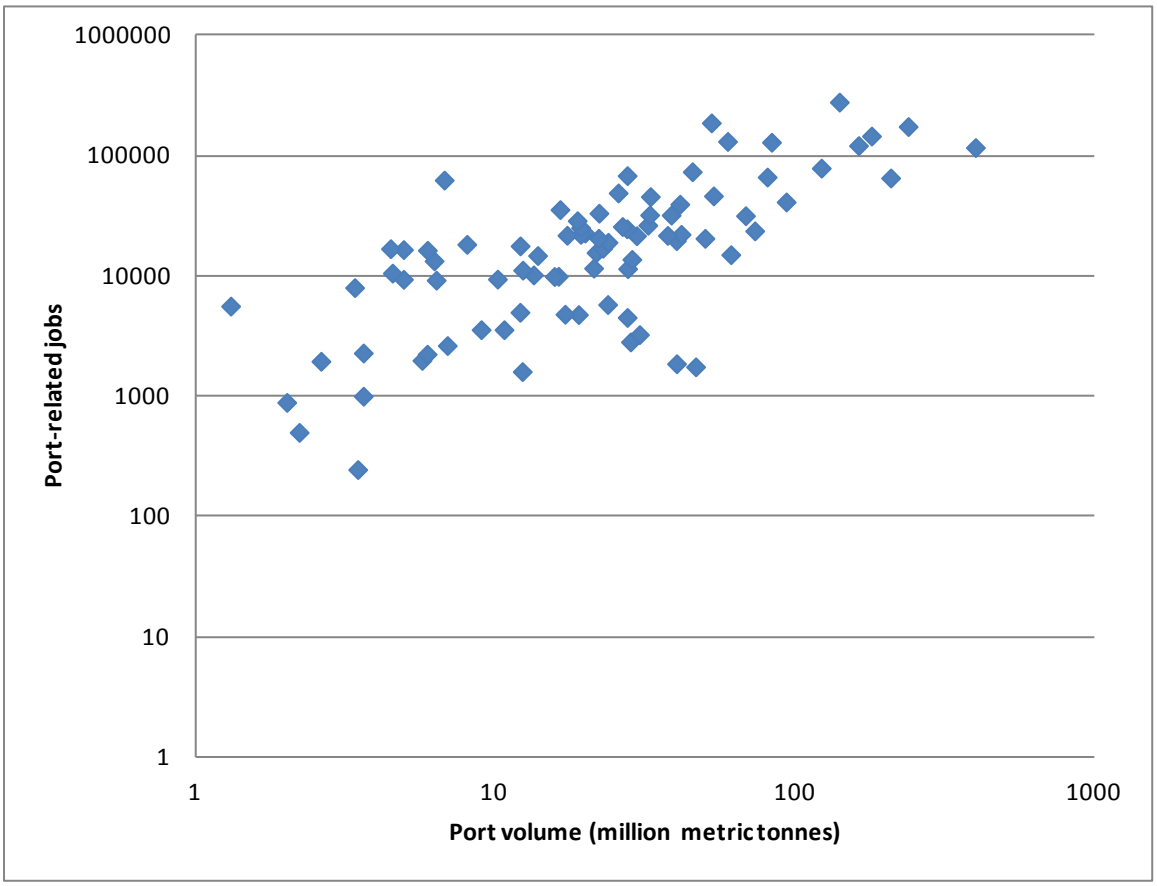
2.1.3 Employment

Port industries require local employment, but this is relatively marginal in comparison with the wider regional economy in which ports operate. Even in the largest ports, port and port required employment rarely exceeds a few thousand jobs. Several trends, including containerisation, automation and economies of scale, have made port operation and cargo handling increasingly capital- and land intensive, and decreasingly labour-intensive. Over the last decades, many ports have shed labour in order to become more productive and competitive. Direct port value added is also relatively small. The economic impact of a port is context specific and to some extent determined by its specialisation. Some commodities generate more value added for a port than others, with general cargo generating more value added per tonne of throughput and crude oil and containers the least in North West European ports, for which such an analysis was conducted (Haezendonck et al. 2000).[1]

The larger the port, the more port-related employment the area has. A meta-study of approximately 150 port impact studies, conducted for this report, indicates that on average one million tonne of port throughput is associated with 800 jobs. This number includes direct and indirect port jobs and should be interpreted with caution because it is based on port impact studies that use different definitions of ports and apply different methodologies. The variation of results is fairly large, but two thirds of the ports in the sample have between 200 and 1500 jobs per million tonne of port cargo. There are a few outliers that distort the correlation, but in general the link between cargo volume and port-related employment holds (Figure 9). With respect to cruise ports, the average number of direct and indirect jobs is 3.5 per thousand cruise passengers.

Port-attracted industries can represent a relatively large share of employment and value added of port regions, e.g. up to 10% of employment and 16% of value added of the main port regions in North West Europe. Much depends on which sectors are included in the port-attracted industries. Some studies follow the boundaries of the port area: all the industries that are located there are then considered port-attracted industries.[2] E.g. the annual studies of the National Bank of Belgium on the economic impact of Belgian ports incorporate all activities located in the port areas (Mathys, 2010). Some firms that might be located in the firm could in fact have no relation to the port, whereas other firms could be located near the port because they need good access to the port, while not actually located in the port. For this reason, often a more functional approach is often used to capture the port-attracted firms within certain defined regional boundaries. Input/output-models are frequently used to identify inter-sectoral links with the port, that is: their backward and forward linkages. Much depends of course on the port in question, but usually seaports have interlinkages with the transport equipment sector and the wholesale and retail sector. The challenge here is to find a coherent demarcation of port attracted industries: what is considered port-related industry in one study is different from another study. In order to overcome this discretionary distinction between port-related and non-port-related industries, an alternative approach has been to use the actual differences in economic specialisation between port regions and non-port regions as a way to determine which sectors could be considered port-related sectors; such an approach has been applied to Italy (Musso et al. 2000).

Figure 9. Relation between employment and port volume



Source : elaboration based on compiled dataset of existing port impact studies

At the same time, port throughput is positively correlated to employment in port regions, according to our analysis of European port-regions. This study indicates that an increase of one million tonnes of port throughput is associated with an increase in employment in the port region of 0.0003% (Ferrari et al. 2012). This means that in a region with one million employees, employment would increase by 300 units; in the long run this increase would be 7500 units. This impact is slightly larger on industry than on service employment. These conclusions are based an evaluation of the impact of port activity on regional employment in a sample of 560 regions in 10 European countries, 100 of which home to one or more port, from 2000-06. If liquid bulk is not included in port throughput numbers, the employment impact in the region doubles: an increase of one million tonnes port throughput is then associated with a regional employment increase of 600 units. This finding confirms the fact that only a few jobs are needed to handle liquid bulk, due to loading and unloading of a large part of this bulk by pipelines. No significant employment impact was found for (ferry) passengers.

2.1.4 Ports and innovation

Ports determine to some extent the direction of research and innovation. Port-cities are very dominant in port-related patents, such as shipping, petroleum and hoisting-lifting. Almost all of the 10 world regions with the largest amount of patent applications in shipping are home to one or more large global ports, including Houston, Los Angeles/Long Beach, Tokyo, Oakland and Rotterdam (Table 13). Of these regions in the top 10 for shipping patents, only the Zürich region does not have a port. The regions of Stockholm and Rogaland have ports (Stockholm and Stavanger respectively), but they are not among the top 125 world ports. Port-regions are also strong with respect to patents in port-related in a wider sense. These include patents in technologies that are used in the port sector (constructions, hoisting-lifting-hauling), or important commodities handled in port areas, such as petroleum and food stuffs.

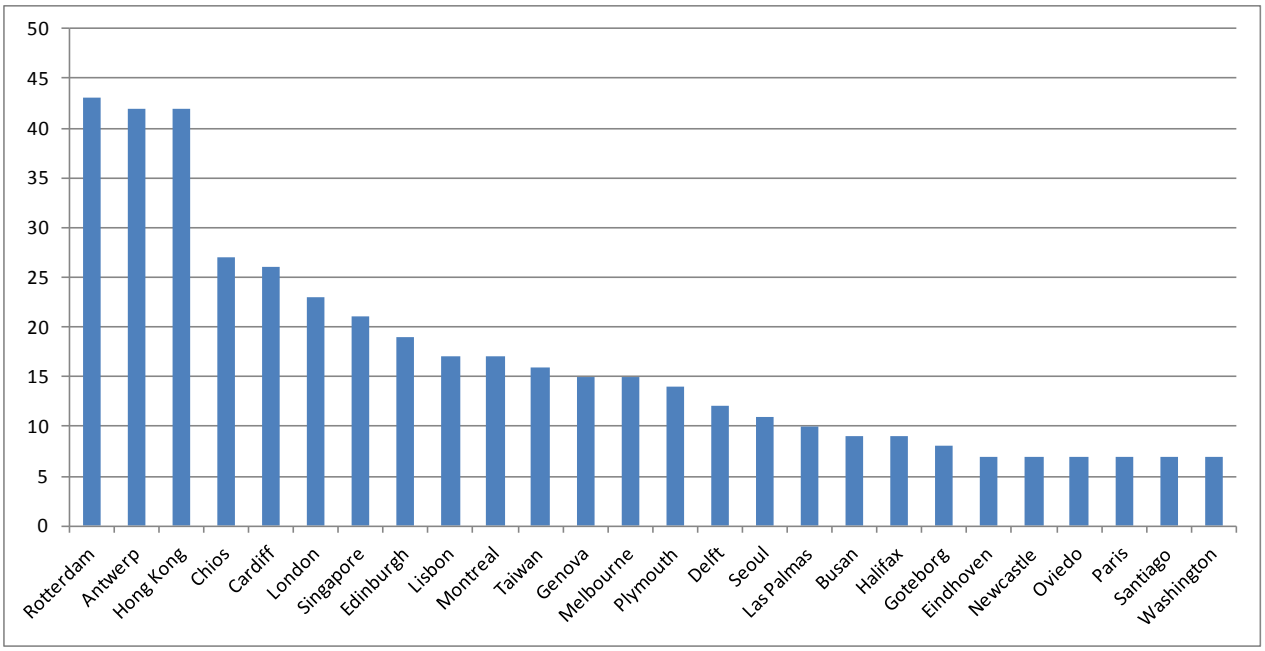
Table 13. Top 10 world regions for shipping patents (2005-2007)

Region	% of shipping patents	Top 125 ports
1. Houston-Baytown-Huntsville (US)	3.9%	Houston
2. Los Angeles-Long Beach-Riverside (US)	2.1%	Los Angeles & Long Beach
3. Tokyo (JP)	2.1%	Tokyo & Yokohama & Chiba
4. San Jose-San Francisco-Oakland (US)	2.0%	Oakland
5. Zuid-Holland (NL)	1.9%	Rotterdam
6. Västra Götalands län (SE)	1.5%	Gothenburg
7. Zurich (CH)	1.4%	
8. Stockholm (SE)	1.4%	
9. New York-Newark-Bridgeport (US)	1.3%	New York/New Jersey
10. Rogaland (NO)	1.2%	

Source: Own elaborations based on OECD Patent Database

Port-related research is primarily conducted in universities in port-cities, and not in most other cities. This can be concluded from a count of the city affiliations of the authors and co-authors of 576 port-related articles published in leading peer-reviewed academic journals between 1997 and 2011 (Figure 10). Rotterdam is the city that ranks highest on this count, closely followed by Antwerp and Hong Kong. As becomes clear from this ranking, the location where port-related research is conducted is strongly related to the presence of ports: almost all the highly ranked cities in this list are port-cities and this selection of places does in no way resemble the worldwide university rankings, in which leading US and UK universities, such as Harvard, Oxford and Cambridge, tend to figure. Several of these port-cities, such as Hamburg, Copenhagen and Marseille, also offer maritime business education programmes, such as maritime MBAs.

Figure 10. Leading cities in port-related research

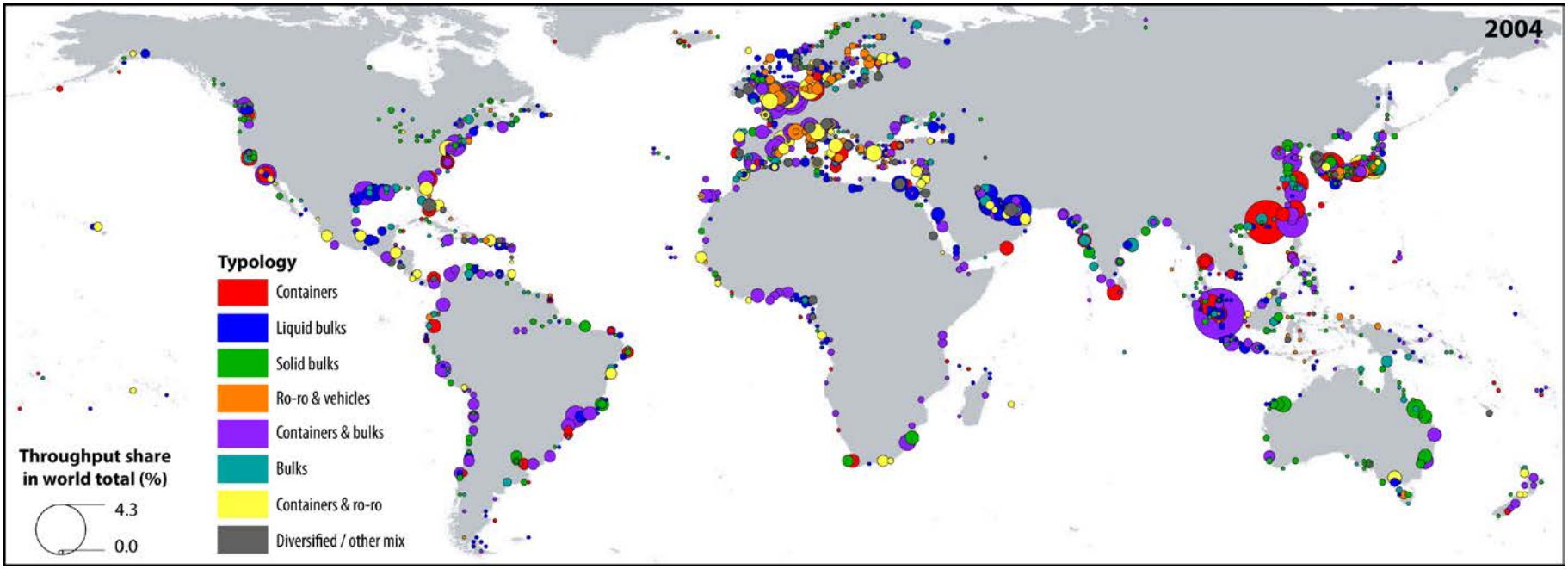


Source: own data compilation based on list of articles mentioned in Pallis et al. 2010 and www.porteconomics.eu

2.1.5 Where do the impacts take place?

Port-cities benefit from part of the economic impacts of ports. Most of the direct port-related value added is still created in port-cities. Port-cities also benefit from the effects of clustering industries in a port area, and the possible economies of scale and knowledge transfer related to it. Several resource-intensive industries continue to be attracted by port areas, as location in a port limits their transportation costs. Port traffic is very sensitive to the nature of the local economy in which they are handled: in larger and richer regions with large tertiary sectors the port volumes are often more diversified and include more high value added goods, such as containers and consumer goods, whereas agricultural and industrial regions are usually more specialised in bulk traffic (Ducruet et al. forthcoming). This is a relevant finding that could explain the wide variety of port specialisation profiles all over the world (Figure 11).

Figure 11. Port specialisation profiles



Source: own elaboration based on dataset from Lloyds Marine Intelligence Unit (LMIU)

However, most of the indirect and catalytic effects of ports take place outside port-regions. Firms in other regions also benefit from efficient ports in that it reduces their transport costs and facilitates their exports and imports. Backward and forward linkages of port clusters stretch out over the whole country; these impacts are usually fairly small in the port-city itself. This can be concluded from analysis conducted in the various OECD Port-Cities case studies in which port clusters were integrated in multi-regional input/output-tables, which makes it possible to identify where main linkages take place. Our analyses shows that only a very limited part of these linkages takes place in the port or the port-region, with a larger share in the main economic centre of the country, which could be relatively far away from the port, e.g. Ile-de France for the ports of Le Havre and Marseille; and Bavaria and Baden-Württemberg for the port of Hamburg. Port-related employment has tended to partly shift to other regions as well, in parallel with the relocation of logistics activity further away from ports. In many cases spillovers take place not only to other regions in the same country, but also into other countries, e.g. the port of Rotterdam plays an important role for German industries, and several European ports for the land-locked central European countries.

2.2 Negative port impacts

2.2.1 Environmental impacts

There is a variety of environmental impacts related to port activity. These impacts are related to shipping activity in a port, the activity on the port land itself and the environmental impacts of hinterland transport to and from ports. Main impacts are within the field of air emissions, water quality, soil, waste, biodiversity, noise and other impacts. These environmental impacts can have severe consequences for the health of the population of the port-city, especially for the poorer parts of port-cities.

Air emissions

Air emissions can be divided into two groups: Common Air Contaminants (CACs) and Greenhouse Gases (GHGs). Each of these groups is gathering diverse gases. Main CACs are: Oxides of nitrogen (NO_x), oxides of sulphur (SO_x), particulate matter (PM), among others. GHGs are gases present in the earth's atmosphere that reduce the loss of heat into space[3]. Main GHG gases are: Carbon dioxide (CO_2), Methane (CH_4) and Nitrous Oxide (N_2O). GHGs affect climate as they concentrate in the Earth's atmosphere and trap heat by blocking some of the long-wave energy normally radiated back into space. Common air contaminants have a local or regional impact on air quality, whereas GHG pollutants have global impact on climate. Considering other types of air emissions, Schreier et al. (2006), underlines that particle emissions from ships change the physical properties of low clouds, for the so-called indirect aerosol-effect. Particles and their precursors from ship emissions are able to act as cloud condensation nuclei (CCN) in the water-vapour saturated environment of the maritime cloud (Miola et al. 2009).

Air emissions represent a major port-related negative environmental impact. Even though maritime transport is seen as a rather clean mode of transport in terms of emission/km, shipping-related carbon dioxide emissions were estimated to be 3.3% of global emissions on 2007. Worldwide, NOx from shipping have been estimated to about 10% to 15% of the global anthropogenic NOx emissions from fossil fuels (OECD, 2010). At a regional level, it is estimated that annually, 1,725,000 tons of NOx and 1,246,000 tons of SOx are released by ships in passage or arriving at/departing from ports in the Mediterranean and the Black Sea (Abdulla and Linden, 2008). Despite its "green" image, Miola et al (2009) underline that ship emissions let out 150-300 times more sulphur per tonne kilometre than a truck (with low sulphur content of diesel oil) and twice as much NOx per tonne-kilometre than a truck. Dalsøren et al. (2009) found that around 6% of fuel consumption from ships is consumed in in-port operations. According to another study, the amount of pollution emitted by vessels during manoeuvring, loading, unloading, and hotelling phases are 4.5% of SO2 and 6.2% of NOx of the total pollution emitted by the ships (Gariazzo et al. 2007, cited in Castells Sanabra, 2013). Port-related emissions thus appear important in maritime-related air pollution.

Shipping-related emissions can present a large share of the total emissions in the port-city. These impacts can represent up to half of the emissions of the port-city, e.g. the case for Hong Kong and LA/Long Beach with respect to SO_2 emissions (Table 14). Ports can also have considerable impacts in other air emissions of cities, such as NO_x and PM_{10}. In addition, most large port-cities are also industrial estates with their own air emission that are not included in the table below. However, it is not easy to coherently collect and compare these data. This is related to a different focus and scope of the air emissions inventories of ports and cities. City inventories do in many cases not include the port area, do not focus on transport-related emissions or focus on GHG emissions, whereas the main air emissions impacts from ports come from SO_x, NO_x and PM.

Table 14. Shipping-related emissions as share of total city emissions

Port	SO_2	NO_x	PM_{10}
Hong Kong	54%	33%	
Shanghai	7%	10%	
Los Angeles/Long Beach	45%	9%	
Rotterdam		13-25%	10-15%

Source: own data compilation based on port's air emission inventories

Among the air contaminants in ports, $PM_{2,5}$ and NO_x present higher externalities, thus being the most pressing air contaminants to measure and mitigate. In their study on 13 selected Spanish harbours, the main pollutant regarding emitted quantity is NO_x, representing 86% of total emissions of air contaminants. However, it is important to underline that the kind of ship matters. Indeed, the Vancouver 2011 emission inventory explains that containerships and cruise ships play a particular part in port-related emissions. If containership represents 26% of total port calls, it is the main source of emissions of NO_x (33.6% of total). Parallel, cruise ships represent 14% of calls but 32.5% of port-related emissions of CO_2.

Due to the huge differences in terms of air emission measurements and port characteristics, it is difficult to comparisons air emissions of each port. Several ports publish a sustainability report presenting different indicator on their environmental impacts, including air emissions. Examples of ports with such sustainability reports are Los Angeles, Long Beach, Houston, Vancouver, Seattle, Sydney, Auckland, Hong Kong, Gothenburg, Barcelona, Hamburg and Antwerp. As there is no definite list of common air contaminants, each port can make its own. For example, the port of Antwerp in its sustainability report contemplates sulphur dioxide (SO_2), nitrogen oxides (NOx) as well as particulate matter (PM_{10}) for air pollution, whereas the port of Vancouver takes into account more gases in its landside emission inventory, such as Carbone monoxide (CO), Volatile organic compounds (VOCs) and ammonia (NH_3).

Air pollution of ports presents large external costs to their cities. MacArthur and Osland (2011) estimate the monetary value of air emissions of ships at berth in the port of Bergen between EUR 10 and 22 million. Castells Sanabra et al. (2013) estimated in their study on 13 selected Spanish harbours that the overall externalities were valued at almost EUR 206 million, whereas the individual contribution of $PM_{2,5}$, SO_2 and NO_x was EUR 95, 65 and 46 million respectively. Tzannatos (2010) estimated the external costs from in-port activity per cruise passenger in Piraeus in 2008–2009 at between EUR 2.9 and EUR 10.4. Berechman and Tseng (2012) found in their study on Kaohsiung, Taiwan that the cost of emissions from ships at berth in this port was USD119.2 million in 2010. Air pollution costs tend to increase with the amount of population of the nearby city, with a factor of 1 to 15. For a standard city with a population of 100 000 people, a tonne of $PM_{2,5}$ presents social costs of approximately EUR 33 000, whereas it presents social costs of EUR 495 000 for a city of several million people. The same applies to SO_2, which costs varies from 6 000 EUR/tm to 90 000 EUR/tm respectively (Holland and Watkiss, 2002, cited in Castells Sanabra et al. 2013).

Water quality

Ports are a source of pollution of water, but detailed information on emissions in water is rather scarce in comparison with air emissions. One major source of water pollution in ports is **oil spills**, coming from port runoff, unloading and loading of oil tankers, removal of bilge water, and leakages. Oil spills are coming from normal activities, accidents and illegal dumping practices. Even though tanker accidents are remembered as an important source of water pollution, some estimates indicate that normal shipping operations are responsible for over 70% of the oil entering the sea from marine transportation. Statistics also show that 80% of oil spills occur in harbour waters (Miola et al. 2009). Bailey et al. underline that in

the year 2000, 8,354 oil spills were reported in U.S. waters, accounting for more than 1.4 million gallons of spilled oil. These spills caused up to three times as much oil contamination as tanker accidents.

The other main source of water pollution is the transfer of harmful aquatic organisms (including dormant stages of microscopic toxic aquatic organisms such as dinoflagellates, pathogens such as the bacterium vibrio cholera) due to the **discharge of ballast water**, used to stabilise vessels (Miola et al. 2009). According to the IMO, about 10 billion tonnes of ballast water is transferred each year, amongst which 3500 million tonnes is discharged (Endresen et al. 2004). Other sources of water pollution are pollution from slop (residual of chemical products contained in the tanks and of the product used in the washing operations), whether it is treated or illegally discharged, and leaching of antifouling paints. These paints are used to coat the bottom of ships to prevent the development of sealife attaching itself to the hull and slowing down the ship and increasing fuel consumption (OECD 2011). Finally, dredging represent the last source of water pollution. Dredging is essential for port activity, because it guarantees their accessibility, but it can contaminate sediments and therefore surrounding water.

First, it is important to adopt a methodological framework to measure the impacts on water. In this perspective The European Water Framework Directive summarises 33 priorities and 8 other contaminant substances (Miola et al. 2009). Once the measures are accurate, it is necessary to develop a methodology to estimate monetarily impacts on water. These studies proliferated after the Prestige spill episode (2002), in order to find ways to compensate for damage occurred in publicly-owned natural resources. One method is the economic damage approach, in which the economic damage is assessed on the basis of income losses resulting from restricted or suspended marine resource use, another approach is the willingness to pay concept.

Soil

Soil pollution from the maritime transportation sector is mainly linked to the terrestrial activities in port areas. There are multiple sources of soil pollution in port areas: discharge of oil on the soil (from the vehicles and fuel deposits), spill of chemical from demolition of ships; and emissions of SO_2, NO_x causing acid rain and consequently, soil acidification. However, the main impact of ports on soil is erosion. Because the presence of a port modifies the natural coastal sediment transport, it causes erosion. This can produce a degradation of natural impact and harm the local biodiversity. Secondly, it can cancel out portions of land that could be used for recreational or productive uses (Miola et al. 2009).

Waste

Port activities produce waste, especially from oil terminals, fuel deposits and dry-docks operations, which produce oily and toxic sludges. But waste comes from other sources too: waste from ships, from dredging operations (Miola et al. 2009). A crucial role is played by cruise ships; although they represent less than 1% of the global fleet, they are responsible for 25% of all waste, consisting of glass, tin, plastic, paper, cardboard, steel cans, kitchen grease, kitchen waste and food waste (Miola et al. 2009). Waste represents a challenge for port authorities, which have to collect and treat it. For example, the port of Antwerp collected more than 250 tons of oil-containing and various hazardous wastes submitted in the waste dumps of the port and collected nearly 400 tons of non-hazardous waste in 2010 (Port of Antwerp, 2010). Plastics are an important source of waste, as plastics released from vessels makes up almost 80% of all garbage found on shorelines and on the sea floor in the Mediterranean Sea (Abdulla and Linden, 2008). Waste is linked to health and land use issues. Indeed, as the port of Houston underlines, improving recycling of waste is a way to reduce landfills.

Biodiversity

Ports' impacts on biodiversity mainly come from air emissions, dredging and the transfer of ballast water (Table 15). One of the main sources of disruption of the balance of ecosystems is the introduction of non-indigenous marine species through the transfer of ballast water. These alien species can enter in competition with local species and cause heavy environmental impact. Sulphur and nitrogen compounds emitted from ship, oxidising in the atmosphere, can contribute to acidification, causing acid depositions that can be detrimental to the natural environment, such as lakes, rivers, soils, fauna and flora. NO_x deposition is also a vector of eutrophication, which can alter ecosystems. Dredging has an impact on ecosystems because it can destroy the habitat of marine species. Finally, noise can disturb animals both at sea and in port areas.

Economic valuations of port-related biodiversity loss appear substantial. It appears rather difficult to valuate economically these impacts, but it has been can be done when the loss regards species with a value on the market (fishes and seafood). For example, the study of Ruiz et al. (2001) accounts the loss of zebra mussel for over $500 million/year. This paved the way for compensatory policies. Landside impacts of ports concern mainly birds, because ports' land could be a breeding area for them, and light induced by industrial activity can provoke damages in birds' populations.

Table 15. Port impacts on biodiversity

Source	Effects	Species affected
TBT paint	Morphological change, change in population structure	Marine invertebrates
Anchoring	Sediment resuspension, decrease of photosynthetic ability	Marine organisms living in harbours, seagrass
Oil discharge	Genetic damage, oxidative stress, behavioural abnormalities	Marine vertebrates, birds
Gas emissions	Ocean acidification	Plankton, coral, organisms with calcification process
Chemicals	Accumulation of substances in organisms causing disruption of endocrinal system	Predators at the top of the food chain
Waste	Eutrophication	Seagrass, fish
Debris	Death by ingesting floating plastics	Seabirds, turtles, whales
Ballast water	Introduction of invasive non-indigenous species, extinction of native species	Entire ecosystem
Noise	Problems of communication for animals, collisions	Cetaceans, marine mammals
Collisions	Death	Cetaceans, other marine vertebrates (whales, dolphins, turtles)

Source: own elaboration on the basis of Ameer Abdulla, Olof Linden (eds). 2008.

Noise impacts

There are various noise impacts from ports, coming from different sources: ships, cranes, trucks, trains and industrial activity. These different sources of noise can have large impacts. In Livorno, the port-related road traffic of heavy vehicles was recognised as one of the main cause of noise impact on urban residential areas. In terms of absolute noise emission, the industrial area predominated, but the large distance from the urban area permits noise to decrease to negligible levels. Berthed ships represent another significant noise source; a significant contribution comes from ferries and cruise vessels, because of the proximity of the passenger terminals to the city centre (Morretta et al. 2008). A ship which fulfils the external noise limits for ships of the IMO can have a diesel generator exhaust sound power of 107 dB(A). If the sound power is 107 dB (A) and the noise limit for city residential areas is 40 dB(A), as is the case in

various countries such as Denmark, the ship should be berthed more than 600 metres away in order not to exceed the noise limit (Lloyd's Register ODS, 2010).[4] Not surprisingly, noise has been one of the sustainability priorities of European port authorities over the last decade, consistently ranking in the top 5 of most important environmental impacts as perceived by European ports, according to surveys by the European Seaports Organisation (ESPO, 2013).

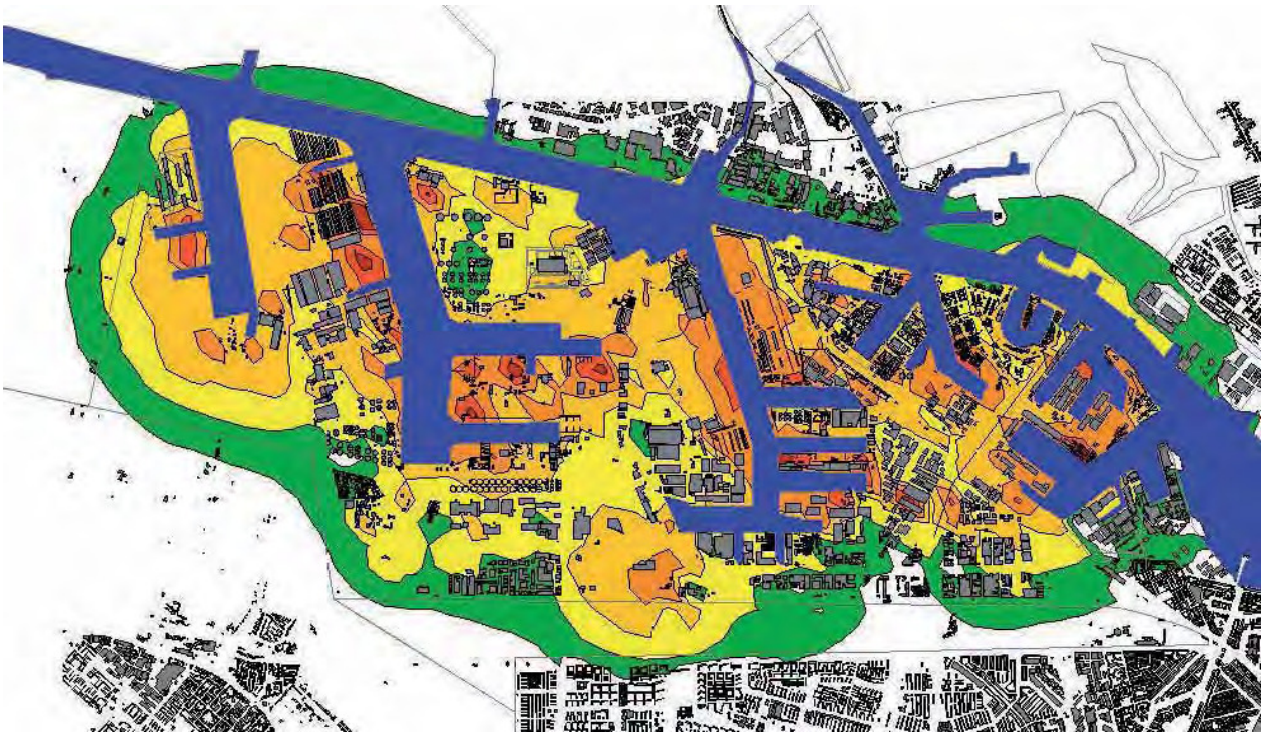
A significant number of urban residents can be affected by port noise. This can be illustrated by Strategic Noise Maps that have been made to characterise the port noise climate, creating for each noise source an acoustic map, as well as a map with overall port-related noise impacts (Figure 12 for an example for the port of Amsterdam). Through cross-comparisons between characteristic sound levels of the port area and the surrounding urban areas, the number of persons harmfully affected can be established. Based on a limited number of cases for which such an exercise has been conducted, the total number of people exposed to port-related noise ranges from 240 to 900 inhabitants per port (Table 16). Nightly activities could highlight a more critical situation for terminal and industrial activities that run 24 hours a day; for example the number of people exposed to a nightly sound value larger than 50 dB (A) was 900 inhabitants, whereas the daily impact was 300 inhabitants (taking into account the daytime limit of 60 dB (A) (Morretta et al. 2008). The number of people exposed to noise from water traffic and ports in Finland was estimated between 100 and 500 people. However, many areas with special sensitivity to noise, such as schools, hospitals and cultural centres, are not only exposed to port noise, but also to other noise sources (road, railways), which can interfere in the result of the measurements, which makes it complicated to identify a direct assessment of the particular impact of the port (Rizutto et al. 2010).[5] The main damage caused by noise to exposed population is annoyance and sleep disturbance, because they are more sensible to noise levels than other harmful effects.[6] According to the WHO, sound pressure levels at the outside facades of living spaces should not exceed 45 dB at night, so that people can sleep with bedroom windows open (Berglund et al. 1999).

Table 16. Urban residents exposed to daily port noise

Port	Number of people exposed to daily port noise > 60 dB (A)
Amsterdam	242
Livorno	300
Valencia	856

Source: NoMEPorts 2008b

Figure 12. Noise map of the Port of Amsterdam



Source: NoMEPorts 2008a

Health impacts of ports

Negative social impacts of ports are often health-related and generated primarily by pollution (air and water) and noise. Air pollution negatively impacts society by causing various respiratory and cardiovascular diseases while water pollution from the storm run off of port related activities can result in skin and neurological health problems (Human Impact Partners 2010). Over a concentration of 0.06 mg/m3, SO_x can affect the respiratory system and trigger bronchitis episodes and chest infections. Nitrogen oxides can also provoke serious damages to the breathing apparatus when their concentration is over 100 mg/m3, and even be lethal when the level is 300-400 mg/m3 (Batistelli et al.). Particulate matter (PM) also contributes to serious health problems such as premature mortality, asthma attacks and millions of work lost days (Miola et al. 2009). These environmental impacts that render unhealthy living conditions can be categorised as direct effects. Several studies also cite collisions and pedestrian safety as health issues directly related to living near a port. The British Department of Transportation, however, also considers indirect health impacts such as deprivation of parks, community centres, and clinics that can contribute to mentally and physically healthier populations (Department of Transportation 2011). Perceived health impacts are also important to consider, as shown by a community survey in Seattle that uncovered that 34% of residents in the two port communities of Georgetown and South Park rated their health status as "poor" or "fair" while 10.5% responded this way throughout King County, Washington (Community Coalition for Environmental Justice and Puget Sound Sage 2010).

Most of the studies concerned with health impacts of ports on the immediate population come from the United States, with several of these studies in Los Angeles and Long Beach, and mounting efforts in Houston, Seattle, and New York/New Jersey. Los Angeles/Long Beach appear to produce the most complete data regarding health impacts of ports, reporting that data from the Los Angeles County Health

Survey reveals that Long Beach communities (in close proximity to the L.A. port) experience higher rates (2.9 percentage points average) of asthma, coronary heart disease and depression, compared to communities in L.A (Human Impact Partners 2010). Additionally, the California Air Resources Board attributed 3700 premature deaths per year to ports and the shipment of goods (Sharma 2006). Europe has also made significant advances in determining negative environmental effects of port activity, while not always linking these impacts to public health literature and studies.

Regarding air pollution, nitrogen dioxide and organic carbon emitted from various port activities have been linked to bronchitic symptoms (Peters 2004 in Sharma 2006). In 2011, 54% of sulphur dioxide emissions in the city of Hong Kong emanated from the marine sector.. Exposure to this gas is associated with respiratory issues and premature births. Another port source of harmful air pollutants is trucks travelling in and out of the port producing harmful emissions that lessen air quality (UCBHIG 2010). The Healthy Port Communities Commission has growing concerns, stating that communities surrounding the Port of Houston have the highest air toxicity rates and elevated rates of cancer and asthma compared to Greater Houston more generally (The Citizen, 2013). Specific pollutants found in water related to adverse human health conditions include TBT (used to ward off barnacles and other marine organisms), oil, toxic substances stirred up from port dredging, and high concentrations of heavy metals. Additionally, ballast water can carry disease-causing organisms and contaminate seafood for human consumption (Sharma 2006). Valuation of health impact can be done through measures of mortality and morbidity. One can either refer to the Value of the Statistical Life (VSL) or the Value of a Life-Year (VOLY). The monetary value of health impacts has been calculated for example by the EPA in the US: a chronicle bronchitis is worth USD 420,000 in 2010 income (Miola et al. 2009).

Noise from port operations can cause high blood pressure, heart disease, and other stress-related symptoms. In Shanghai for example, the population is said to suffer more from noise pollution than air pollution caused by ports (Yang in Sharma 2006). Children can be particularly affected by the noise generated by port activity with delayed learning being related to noise in public health literature (ibid). This “port noise” is caused primarily by diesel engines approaching and idling in the dock, capable of reaching between 80 and 120 dB, as well as the loading and unloading of goods (Sharma 2006; Moretta et.al. 2008). A study found that port-related vehicle traffic (in combination with public transit and train traffic noise caused more than a third of West Oakland residents to be highly annoyed by noise, with eight myocardial infarction deaths (15% of all myocardial infarction deaths) per year that may be associated with this noise exposure, and one third of residents that may be at risk of sleep disturbance. Compared to a standard of 60 dB, the existing noise levels were said to possibly result in a 29% impairment in recall and reading and a 4% impairment in recognition and attention, which may have considerable consequences on the cognitive development of West Oakland children.“ (University of California Berkeley Health Impact Group 2010).

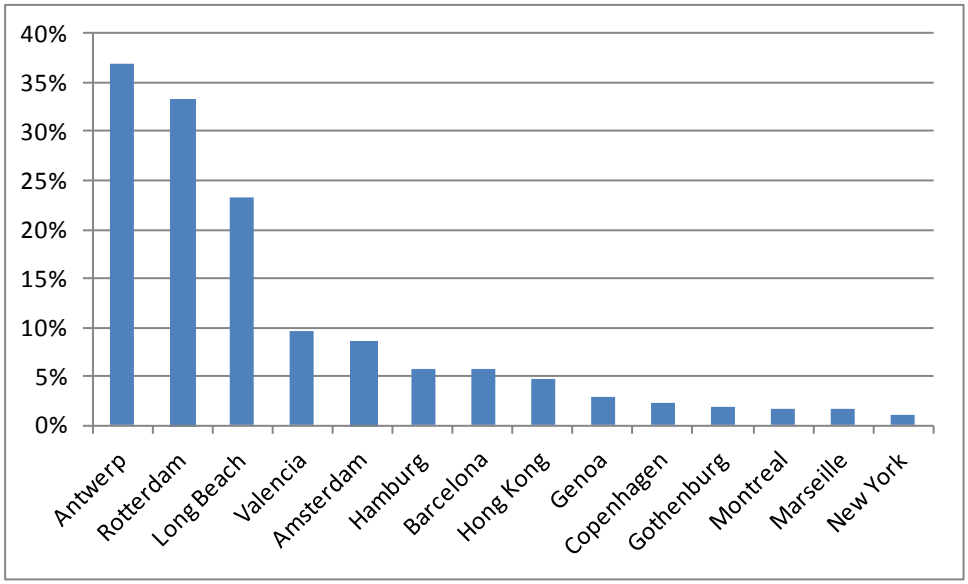
2.2.2 Land use impacts

Another characteristic of modern ports is their space-intensity; they occupy a relatively large share of the metropolitan land surface. Among selected port-cities, Antwerp, Rotterdam and Long Beach have a very large share of urban land used for port activities (Figure 13; Figure 14). Other large ports tend to use a share of the city surface that is lower than 5%. Even a port like Hamburg, located in the very core of the city, uses only slightly more than 5% of the land surface of the city. Evidently, one needs to be cautious with these comparisons as the administrative boundaries of cities vary a lot, but have a large impact on the outcome of these calculations. Still, these comparisons are not meaningless. Land use impacts often become prevalent in case of port development projects, because they enter in competition for land with

other uses of the city surface, or can provoke degradation of natural habitat and biodiversity if they occur in areas that were not previously developed, as is often the case.

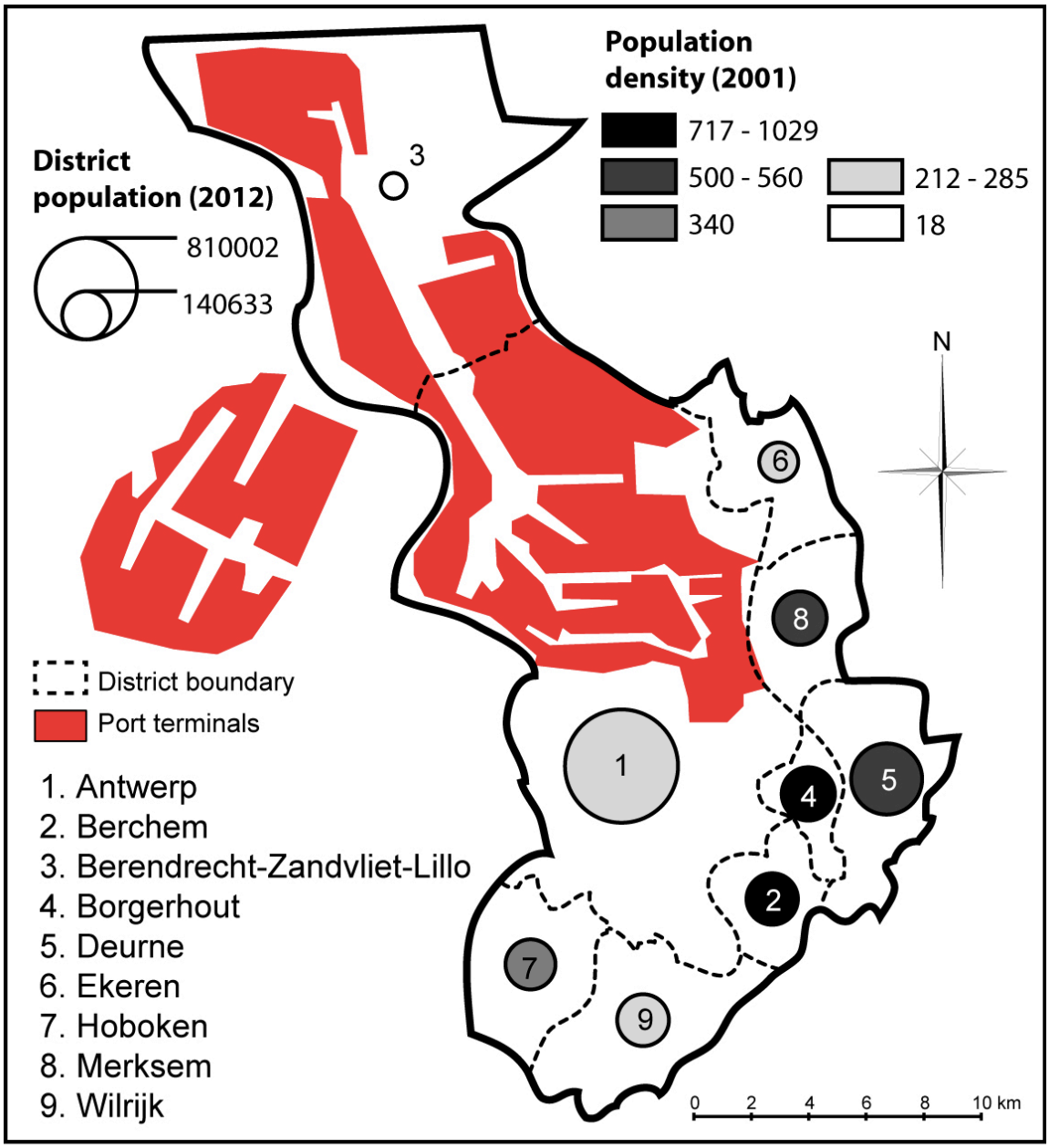
Apart from the environmental dimension connected to port land use, there is also an economic dimension, because there could be opportunity cost of port land use. Agglomeration effects and high job density are generally considered to be factors of urban economic growth, and these agglomeration effects might be constrained by the presence of large port areas. As large port areas are generally not easily accessible to the public, they could not be expected to generate the agglomeration effects associated with urban areas in terms of knowledge spillovers, although there could be clustering effects in port areas that might be dependent on size.

Figure 13. Port land surface in selected port-cities (as share of total city area)



Source: own data collection based on data provided by port authorities

Figure 14. Land surface of the port and the city of Antwerp



Source: own elaborations

2.2.3 Traffic impacts

The presence of a port can lead to urban congestion caused by the hinterland traffic to and from the port area. A large share of freight transport between port and hinterland is by truck, which adds to road traffic volumes, and often to congestion costs in metropolitan areas that are struggling with congestion. For example, the costs of road congestion due to 6% rise in freight volumes in the Port of New York – New Jersey have been estimated to be between USD 0.3 and 0.8 billion per year (Berechman, 2009). The port cities of Rotterdam and Antwerp provide relevant examples of port cities that have experienced greater

congestion due to the growth of port activity in these regions (De Borger and De Bruyne 2011). The issue is even more pronounced in developing countries and emerging port cities. Congestion in urban areas attributable to port activity and traffic heightens the negative economic and environmental impacts of the global shipping trade on metropolitan regions hosting port facilities. These growing challenges require innovative policy solutions to promote sustainable port activities and efficient transport infrastructures between the port and the hinterland.

Urban congestion due to port-related traffic originates at the port-land interface. While containerised cargoes were, in part, made to facilitate intermodal movement between port and hinterland, urban areas do not go unaffected by such large shipments or movements of goods. Inadequate port services and cargo handling equipment, availability of storage space, excessive turn-around times and unloading time can all contribute to delays in urban traffic flows (Yingigba Jaja, Chioma 2011). Furthermore, high truck volumes and their large cargoes contribute disproportionately to traffic accidents and ensuing delays (Giuliano and O'Brien 2008).

Congestion on urban road networks due to increased cargo throughput at a port can, in turn, negatively impact the port. It is widely acknowledged that port activities and transport network operations cannot function separately of each other. The inefficiency of either one will forcibly negatively impact the other, which stands as a testament to the highly intertwined nature of inland networks and seaports (Notteboom and Rodrigue 2008). In U.S. port cities, intensified port competition can result from such congestion, as clogged networks tend to correlate to a shift from shipping companies to a neighbouring and often rival port (Wan et. al. 2011).

2.2.4 Other impacts

Ports have different kind of other impacts that can be sources of nuisance for local citizens. These include:

- **Visual impacts**. First, industrial activities, of ports, with bulk cargo piles, and ugly materials stacked may give an unpleasant impression (Economic and Social Commission for Asia and the Pacific, 1992). Then, particles and NO2 linked to air emissions from maritime transport activities, as highlighted by Holland et al.(2005), can have impacts on visibility, by reducing the visual range (Miola et al., 2009). The last issue in relation with visual impact of ports concerns artificial lights burning 24 hours a day. Lighting may cause nuisance for nearby community of men, but also have negative effects on wildlife, including disorientation and confusion of biological rhythms. Lighting can cause mortality among bird populations, because they are attracted to brightly lit buildings, and circle these structures until they die of exhaustion or run head into them (Bailey et al., 2004).
- **Odour**. Diverse port activities can provoke unpleasant smell that can harm local residents' quality of life. The port of Antwerp, in its sustainability report, highlights that if the petrochemical industry appears to be the largest source of environmental damage in the port area, the majority of the complaints involve complaints about odours. It appears thus that there is a discrepancy between the most important concerns of port authority and the most important negative impacts for local residents, because odours are not part of the top concerns of port authorities (ESPO, 2010).
- **Dus**t is produced in ports mainly by bulk cargo handling and storage, construction work and road traffic. It is measured by suspended particulate matter (Economic and social commission for Asia and the Pacific, 1992). Particles can penetrate the human respiratory tract and exacerbate respiratory conditions such as asthma (Fortescue, 2011).
- **Social impacts** of ports include all the impacts of the development of ports that could influence the life of local communities, such as relocation of villages, disruption of lifestyle, formation of slums, etc. indeed, modernisation brought by the development of ports can change the cultural traditions and the everyday life of the local community, for example by disturbing the local fishery operations, as well as increasing the risk of accidents, a worry for local populations (Economic and social commission for

Asia and the Pacific, 1992). Furthermore, oil and wastes discharged from ships can reach beaches and disturb recreational activities as well as tourism.

- Ports are closely tied to tremendous **security issues**, especially because they are lined with military installations, nuclear power plants, oil refineries, fuel tanks, pipelines, chemical plants, and major cities with dense populations. First, transport of hazardous goods poses risks of **explosions**. For example, in November 2002, an explosion involving improperly stored fireworks and calcium hypochlorite containers (a bleaching agent used in swimming pools) caused one death and extensive damage to the 4389 TEU *Hanjin Pennsylvania* and its' cargo near Sri Lanka (OECD, 2003). Then, ports are crucial places for international contraband; as Monson et.al. underline, 12 seaports surveyed by the United States Interagency Commission on Crime and Security in American Seaports accounted for 69%, 55%, and 12% respectively for all cocaine, marijuana and heroin seized nationwide (by weight). These use of containers for illegal purpose Is all the easier than it is impossible to verify all the containers. In the US, only 4 to 6% of their content is verified (Monson et al., 2006). It is noteworthy to underline a dramatic shift after the terrorist attacks of 9/11: security concerns shifted to assessing threats of possible **terrorist attacks**, through the smuggling of weapons of mass destruction shipped into a country and detonated at a port, using containers for transport or even an entire ship as a weapon.
- Although not an impact of ports on their environment, seaports are particularly vulnerable to **climate change impacts**, because of their location in coastal zones, low-lying areas and deltas. They can be particularly affected by rising sea levels, floods, storm surges and strong winds. Climate change is expected to have a range of diverse environmental, social and economic impacts. In its Fourth Assessment Report, published in 2007, the IPCC estimated that global average sea level will rise from 18 to 59 cm by the last decade of the 21st century (US Environmental protection Agency, 2008). One recent study has estimated that assuming a sea level rise of 0.5 meter by 2050, the value of exposed assets in 136 port megacities may be as high as US$ 28 trillion (Lenton et al. 2009). Ports will also have to consider anticipated sea levels not only for economic reasons, but also to prevent leeching of contaminants. But the severity of these impacts will vary widely by geographical location and depend on a number of factors, and this is the uncertainty of their magnitude that makes adaptation measures hard to take.

2.2.5 Where do the negative impacts take place?

Port impacts have generally become sub-urbanised, as many port sites have relocated from city centres. Port relocations and gradual spatial disintegration of ports and cities over time have taken place in many countries and have had a profound influence on port impacts. Remaining port functions near highly populated areas have become constrained by limited acceptance by the population of negative impacts. However, there is a large variety between port-cities. As ports are capital intensive, port relocations can in many cases not immediately take place and have in many cases been a gradual shift, through new terminal development away from city development. Several ports have thus developed on multiple sites, which adds a new layer of complexity in terms of disintegration of positive and negative impacts. Port lay out also is important, as the boundary of the port area with the city could be considered the area were most of the environmental impacts take place. If this boundary touches a large population concentration, the intensity of port impacts will evidently be larger. Finally, there is also a governance component to this discussion, when most of the impacts touch surrounding municipalities, which would imply a metropolitan or regional approach to these impacts..

The effects of pollution, dust and noise are all very localised and most of the congestion costs occur close to the ports. Other regions are also subject to the negative impacts of the hinterland transport of port cargo to or from their region, but these effects are more diluted than the impacts in the port-city. Moreover, there is a large skewedness with respect to the negative impacts; large port-cities can be considered

environmental hotspots. According to our estimates the largest 25 ports in the world account for around half of the shipping emissions in all ports in the world (Merk, 2012). So there is a large difference in negative port-city impacts depending on port size. Other environmental impacts from shipping are evidently global impacts, and many of these actually take place at sea, but these impacts become particularly evident in port-cities.

2.3 Confronting benefits and negative impacts

The overview of impacts presented in this chapter shows that costs and negative effects are localised, whereas the benefits would be generated at the supra-regional (national) and even supranational level (Table 17). This finding is in line with the mismatch suggested by various authors (e.g. Musso 1996, Hesse 2006). There are substantial benefits from ports, but they can have considerable leakages to other regions. These spillovers include lower costs of external trade, indirect economic linkages including supplier linkages and economic specialisations that spill over to other regions. E.g. maritime-related engineering services are to a limited extend located in Rotterdam, but to a much larger extent in the Rotterdam metropolitan region and the rest of the Netherlands (Merk and Notteboom, 2013). Port-related employment is increasingly de-concentrating, in many cases away from port regions. The port can be a revenue source for local governments if they are in charge of the ports, but in many cases the national government receives the net profits of ports. Ports can provide very interesting locations for renewable energy production, in particular biomass production considering the large diversity of commodity flows and sophisticated refinery infrastructure, but this production capacity will most likely serve a wider area than just the port region. Most of the negative effects of ports are localised, including the environmental effects identified in this chapter. The impacts of hinterland traffic are also mostly local, also because most of the short range hinterland traffic is by truck (and thus most polluting), whereas most of the longer range hinterland traffic is by modes with less negative externalities (rail and barge).

Table 17. Costs and benefits of global ports

	Local	National	Supra-national
Costs			
- Economic	Infrastructure investments Opportunity costs land use	Infrastructure investments	
- Environmental	Air, water, waste, noise, odour Hinterland traffic		
Benefits			
- Economic	Port-related value added Agglomeration effects Knowledge spillovers Lower costs of trade	Forward/backward linkages Lower costs of trade	Lower costs of trade
- Environmental		Renewable energy production	

Source: own elaboration

Comprehensive evaluation of this mismatch is difficult to quantify, in particular due to difficulties to quantify negative impacts. However, various studies have been conducted over the last decades that give quantitative indications on negative impacts. For a start, there is a growing literature on the external costs of hinterland traffic. These external costs include costs related to congestion, accidents, air pollution, noise and other external costs. Haezendonck and Coeck (2006) calculated the external costs of hinterland traffic related to the port of Rotterdam to be around € 240 million in 2000. Even if these calculations are dependent on the data quality and underlying assumptions, there is a growing academic literature underpinning such results (Maibach *et al.,* 2008).

One of the emerging approaches for economic appraisals of the port-city relationship - in particular the impacts on the city population - is the contingent valuation method, based on an analysis of the

willingness to pay of the local population for certain policies or to avoid certain proposed measures (Saz-Salazar et al. 2013). Examples of such studies are on the renewal of vacant port areas for recreation purposes in the Spanish port-city of Castellón (Saz-Salazar and García-Menéndez, 2003), and the valuation of negative externalities resulting from port expansion in Valencia (Saz-Salazar et al. 2012). This last study calculated that the average compensation that would be required would be around EUR 100 per family negatively affected, which would amount to a present value of the costs borne by local citizens of approximately EUR 41 million. A more or less comparable study on Tianjin (China) showed that citizens had no statistically significant preference or disapproval of port construction (Zhai and Suzuki, 2008). Another approach to quantify port impacts is the hedonic price analysis.

Hedonic price analysis studies have found negative price effects for industrial zones, but not necessarily for port areas[7]. Proximity to an industrial site exhibits a statistically significant negative effect on the value of residential properties in the Randstad region (Netherlands), but the effect of closeness to a port area was found to be insignificant (De Vor and De Groot, 2010). Hedonic price analysis conducted on St. Nazaire showed no linear and univocal relation between proximity to the port industrial zone and housing prices, possibly explained by a positive effect of proximity to place of work or easy access to the transport network, which can offset air pollution or environmental risks (Maslianskaia-Pautrel, 2009). Similarly, close proximity of housing to a seaport was found to have an insignificant effect on individual well-being in Ireland (Brereton *et al.*, 2008). There is some evidence of negative effects on house prices due to proximity to the port-industrial complex of Port Jérôme, which is part of the Rouen port cluster. Hedonic price analysis, taking into account a house's intrinsic characteristics, shows that close proximity to this port-industrial complex leads to a price discount of approximately 12% of the average price for a similar house. Proximity to the Seine River leads to an even larger reduction, namely 38%; the Seine is thus not considered an asset in this area (Travers *et al.,* 2009). The lack of a broad base of quantitative assessments makes it difficult to generalise about the extent of the port-city mismatch of benefits and negative impacts; much is unknown and much depends on local circumstances.

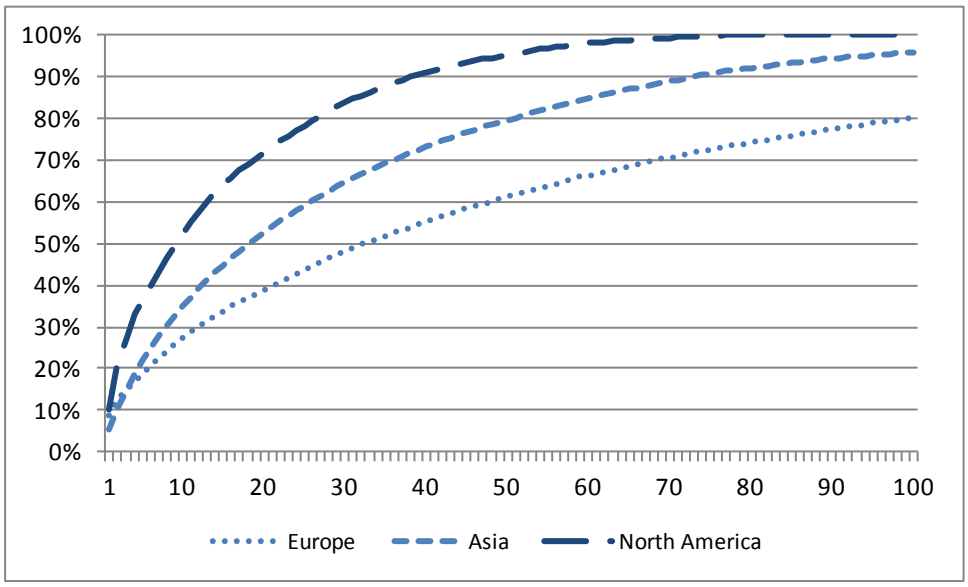
The character of the port-city interface is one of the determinants of the mismatch of benefits and negative impacts. This can be illustrated by the distinct perspectives for Rotterdam and Amsterdam, the first and fourth largest European seaports, both located in the Netherlands. In spatial terms, port functions and urban functions have become increasingly disintegrated in Rotterdam, with the newest and most active port terminals now at more than 40 km from the city centre, and part of port activities taking place in inland terminals (extended gates such as Moerdijk). In Amsterdam, port functions have retreated to some extent, but a significant part of the port activity is still taking place relatively close to the city centre. As a result, the port-city challenges are different. In Rotterdam, the congestion and environmental impacts related to the port-industrial cluster can be felt in the city, but most of the port jobs are now occupied by workers from outside the city and the connection of urban citizens and businesses to the port complex is becoming loose. In Amsterdam, there is a strong pressure on transforming parts of the port land in order to develop other urban functions, such as housing and office development (Merk and Notteboom, 2013).

Emerging trends influencing port impacts

Several developments have increased the port-city mismatch of benefits and impacts over the last decades. Containerisation has led to a standardisation of cargo handling, requiring less local manpower. Growing ship sizes fuelled a process of port concentration and the emergence of a hub and spoke-port-networks. The first ten North American ports in 2009 handled half of the total port volume on their continent; this share was 35% for Asian ports and 27% for European ports (Figure 15). The concentration among container ports has increased over the last decades, as can be shown by increasing scores on the Gini coefficients among ports in Europe, NAFTA and Asia (Figure 16). Analysis of the most dominant relation of each port with other ports, based on a dataset of vessel movements, shows that ports are indeed

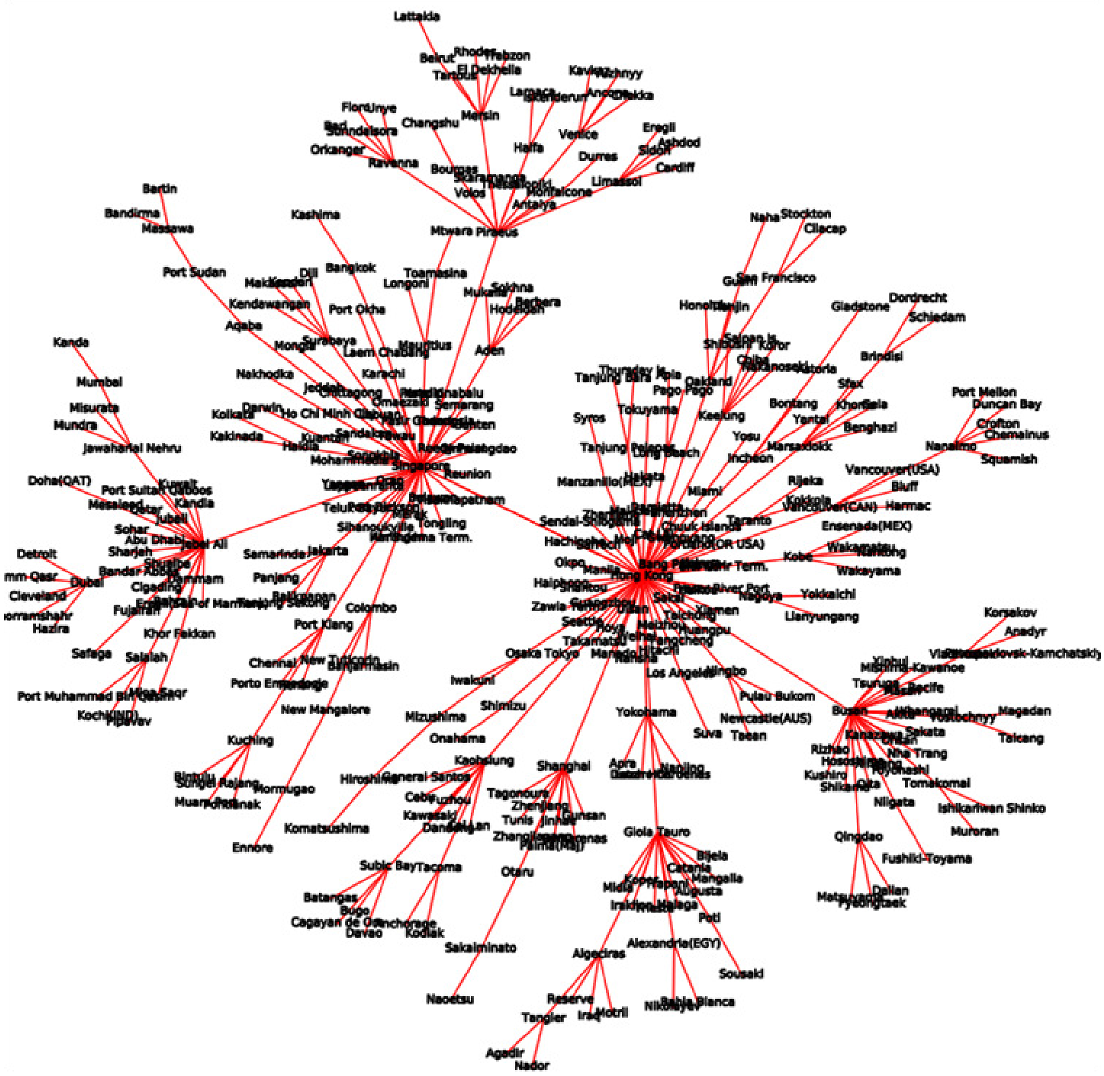
subject to hub and spoke tendencies, with a limited number of ports, such as Singapore and Hong Kong, having a central node function for many other ports (Figure 17).

Figure 15. Port concentration in Europe, North America and Asia (2009)



Source: Own elaborations based on data from Journal de la Marine Marchande
Note: Horizontal axis indicates the top 100 ports; the vertical axis indicates the cumulative traffic share of the first port to the first 100 ports.

Figure 16. Container port hubs



Source: own elaboration based on dataset from Lloyds Marine Intelligence Unit (LMIU)

As a result port functions in several cities declined or stagnated. Logistics activities moved out of port regions to places where land is less scarce, leading to a spreading out of port-related employment. Large ports expanded their hinterlands towards new regions, reducing their dependence on this port-city. Consolidation and globalisation of the shipping and port terminal industry changed the balance of power vis-à-vis port authorities; whereas terminal operations used to be a public or local activity, the last decades have seen the emergence of global terminal operators that have massively expanded, often at the cost of local operators and are now present in all large world ports. These less locally embedded operators could be expected to be less inclined to take local societal benefits or impacts into account. Global carriers have developed into important players with huge market power that are able to shift almost instantaneously their use of one port to another, which has occurred at several instances with considerable impacts on the local ports, as some of these large carriers might represent up to a quarter of local port traffic (Table 18). Moreover, these carriers have been able to impose costs of increased vessel sizes, such as dredging and hinterland infrastructure, to public authorities.

Table 18. Port use shifts by global carriers

From	To	Volume TEUs	Date	Carrier
Singapore	Tanjung Telepas	1000000	2005	Maersk
Gioia Tauro	Port Said and Malta Freeport	700000	2011	Maersk
Algeciras	Tanger-Med	500000	2010	Maersk
Ningbo	Busan	400000	2007	MSC
Tacoma	Seattle	180000	2009	Maersk
Barcelona	Tercat	130000	2009	Evergreen
Tercat	Barcelona	120000	2009	Maersk
Barcelona	Tarragona	70000	2009	ZIM
Seattle	Tacoma	n.a.	2012	Grand Alliance
Auckland	Tauranga	n.a.	2011	Maersk
Manzanillo	Lazaro Cardenas	n.a.	2004	Maersk
Valencia	Barcelona	n.a.	2007	China Shipping
JNP	Mundra	n.a.	2011	Hapag Lloyd

Source: own data collection based on articles in Port Strategy magazine

These developments are expected to continue. The average container vessel size doubled over last decade from average capacity of 2000 TEU in 2000 to more than 4000 TEU in 2010, a trend that is continuing with a current wave of new vessels up to 18,000 TEU coming into operation, which could enforce the process of port concentration. A process of port regionalisation is on-going in several countries, which will arguably spread out even more the employment and value added related to port activity. New emerging markets attract the interest of global port terminal operators, which might lead to a reduction of local embeddedness of ports in these countries.

The implications of these developments are increasing pressure on port-cities to illustrate that ports can continue to be an asset for urban development. With economic benefits increasingly spilling over to other regions and negative impacts highly localised and increasingly concentrated in line with port concentration, port-cities will be more and more confronted by existential questions that might erode its local support and “license to operate”. In this context, it is more than ever necessary that port-cities find ways to address the imbalances related to their port. How to make sure that the port creates value for the city? How to make sure that negative impacts are mitigated? How to get to a new balance of benefits and impacts? These are the questions that will be discussed in next chapter.

3. HOW TO FACILTATE COMPETITIVE PORTS?

How to facilitate competitive ports? That is the core question of this chapter, which has huge relevance to port-cities, as only well-functioning, competitive ports are able to create economic value. The three main determinants for competitive ports, identified here, are: extensive maritime forelands, effective port operations and strong hinterland connections. Long-term competitiveness of the port is also dependent on the support of the local population, necessary to sustain port functions in metropolitan areas.

Table 19. Overview policy instruments for competitive ports

Determinant	Instrument	Examples
1) Maritime connectivity	Transhipment	Singapore
	Nautical access	Deep sea ports
	Internationalisation strategies	Rotterdam, Antwerp
2) Port operations		
Quality of inputs	Skills mapping and matching	New York/New Jersey
	Training and education	Singapore
	Social dialogue	Antwerp
	Upgrading equipment	Hamburg
	Land availability	
Quality of organisation	Port planning	Rotterdam
	Port information systems	Valencia
	Competition	Most large ports
	Coordination between ports	Copenhagen/Malmö
3) Hinterland	Links port with other transport modes	Rotterdam
	Dry ports and extended gates	Gothenburg
	Freight corridors	Betuwe-line
4) Local goodwill	Port centres	Genoa
	Port education	Long Beach
	Maritime museums	Antwerp
	Port events	Rotterdam
	Information and social media	Incheon
	Public access to port	Hamburg
	Other goodwill projects	Valparaíso

Source: own elaboration

The schematic representation of policy instruments to facilitate competitive ports (Table 19) is based on an extensive literature on port choice. A competitive port is a port that is chosen more regularly than other ports, facilitating the growth of its market share. Port choice has been studied intensively over the last decades, in particular to assess what are the main actors determining port choice, and on the basis of which criteria. An overview of these different studies reveals that most of these studies identify shippers as the main decision-maker on port choice, followed by forwarders, shipping companies and terminal operators. The results of these studies heterogeneous (Table 20), with a large variety of port choice criteria identified in the different studies, but it is nevertheless possible to extract the draw some generic conclusions from all these studies. There is a growing tendency to consider port selection as involving several actors, instead of just one. In addition to a port's attributes, its integration in a wider set of criteria concerning global supply chains is of special importance (Magala and Sammons, 2008; Robinson, 2005; Bichou and Gray, 2004).

Table 20. Determinants of port choice

Decision maker on port choice	Port choice criteria (in order of importance)	Sources
Shippers	Costs, port operations quality, port location, frequency of shipping services, speed/time, service efficiency, port efficiency, port facilities, port information systems, hinterland connections, port congestion, port services, flexibility for special cargo	Slack (1985), Branch (1986), Murphy et al. (1992), Murphy and Daley (1994), Kumar and Vijay (2002), Nir et al. (2003), Tiwari et al. (2003), Malchow and Kanafani (2001), Malchow and Kanafani (2004), Song and Yeo (2004), Cullinane et al. 2005), Guy and Urli (2006), Ugboma et al. (2006), De Langen (2007), Leachman (2008), De Martino and Morvillo (2008)
Forwarders	Port efficiency, port operations quality, reputation, cost, frequency, location, speed/time, port information systems, hinterland connections	Slack (1985), Bird and Bland (1988), Murphy et al (1992), Tongzon (1995), Tongzon and Sawant (2007), De Langen (2007), Grosso and Monteiro (2008), De Martino and Morvillo (2008), Tongzon (2009)
Shipping companies	Cost, port location, port facilities, port operations quality, speed/time, port efficiency, port congestion, frequency of shipping services, hinterland links, port information systems, information availability, port administration, port services, flexibility for special cargo	Murphy et al. (1992), Lirn et al(2004), Ha (2003), Song and Yeo (2004), Shintani et al. (2007), De Martino and Morvillo (2008), Meersman et al. (2008)
Terminal operators	Port facilities, port operations quality, cost, location, hinterland connections, Port information systems, port congestion, port efficiency	Song and Yeo (2004), Acosta et al. (2007), Meersman et al. (2008), Wiegmans et al. (2008)

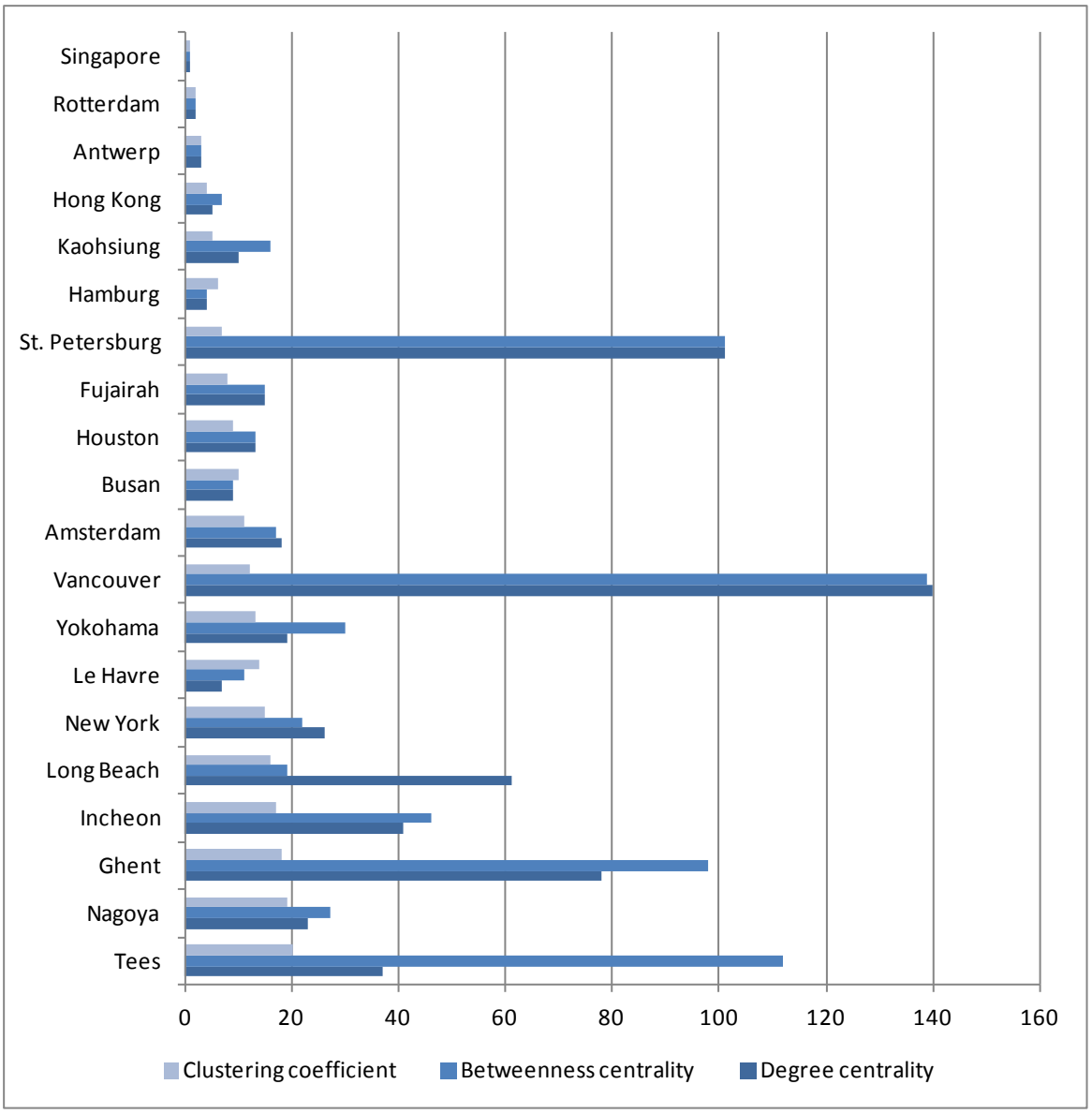
Source: Literature overview based on Aronietis (2013) and own compilation

3.1 Maritime connectivity

Maritime connectivity is essential for competitive ports as they determine the frequency of shipping services. Ports with more extensive maritime connections are more attractive to shippers as these ports can offer direct services and this speedier delivery of goods. If sufficient volume is shipped between these ports, frequency of shipping services and thus greater reliability can be guaranteed. If maritime forelands provide a competitive advantage for ports that can attract additional shipments, maritime connectivity is also a dependent variable: more competitive ports will be more attractive for various reasons (e.g. port efficiency or good hinterland connections), attract new traffic for that reason, and thus achieve more extensive maritime forelands. There are however also specific policy instruments to increase maritime connectivity, that will be discussed below.

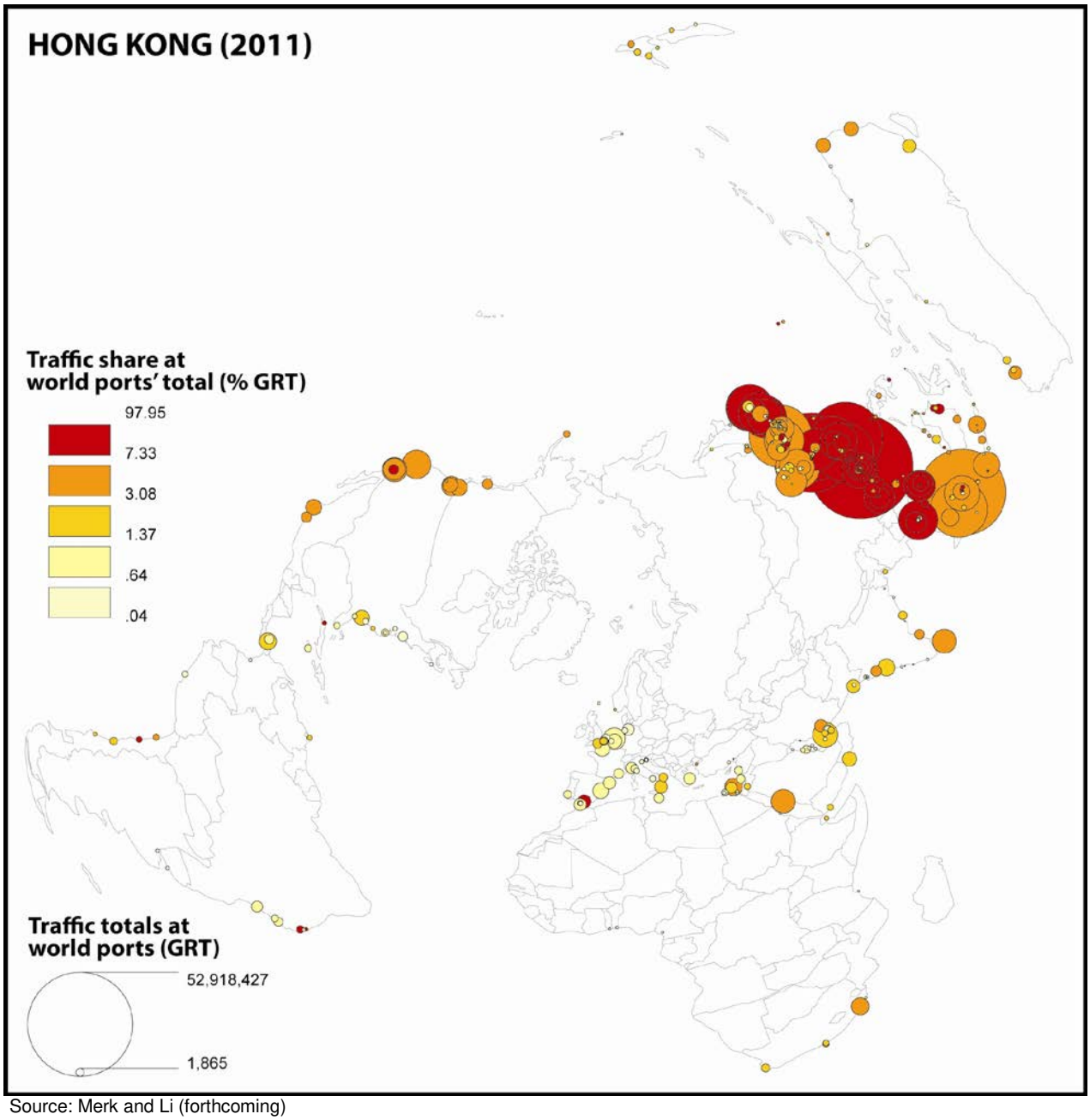
Maritime connectivity not only refers to number of connections with other ports, but also the place of a specific port in networks (centrality). There are various indicators to measure port centrality, including degree centrality, betweenness centrality and clustering coefficient. Larger ports are generally more connected and more centrally positioned in maritime networks, which is logical, but there is not a perfect correlation between size and port centrality; some large ports manage to be much more connected than other ports of similar size (see Figure 17 for the most central ports in the world). Ports that are closely located to each other can have the same profile of maritime connections, as is the case of Hong Kong and Shenzhen (Figure 18-19), but also be complementary to each other with respect to maritime connections. For example, the port of Hamburg has strong maritime connections with Asia, whereas the nearby port of Bremerhaven has strong maritime connectivity with North America, which provides synergies between the two ports (Merk and Hesse, 2012).

Figure 17. World port ranks on centrality measures (2011)



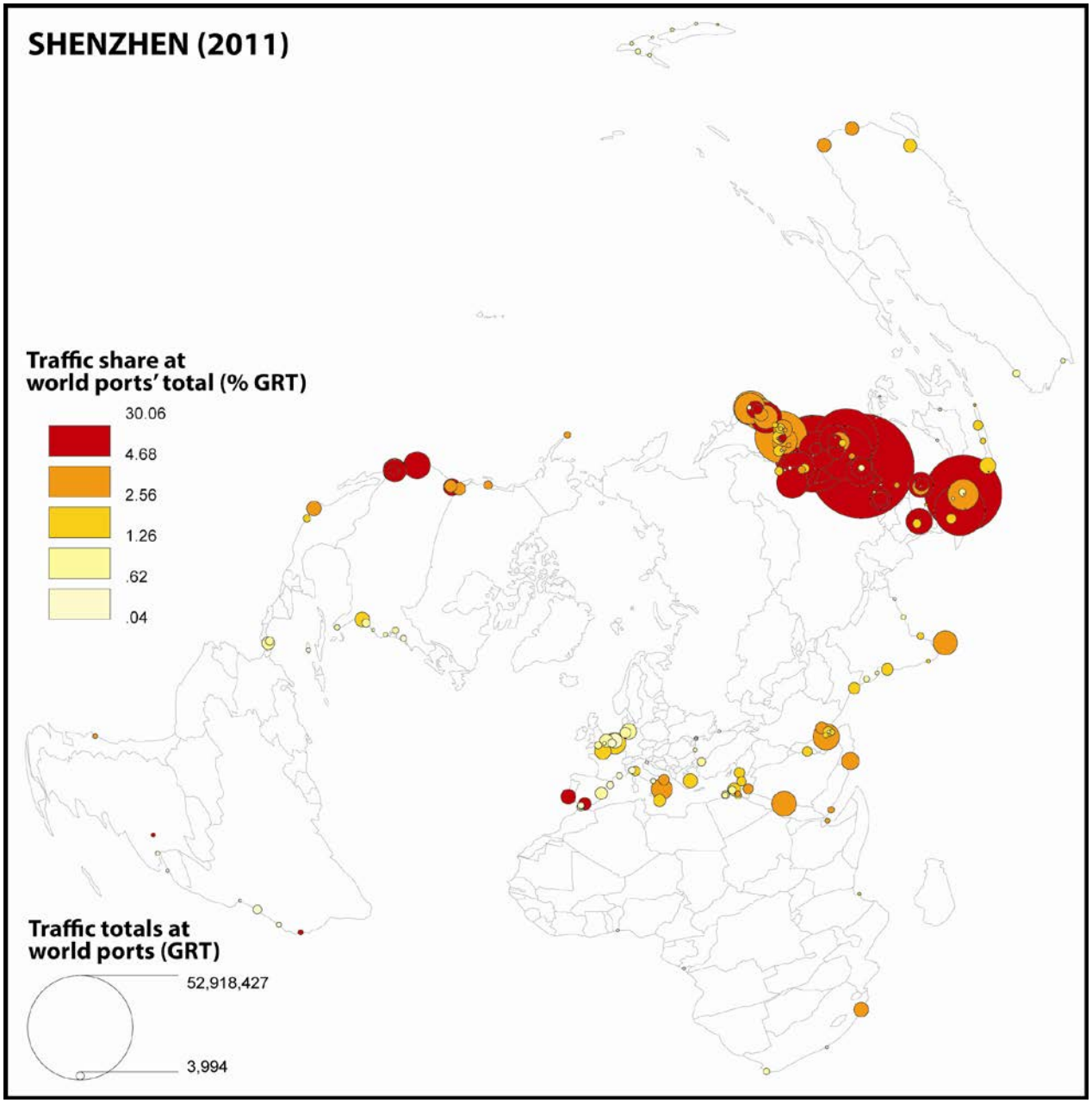
Source: Author's own elaboration based on dataset from Lloyds Marine Intelligence Unit (2011)
Note: the horizontal axis indicates the port rank on the three different indicators. Degree centrality expresses the number of adjacent neighbours of a node; it is the simplest and most commonly accepted measure of centrality. It often correlates with total traffic (more connections imply more traffic). Betweenness centrality expresses the number of shortest paths going through each node. The clustering coefficient estimates whether the adjacent neighbours of a node are connected to each other (i.e. "my friends are also friends"), thus forming triangles (triplets); the coefficient is the ratio between the number of observed triplets and the maximum possible number of triplets connecting a given node.

Figure 18. Maritime forelands of Hong Kong and Shenzhen (2011)



Source: Merk and Li (forthcoming)

Figure 19. Maritime forelands of Hong Kong and Shenzhen (2011)



Source: Merk and Li (forthcoming)

Transshipment provides a way for large ports to increase their maritime connectivity. Most ports of large port-cities are gateway ports, that is: most of the port traffic serves the metropolitan area and its hinterland. Some ports at strategic locations – close to main shipping routes - have developed in pure transshipment ports, that is: ship to ship traffic and limited interaction between maritime and land transport. Gateway ports can also perform transshipment functions to a more or lesser extent. These functions are generally less interesting for the port-city as they do not generate a lot of value added, but

take up port capacity. However, because of the lumpiness of port infrastructure and equipment, many ports are not at their optimal utilisation rate; transshipment could help to reach a more optimal utilisation rate whilst it also helps to increase maritime connectivity, as it can facilitate a network of connections that would otherwise not be sustainable.

Good nautical access is essential for maritime connectivity of ports. Over the last decades, ships have rapidly become bigger and deeper: e.g. the draft of the largest container ships at this moment is approximately 14.5 meters, which is deeper that most ports can accommodate. Port depth thus becomes a competitive advantage for attracting the largest ships and a challenge for many ports that are estuary ports and that have no direct deep sea access. E.g. the biggest containerships are currently able to call at the port of Hamburg only within certain high tide time slots. For this reason, many ports are engaged in dredging port berths, access channels and indeed whole rivers in order to ensure sufficient depth. The on-going expansion of the Panama Canal has provoked a wide interest of US East Coast ports in port dredging. However, concerns on the environmental impacts of dredging make it a challenging undertaking for many ports. Various recent new port development projects are off shore ports on reclaimed land, in order to ensure sufficient nautical access.

Ports can increase maritime connectivity by engaging in internationalisation strategies. Ports traditionally market themselves vis-à-vis shipping lines, freight forwarders and shippers, which is self-evident considering their large roles in port choice. However, some ports are increasingly focusing on cooperation with ports in emerging markets. The port of Rotterdam has financial participations in the ports of Sohar (Oman) and Suape (Brazil), where Antwerp has similar participations in Duqm (Saudi-Arabia) and India. Other forms of cooperation with ports in emerging markets include consultancy and training provided by the port authority or one of its subsidiaries, for example Port of Antwerpen International (PAI) and Port of Rotterdam International (PORint). Some of these cooperation arrangements seem to be based on links from the past, e.g. partnerships of the port of Rouen with West-African ports (Merk et al. 2011), but such partnerships could well be transformed into occasions for attracting traffic from these regions. The financial participations of the port of Rotterdam in the port of Sohar has been observed to have generated “strategic value” for the maritime cluster in Rotterdam, as it facilitated market access of maritime service providers, such as dredgers, from Rotterdam into Oman (Van den Bosch et al. 2011).

3.2 Effective port operations

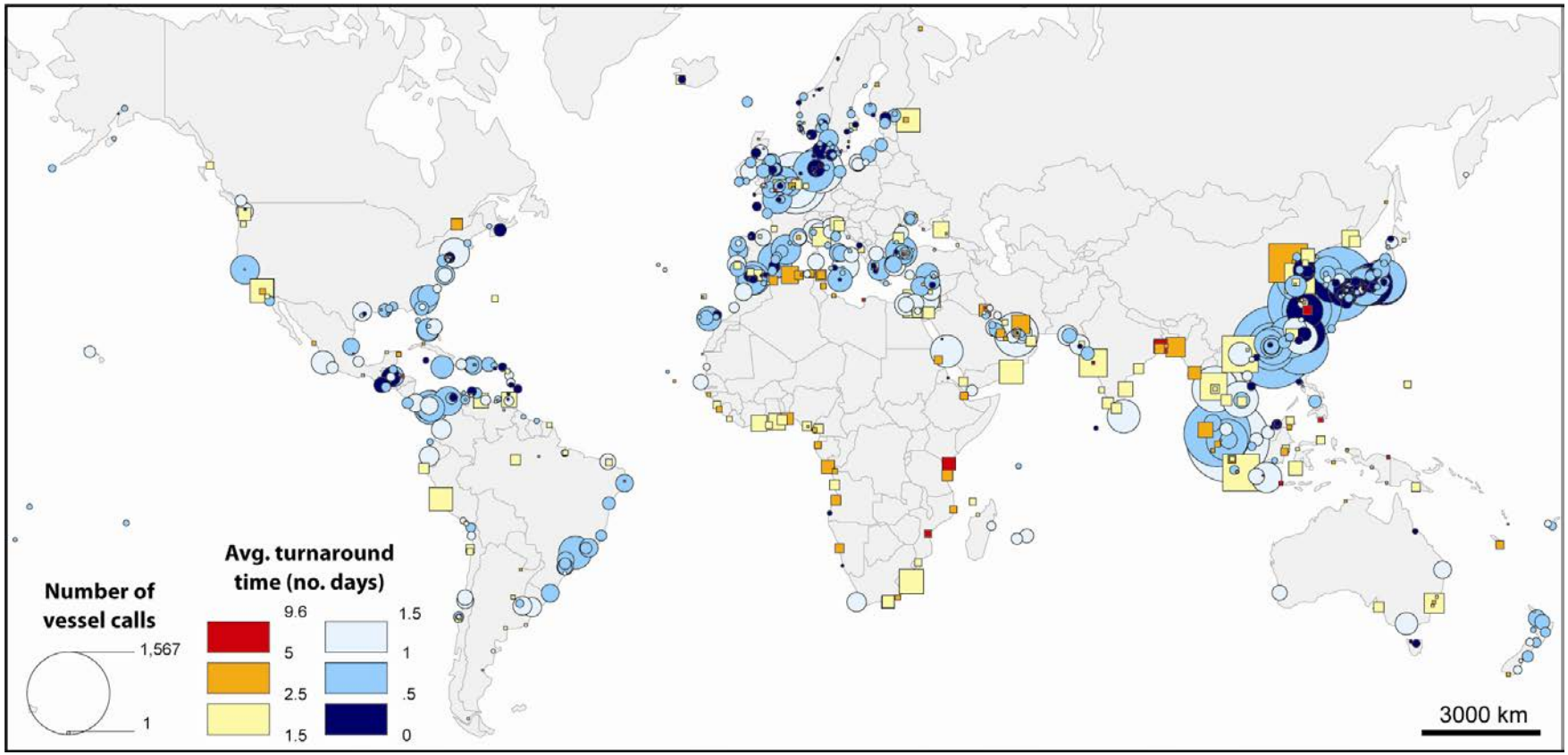
There are various performance indicators for port operations, that all provide part of the picture of port performance. Main performance metrics exist on the level of cranes, berths, yards, gates and gangs, both in terms of utilisation rates (such as TEUs/year per crane, vessels/year per berth, TEUs/per year per hectare, and containers/hour per lane) and productivity (moves per crane-hour, vessel service time, truck time in terminal and number of gang moves per man-hour). These statistics are collected and sold by specialised consultancies; their databases indicate that on average in large port terminals the following performances are reached: around 110,000 TEUs handled per crane, 25-40 crane moves per hour, a dwell time of import boxes of 5-7 days and export boxes of 3-5 days. Performance benchmarks on terminals other than container terminals are rarer.

A large number of port efficiency studies exist, but these studies also have their flaws. Academic research has focused on port performance from the angle of port efficiency: how many throughputs (tonnes or TEUs) are reached using similar inputs (such as cranes, quay length and terminal surface). Most of these studies use DEA- or stochastic frontier-approaches, and almost of all these studies focus on container ports or terminals, with the notable exception of Oliviera and Cariou (2012) that also look at ore and coal terminals and Merk and Dang (2012) that include oil, ore, coal and grain. Although port efficiency studies have their merits in terms of appreciating the value for money of port terminals, they also have their flaws and tend to be misinterpreted. As most of these studies look at outputs and inputs in one particular year, the

results in other years can be quite different considering the lumpiness of port terminal investment. Moreover, port equipment is in almost all these studies considered a proxy of labour, which ignores differences in labour productivity between ports that can be assumed to be substantial.

A relatively balanced assessment of port performance can be given by looking at vessel turn-around times in ports. This is the average time that a vessel stays in a port before departing to another port, which is known through detailed vessel movement data, as collected by Lloyd's Marine Intelligence Unit (LMIU). This turn-around time is generally considered to be an important determinant of port competitiveness as quick turn-around allows for reduction of port congestion and larger port throughputs. An overview of average turn-around time per port is provided in Figure 20. The most time efficient ports can be found in East Asia, Europe and the Caribbean, whereas the least time efficient ports are located in Africa and South Asia (including India). An assessment of vessel turn-around times over time illustrates the rapid increases in time efficiency of Chinese ports; still very inefficient in 1996, these ports have become among the most time efficient ports in 2006 and 2011. When analysing vessel turn-around times in different ports world-wide, it becomes evident that there is an important national factor to this, as many ports in the same country have more or less the same vessel turn-around times (Ducruet and Merk, 2013).

Figure 20. Average turn-around time (in days) of ports in the world, May 2011



Source: Ducruet and Merk (2013)

The general picture arising from all these port performance indicators is fairly consistent: ports with the most effective operations seem to be located in South East Asia, the Far East, Middle East and North-West Europe. A few examples to illustrate this: the average crane productivity in 2009 was 136,531 TEU per crane per year in the Middle East, 124,581 in the Far East and 119,276 in South East Asia; the lowest scores were reached in Eastern Europe (56,063) and North America (71,741) (Drewry, 2010). The top 10 ports in terms of berth productivity in 2012 were located in China, United Arab Emirates, Malaysia, South Korea, Oman and the Netherlands (JOC, 2013). Many Chinese ports can be identified among the more efficient in port efficiency studies, whereas the Far East ports score very high with respect to time efficiency (Ducruet and Merk, 2013).

How can effectiveness of port operations be explained? What are the determining factors for having an efficient port? Based on our review of literature and survey among a wide range of actors in worldwide ports, we assume that effective port operations are dependent on the quality of inputs and the quality of organisation and institutions. Both building blocks for effective port operations are discussed below.

a) Quality of inputs

Effective port operations depend evidently on the quality of the inputs needed for port operations: labour, equipment and land. Port operations are generally capital-intensive and land-intensive and have become less labour-intensive. However, labour continues to be an important production factor, even in automated terminals. Containerisation and increased economies of scale in shipping have underlined the importance of equipment and large port lands.

Labour

Labour is an important production factor for port terminals. Labour costs can account to more than half of the operating costs of port terminals. The share of labour costs in total operating costs ranges from 15%-20% in dry bulk terminals, to 40%-75% at general cargo terminals and 50%-70% at container terminals (Barton and Turnbull, 2002; van Hooydonck 2013). This translates into considerable labour costs per goods shipped. The average labour cost is close to USD 200 per container shipped in Los Angeles. These labour costs are only to a limited extent sensitive to market fluctuation: the labour costs to box costs is non-negotiable because of the duration of the terms negotiated with the trade unions, usually six years in the case of ILWU, the dominant trade union at the US West Coast (Kelly and Agnone, 2009). An efficient labour force is an important port choice determinant for shipping lines and terminal operators. Jaffe analysed how in the case of Jaxport (Florida) labour-management conflicts between the trade union ILA and the shipping lines Mitsui/Tra-Pac and Hanjin were important factors in the selection decisions of terminal operators and global shipping lines, with make-or-break threats to take cargo elsewhere along the East Coast (Jaffee, 2010).

The fundamental challenge of port labour markets is the irregular demand for workers, determined by the irregular arrival of ships in the port. In addition, port work can be more or less seasonal; traffic flows in ports often depend on the time of harvest of agricultural products such as grain, cotton and fruit (van Hooydonck, 2013). However, the irregular character of shipping has changed over time. Containerisation has facilitated the enhanced accuracy of ship sailing schedules, reducing the irregularity and unpredictability of employment (Haralambides, 1996). Demand for port workers has in many container ports become relatively stable and predictable, but work remains large irregular in bulk ports and small ports. The irregularity of demand is solved by overtime, extra shifts, but also by casual workers that supplement the core workforce; these casual workers may be port pool workers, workers temporarily hired out by other cargo handling companies, workers supplied by sub-contractors, temporary agency workers or occasional workers. In most cases, these casually employed workers enjoy no income guarantee (van Hooydonck, 2013).

As a response to the casual nature of port employment, various controls on the free market system have come into place in ports, also referred to as dock labour schemes. These systems attempt to control labour supply, ranging from union hiring halls (e.g. US West Coast, to worker cooperatives (e.g. Italy), state-mandated registration schemes (e.g. Belgium), mandatory labour pools and other measures that could be considered restrictions on employment, such as prohibitions on permanent employment, prohibitions on self-employment, the requirement of union membership and nepotism (Turnbull 2012; van Hooydonck, 2013). These practices continue to characterise port labour markets, even if the casual nature of port employment has decreased. E.g., in Germany and the Netherlands, employers are able to hire permanent company employees directly from the external labour market, but any additional (casual) labour must be hired from a state-regulated labour pool, which in both countries is a stronghold of union organisation (Turnbull and Wass, 2007). Fifteen out of 22 EU member states have some kind of port labour pool system, and in eleven of these pool workers have preferential rights (van Hooydonck, 2013). The differences between ports in this respect can be large, even between ports that are similar in many other aspects: the share of workers in labour pools in the port of Antwerp was 62% in 2000, but only 14% in Rotterdam (Smit, 2013).

Over the last decade, port employment has undergone large changes. The port industry has become less labour-intensive, because less focused on break-bulk handling and more on specialised operations. As a result, port workers became more multi-skilled and specialised, with more formalised training that replaced part of the former informal on-the-job training. Permanent employment became more dominant in an industry characterised for a long time by casual hiring. The port workforce diversified, less dominated by males; in Valencia 12% of the port labour pool consists of women (ILO, 2012; Turnbull 2011). Ship operators increasingly expect a 24/7 service, which means that staff is employed on flexible working schedules. Continuous working via individual rather than collective breaks, flexible start times, variable shift lengths and weekend working have all figured prominently in contract negotiations over the last decades (Turnbull and Wass, 2007). In return for uninterrupted and efficient cargo handling, port workers world-wide received guarantees of high wages and regular pay, regardless of fluctuations in the need of dock labour, although port privatisation has sometimes also increased the vulnerability of port workers, illustrated by the case of Port Klang in Malaysia that mainly employs semi-skilled and unskilled migrant workers from South Asia(Hill, 2012).

Containerisation and information technologies have changed the content of port labour. Many functions formerly performed at port sites have been consolidated in back-office computer laboratories or shifted to locations outside the traditional port premise. The skill-sets of the port workforce have been restructured and a blurring of the white collar/blue collar distinction has taken place. This restructuring corresponds to a rebalancing of job content in the whole logistics sector, with a shift from physical handling of goods to the organisation of work via automation and electronic information systems (Butcher, 2007). Some of the jobs that remain in ports have experienced contraction, routinisation and work intensification. An integrated form of managing the labour process has been created, which leads to situations where the exercise of control becomes opaque, as is illustrated by a study on managerial control at the port of Melbourne and Port Botany, Sydney (Gekara and Fairbrother, 2013). The restructuring of labour taking place in many ports has resulted in a smaller and more diversely skilled workforce, with port management increasingly seeking to recruit those working with advanced technologies from outside the port.

There are a considerable number of skills gaps in the port and logistics sectors. A study on future skills needed in the transport and logistics sector identified a substantial number of changes in competences that would be required in shipping and logistics; ranging from 18 for ship officers, 21 for sea transport managers and 26 for business and finance professionals, out of 29 main competences identified

(Davydenko et al. 2009). Thai (2012) identified 65 essential competencies for port personnel, partly based on surveys with port personnel in Singapore and Vietnam, that go beyond competencies in port operations and engineering, but also include a wide scope of other competencies, including management and business skills, and logistics competencies.

A growing number of ports and terminal operators offer elaborate training programmes for new entrants and existing workers to adapt to these new realities of port work. The Eurogate-terminal in Rotterdam introduced semi-autonomous team working, abolishing the old gang-working and supervisory system, with multi-skilled teams that must ensure that two cranes are available and operational at all times throughout the shift. 90% of the company's dockers can now perform all tasks on the container terminal. Another container terminal in the port of Rotterdam, ECT, spent up to 10% of its annual turnover on training to ensure than all of its port workers can now undertake up to four different jobs on the container terminal and the company's collective agreement provides for "functional combinations" of two or three jobs to be performed within the same shift (Turnbull, 2012).

However, port training is often found to be insufficient. An investigation of port training systems of new EU member states identified important training challenges related to meeting customer needs, and safety and security (Casaca, 2006). Another study found that the majority of port workers in the dry bulk sector receive little or no training to work in the operating conditions they encounter, despite the challenging and hazardous nature of working onboard ships and within stockyards (Martin et al. 2011). However, there is a large difference between ports in terms of training and education offered to port workers (De Langen, 2008).

In many ports, recurrent strikes and other forms of industrial action have caused significant delays for shipping. Current port strikes rarely approach the 134 days duration attained in the 1971 US West Coast strike, but frequently last for several weeks (Table 21). Even in countries with few port strikes, the relative share in total national shares can still be relatively high. This relative share of port strikes was exceptionally high during the whole of the 20th century and beginning of the 21st century in the Netherlands, with the most recent share of port strikes (in total national shares) reaching 13% (Smit, 2013). The costs of such strikes can be large. The costs of the 2002 eleven-day lockout of US West Coast ports were calculated at USD 2 billion a day, a figure contested by Hall (2005) as such calculations it does not take into account the possibilities for substitution in distribution and production. But even if the strike costs would be a fraction, they can still considered to be non-negligible: the foregone direct and induced effects of cargo handling activities would amount to USD 70 million a day. Barzman points at the importance of the way strikes are communicated, citing union leaders who suggest that it is not strikes, considered to be relatively light and short, that are at the root of French port decline, but the strong anti-strike communication in France, in comparison with Rotterdam and Antwerp, where port leaders are discrete about strikes that take place (Barzman, 2012).

Table 21. Labour strikes in a selection of seaports

Seaport	Period	Duration
Hong Kong	March-May 2013	40 days
Chile	March-April 2013	3 weeks
Marseille	November-December 2010	33 days
Durban	May 2011	17 days
Sokhna	February 2013	16 days
Karachi	December 2012	11 days
Auckland	February-March 2012	

Source : own data compilation

Unions had and continue to have a large impact on port labour systems. Dockworkers of 2010 have little in common with those of the 1950s or 1930s, except for a culture that continues to form the basis of a collective identity in which trade unionism is still very much a live force according to Pigenet (2012). Political and economic structures of place can outlast those who initially created them, providing a pool of tradition and resources on which workers can draw (Carmichael and Herod, 2012). Militancy in Merseyside (England) has been sustained over tile, even as industrial restructuring has devastated employment on the docks and in the region's car plants from which it initially emerged Darlington, 2005). How unions can determine the outlook of port labour can be illustrated by the different pathways of the ILWU on US West Coast and ILA on the US East Coast. The ILWU developed a strong and cooperative dock regime based on participatory democracy and union capture of hiring, which enabled union leadership to effectively negotiate with members and employers. In contrast, the ILA developed a weak and non-cooperative dock regime based on localist politics and no capture of hiring, making it hard for union leaders to negotiate effectively. These different pathways have led to different outcomes: the ILA has a loose master contract and weak local contracts, has lost control of certain technologies and jurisdiction and is a weak bargaining force, according to Kelly (2008). This had an effect on port workers' earnings. Although dockworkers on all three US coasts are the notable exception to the trend that port-logistics workers in large port-cities do not achieve higher annual earnings than otherwise comparable workers, this is particularly the case on the US West Coast where residence in one of the large port-cities is correlated with additional significantly higher earnings, benefiting – among others – from strong bargaining power of unions (Hall, 2009).

Globalisation of port terminals and shipping has led many to call for a reconstituted scale of collective bargaining, transcending national boundaries, as is for example the case with the cross-national maritime trade union Nautilus International (Carmichael and Herod, 2012). The union campaigns against the EU Port Services Directives proposed in 2001 and 2004 demonstrated that they can divert the course of European policy-making if they project their domestic claims onto international organisations and foreign actors (Turnbull, 2010).

Equipment

Good port equipment is a minimum requirement for effective port operations. This means well-maintained port infrastructure, such as quays, access channels, seawalls, warehouses, and road and railway connections on the port site. In addition to the port infrastructure, there is also the port superstructure, such as ship-to-shore-cranes and the equipment for the terminal yards, such as rubber-tyred gantries deployed in half of world's container terminals, rail-mounted gantries or straddle carriers, mainly in European terminals. The equipment required is fairly specific according to the type of cargo. Whereas most of the cargo in the past was loaded or unloaded with general cargo cranes, the equipment has become more specific. Containers are loaded/unloaded with container cranes, liquid bulk with pipelines and dry bulk with elevators, loading and unloading arms. Ro-Ro traffic needs a Ro-Ro ramp and only cruise ships need relatively little equipment. Every cargo type has different requirements for storage: liquid bulk in tanks, dry bulk in warehouses, silos or stockpiles, refrigerated cargo in refrigerated warehouses or reefer plugs (if transported in reefer containers).

The quality and capacity of equipment has a direct relation with port efficiency. More and larger pipelines, can load/unload more liquid bulk at a time, as is the case for other cargo types. Container cranes come in different types, depending on the ship that it will be serving. Whilst container ships are categorised according to the straits that they can still navigate, container cranes have a categorisation that mirrors this to some extent, with the reach of the crane as one of the main distinguishing factors: a Panamax crane can load and unload containers from a container ship capable of passing through the Panama Canal (ships 12–13 containers wide), a Post-Panamax crane (for ships too wide to pass through the Panama Canal) has a

maximum reach of 18 containers wide, whereas the largest modern container cranes, the Super-Post Panamax are suitable for vessels of about 22 or more containers wide. The most modern container cranes are able to lift several containers at the same time via double lift or tandem lifts, so their throughput per lift is higher than other cranes. Vessel turn-around time will be higher the more cranes can be used per ship (although there are decreasing marginal returns) and yard efficiency will be higher the more yard equipment can be employed.

At the same time, considering the cost of all this equipment, port terminals attempt to optimise the capacity of their equipment in relation to the projected peak cargo flows. This optimum is in practice difficult to reach and not always possible to steer. Industry intelligence shows that a yard occupancy ratio of around 70% will allow terminals to work at maximum efficiency, while working consistently above this threshold will reduce efficiency. Similarly, the optimum level of berth occupancy for a container terminal is estimated at around 65%; beyond this point ship queuing tends to increase significantly and service quality to drop. Dedicated terminals with tightly scheduled ship arrivals can achieve higher berth occupancy levels without congestion, whereas common-user terminals with a more mixed ship arrivals pattern reach their congestion point at a lower berth occupancy level (Drewry, 2010)

The continuous increase of ship size necessitates a regular upgrading of port infrastructure. Most ports anticipate to some extent the increasing economies of scale in shipping, but developments go fast. Over the last decade the average size of container ships in operation has doubled. This has had large impacts on the container handling equipment needed in ports. In July 2013, Maersk took into operation the first Triple E-ships with a capacity of 18,000 TEUs, the largest container ship currently in operation. This ship is 23 containers wide and can be handled by Super-Post-Panamax cranes, which are available in some large world ports, but certainly not a majority. These ships will not call in ports that do not have the equipment to handle these. If ship size increases to 20,000 or 25,000 TEU, as predicted by some observers, would be realised, a new round of upgrading of container cranes would be needed even in the most well-equipped ports of the world. Similar tendencies are occurring in other segments, such as bulk carriers and cruise ships, requiring upgrades in port terminal infrastructure and superstructure.

Table 22. Overview of automated container terminals

Seaport	Terminal	Year of introduction	Type
Rotterdam	ECT	1993	Automated
Hamburg	CTA	2002	Automated
Tokyo	Wai Hai	2003	Semi-automated
Kaohsiung	Evergreen	2006	Semi-automated
Rotterdam	Euromax	2008	Automated
Busan	Han Jin	2008	Semi-automated
Taipei	Taipei Port	2009	Semi-automated
Busan	PNC	2009	Semi-automated
Kaohsiung	Yang Ming	2011	Semi-automated

Source: own elaboration based on Yang and Shen (2013)

To some extent there is a trade-off between labour and terminal equipment. A few port terminals have been automated, in Rotterdam and Hamburg. At such terminals, automated guided vehicles (AGVs) are used to transport containers between quayside and yard side, and the stacking of containers is performed using automated stacking cranes (ASCs). Some ports in countries like Korea and Taiwan have adopted semi-automated container terminals, in which the stacking process is automated but not the transport between quayside and yard side, done by trailers (Table 22). The investment needed for automated terminals is higher than for traditional terminals, but the profitability, quality, safety and environmental performance is all considered to be higher than traditional terminals (Yang and Shen, 2013). Drewry (2010) confirms that automated terminals perform better than the world average (in terms of TEU per metre of quay per year, TEU per crane and TEU per hectare), but notes that they do not achieve similar

performance as large terminals in general. Automation of container terminals leads to an optimisation of the workforce, which implies the replacement of various relatively low-skilled jobs with a few high-skilled supervision jobs. They key justification for automation could be to reduce labour costs in high-wage environments. In countries with low wages, it is usually cheaper and more efficient to remain non-automated according to Drewry (2010).

Land

Modern port terminals require a relatively large amount of land. At the minimum, a functional container port terminal would need a few berths for handling various ships at the same time, a quay side for ship-to-shore operations, a container transfer area, a storage area, an area for delivery and receiving, connected to road and rail lines, a depot for empty containers, a customs area and a truck waiting area. In many cases, logistics activities, such as distribution centres, would also take place in or around the port area. In addition, various ports also locate industries that benefit from the proximity of the port. Most large modern ports take up thousands of hectares, depending on their exact functions and characteristics.

The land intensive character of ports is related to containerisation and increasing ship size. The history of shipping is characterised by a continuous search for reducing costs, resulting in economies of scale, containerisation and continuously increasing ship sizes[8]. This has radically transformed ports and waterfronts over the last decades. Traditional port pier-structures became un-functional and were abandoned and left for other use, or were filled in to create larger terminals, with longer quay length and larger temporary storage space. In many cases new terminals are built further away from city centres, with less space constraints.

b) Quality of organisation and institutions

The quality of input factors, presented above, is in itself not sufficient for effective port operations. These inputs also need to be organised in a smart way, so their successful application is determined by the quality of organisation and institutional arrangements. This organisational quality includes planning, port information systems, competition and coordination between ports.

Port planning

Good port planning can have an important impact on port performance. There are various aspects to this. Port master plans describe the main functions of the port, their location and inter-relations; these plans should indicate where new traffic will be allocated and which actions are required to achieve this. Such a master plan forms the basis of detailed planning on various different levels, such as berth allocation planning, yard planning, traffic planning within the port area, planning of intermodal operations, lock operation planning and planning related to tidal conditions in estuary ports. All these elements should be aligned in order to realise smooth port operations. The gains of sound port planning can be considerable; e.g. the differences between good and bad yard planning in similar conditions can have an impact on handling time of about 30% according to De Koster (2013).

In addition, several ports are engaged in long term strategic planning. Such long-term engagements are expressed in strategic visions that are to a more or lesser extent publicly available. These visions, which can take a time horizon of several decades, can identify new directions of development, prioritise investments and identify future bottlenecks. If well designed, the strategic planning process can help to engage main stakeholders, strengthen links with clients and create local goodwill. Long term planning is most effective when these long-term visions somehow act as a catalyst for innovation and new

perspectives. In order to achieve this, the planning horizon of these strategies would need to be far away (Table 23), targets should be flexible and embedded in different scenarios, and the vision would somehow need to be imaginative rather than technocratic. In order to realise these long-term strategic visions, they would need to get translated in operational plans, and regularly updated and revised.

Wide stakeholder involvement in such a shared vision is essential, along the lines of long term strategic planning in Rotterdam. Port Vision 2030 of the Port of Rotterdam, adopted in 2012, was much less focused on targeting future throughputs, but much more imaginative on how the port of the future could look like based on a comprehensive assessment of a variety of trends that could change the role of ports. With respect to port volumes, it actually described a range of scenarios, emphasising the flexibility that would be needed to be forward-looking. One of its main observations was the changing European landscape of energy production (rationalisation of refineries) and the ambition to be, in close cooperation with Antwerp, the main petro-chemical and energy hub in Europe. However, the most important accomplishment of the Port Vision 2030 might be the process of stakeholder consultation and engagement used to establish the vision, which not only informed the port authority of challenges perceived by its clients and stakeholders, but that also created a form of buy-in of these stakeholders in the strategic vision of the port.

Table 23. Ports with long term strategic visions

Seaports	Timeframe
Hamburg	2012-2025
Melbourne	2009-2035
New York/New Jersey	2005-2020
Rotterdam	2011-2030
Vancouver	2010-2050
Liverpool (Peel Ports)	2011-2030

Source : own data compilation

Port information systems

Port information systems facilitate data sharing among actors in the port community. Such port community systems (PCS) are one of the important determinant factors for port choice by various port users, such as shippers, shipping lines, forwarders and brokers, as well as transport operators (Keceli et al, 2008). A PCS can be defined as a neutral and open electronic platform that optimises, manages and automates smooth port and logistics processes through a single submission of data, enabling intelligent and secure exchange of information between public and private stakeholders (EPCSA, 2012). These systems are firstly set up for the purpose of eliminating, as much as possible, the number of paper documents and clerical work that are used during port operation (Long, 2009). The goal is to streamline the procedures and reduce manual errors through a synchronised and integrated program. The increase in transport capacity, especially for containerised cargo, requires immediate data exchange on location and status of the cargo. In this sense, port information systems can ensure the flow of information in an accurate and timely manner by allowing for simple and smooth administrative procedures, thereby increasing the handling speed and improving operational efficiency at the port. They can also help to avoid the redundancy of data input, improve data quality and integrity, and support port management operations (Vincent, 2003; Zygus, 2006). At the same time, information systems are used to automate the security and control operation, such as customs and inspection. Moreover, the development and application of technologies like radiation detection and radio-frequency identification (RFID) can greatly improve the productivity for operation and provide accurate information to all relevant port users.

The fundamental prerequisite of a successful port community system is the participation of all relevant actors involved in the port community and the integration of information systems into one comprehensive network system. It is essential to establish common goals and reach consensus for a shared

action plan among the members within the port community to achieve the desired development of a PCS (Long, 2009). By providing a proven and effective means of information exchanging, the application of Port Community Systems (PCS) has been widely adopted by many ports in the world. Using the Electronic Data Interchange (EDI) technology, various local Information Technology (IT) systems can be integrated within a PCS to simplify, standardise and accelerate efficient interactions between different port communities and responsible government authorities on institutional communication and processes. The sophisticated information systems of the Port of Singapore Authority have contributed to improved cargo handling capacity, making the port of Singapore one of the most efficient ports (Lee-Patridge et al, 2000).

Implementation is in practice driven by three different actors: national government, the port community and port authorities. The first category of projects is driven by the national government initiatives or national customs project, where the PCS are initially considered to be a form of the "National Single Windows" and an important component for eGovernment process. KL Net in Korea was created under one of the initiatives led by the Ministry of Land, Transport and Maritime Affairs in South Korea to bring in standardisation in documentation formats to 30 ports in the country. The second driving factor is related to the logistics community. Some PCS are established on the basis of a "consensus" within the logistics sectors to improve the operational efficiency in ports, such as gate operation at terminals. Later on, these PCS can be extended to a regional or even national level to create a unified application for the logistics community in order to cope with their needs for operating in multiple ports. For instance, the AP+ in France and destin8 in the UK are two nationwide PCS adopted by ports in each country. The third type of PCS initiative is spearheaded by the local port authorities as an element of the port's strategic plan. It is conceived as a means to enhance the competitive edges for the port as opposed to others. The PCS in Spain is an example where each main port has established its own information system, whereas the Portbase system developed by Port of Rotterdam is actually a joint outcome in cooperation with the Port of Amsterdam (IAPH, 2011). The Port of Valparaíso (Chile) has developed two platforms for the local port community: the "Foro Logístico Valparaíso" (FOLOVAP) and SILOGPORT, a digital platform that allows the exchange and dissemination of information in various stages of the logistics process.

As ports are increasingly linked to dry ports and inland terminals, data sharing should also extend to these places. A more comprehensive port community system that connects and integrates maritime, port, and landside operation collaborating at a broader scale is recommended to further promote seamless cargo movement, achieve cost reduction and potentially enhance the competitiveness for more users. In addition, it provides opportunities to diffuse the best practices it by having more ports, including inland terminals, integrated in a wider system. The Port of Valencia has established a PCS that not only provides services related to maritime transactions and shipping companies on the basis of the existing core port operations, but also incorporates inland and rail transport services (Garcia de la Guia, 2010).

Competition

There are indications that intra-port competition improves port performance. This refers to a situation where two or more different terminal operators within the same port are vying for the same market. This competition provides benefits because it prevents monopolistic rent seeking of port service providers and because it is a means to achieve economies of scope and flexible multi-service organisation structures (De Langen and Pallis, 2005). Internationally based stevedore companies have been found to have a positive impact on the efficiency of container terminals, but not port operators driven by global carriers, such as CMA-CGM and MSC (Cheon, 2009). At the same time, there are barriers to entry in the port sector: a survey of 28 European ports in 2004 showed that there was only one service provider of container handling services in almost half of the ports surveyed (De Langen and Pallis, 2007). Intra-port competition can be limited by relatively long terminal concessions. Although there is no accepted rule of thumb about the duration of concessions in the port sector, there is agreement that the duration of the concession will vary according to the amount of investment required. Port authorities have several reasons to aim at relatively

short concessions: to maximise revenues, to reduce entry barriers and to optimise the possibility of port redevelopment. When the length of concessions is long, concession holders will seek compensation if they are affected by port re-development (Pallis *et al.*, 2008). Port authorities try to find a balance between a reasonable payback period for the investments made by terminal operators on the one hand and the maximum chance of attracting potential newcomers on the other (Theys *et al.*, 2010).

Table 24. Presence of four largest global terminal operators in world ports (2012)

Number or large global terminal operators	Port
Two	Antwerp, Sydney, Brisbane, Chennai, Dammam, Guangzhou, Ho Chi Minh City, Marseilles, Le Havre, Qingdao, Shanghai, Xiamen, Zeebrugge
Three	Busan, Hong Kong, Rotterdam, Xingang
Four	Buenos Aires, Laem Chabang

Source: calculations and elaborations of OECD secretariat based on data of global terminal operators

Coordination between ports

Ports of all sizes increasingly recognise that some degree of coordination with other ports can enable increases in efficiency and supply chain integration that, far from reducing competition, in fact increase ports' competitive standing. The impetus to increase coordination among ports has in part been driven by their changing role within global supply chains, whose structure they no longer determine alone. The rise of Global Terminal Operators and vast shipping networks has diminished the individual capacity of ports to shape trade routes (Notteboom 2004; Slack 2007). Ports must now provide a range of incentives to shippers and operators in order to attract trade volumes, and building cooperative relationships with other ports is one of the ways in which they can do so.

There are several degrees of inter-port coordination (Bengtsson and Kock 1999; McLauchlin & Fearon 2013). At the lowest degree of coordination is its complete absence. Absence of coordination can lead to direct competition, characterised by strong inter-port rivalry, or it can lead to simple situations of coexistence. In coexistence arrangements, ports interact in complementary manners although no formal framework for collaboration exists. The ports of Ghent and Zeebrugge in Belgium, or of Seattle and Tacoma in the USA, coexist in this manner, operating in clearly demarcated markets.

Even under situations of competition, ports can coordinate their activities. When ports coordinate even though they compete with one another, we can refer to this as collaboration: collaboration is often based on *ad hoc* arrangements that endure for the life of a given project, such as joint-ventures, or temporary initiatives. Rotterdam and Amsterdam, for example, though competitors in the field of break bulk (and containers, to a lesser extent), began collaboration on the Portbase project as of 2009. Portbase, which facilitates information exchange between companies and authorities, was formed via a merger of Port infolink in Rotterdam and PortNET in Amsterdam. The aim of the program is to become the national platform for all ports and airports within the foreseeable future, and it could thus provide the momentum for broader forms of port coordination throughout the Netherlands system. Other examples of collaboration between competing ports could include, for example, joint regulation (e.g. Clean Air Action Plan of the ports of LA and Long Beach), and lobby and knowledge sharing organisations (such as the ESPO, IAPH, Ecoports, RETE, PPCAC, WPCI, and so on).

When ports coordinate their activities in a way that minimises competition, this can be referred to as partnership. Partnership denotes long-term, institutionalised forms of inter-port coordination. This can take various forms that are both voluntary and mandatory. Voluntary measures include common port boards (such as the Haropa between le Havre, Rouen and Paris), the formation of national port organisations

(Israel Ports, Spanish National Ports with even an equalisation system between Spanish ports), entering into joint ventures, stakes in inland ports and terminals and stakes in foreign ports to secure maritime forelands.

Mandatory measures include obligatory strategic plans, and nationally imposed inter-port committees (such as those for ports along the Atlantic coast, including Bordeaux, La Rochelle, and Nantes-St Nazaire). In its most advanced form, mandatory partnership results in the merger of port authorities. This usually takes place at a metropolitan scale, where cities with multiple ports merge the authorities into one umbrella structure, as was the case in 2008, when the Canadian Government merged the Port of Vancouver, the Fraser River Port Authority, and the North Fraser Port Authority. Mergers can also take place across national borders, as was the case with the merger of Copenhagen, Denmark, and Malmö, Sweden, in 2001, although this merger was entered into voluntarily. Indeed, the amalgamation of these ports was seen as a way of improving land use planning, marketing, financial resources, operational efficiencies and interactions with the shipping industry. The merger of ports is also determined by their respective specialisations. In Western Australia, which features many small export ports connected to the regional mining industry, around a quarter of which are managed by the Department of Transport, the merger of these small ports into four medium-sized port authorities was seen as a way of reducing levels of bureaucracy and improving their co-ordination and planning. Table 25 below provides a summary of some recent port mergers around the world:

Table 25. Recent port mergers around the world

Year	Countries	Former Ports	New Entity
1998	Netherlands	Terneuzen Port Authority; Vlissingen Port Authority	Zeeland Seaports
2001	Denmark & Sweden	Port of Copenhagen A/S; Malmö Hamn AB	Copenhagen Malmö Port AB
2006	China	Ningbo Port; Zhoushan Port	Ningbo-Zhoushan Port
2007	France	Port of Caen-Ouistreham; Port of Cherbourg	Ports of Normandy Authority
2008	Canada	Port of Vancouver; North Fraser Port Authority; Fraser River Port Authority	Port Metro Vancouver

Source: own compilation of data

It is also worth noting that in countries with one single, national-level port authority, ports are coordinated in a de facto partnership. In South Africa, for example, the Transnet National Port Authority exercises a mandate over all of the ports. Because Transnet also controls rail provision, this institutional framework has significant consequences for inter-port relationships in South Africa, both in the fore- and hinterlands (Notteboom 2010; Rodrigue et al. 2013). For example, the authority has proposed the use of differential tarification structures that would subsidise transhipment to the ports of Ngqura and Port Elizabeth through a levy on transhipment to Durban, as a way of redirecting flows to the former from the latter. In such cases where partnership aggregates decision-making at the national scale, the port system is non-competitive, and more likely to be coordinated in accordance with other national policy objectives such as regional development. National integration of ports systems can thus be used to align maritime transport policy with objectives that might not usually sit at the forefront of a typical port authority's concerns (such as the socio-economic development of distant hinterlands).

The different examples of merger indicate the importance of scale, in addition to degree, when considering port coordination mechanism. It is possible to distinguish between inter-port relationships according to the various scales (international, regional, proximate) and directions (foreland, inland, hinterland) that shape inter-port coordination.

A range of mechanisms is used for port foreland coordination at an international scale. Sometimes, port alliances include multiple ports spread out along a given trade route, such as the Comunidad Portuaria

del Pacífico Sudamericano (COPASUD) including Callao (Peru), Buenaventura (Colombia), Guayaquil (Ecuador) and Valparaiso (Chile), formed to help facilitate better regional integration of South American ports on the pacific coast, and provide a better cargo service to Asia. At a slightly smaller scale, the North Adriatic Port Association (NAPA), including Venice (Italy), Trieste (Italy), Koper (Slovenia), and Rijeka (Croatia) was created in 2010, positioning itself as an alternative to northern European ports. Through this mechanism, these relatively small ports had planned to coordinate investments into road, rail and maritime networks, and worked towards the harmonisation of their regulations and procedures to make service deliver smoother. So far, however, coordination of planning and investments has proven difficult, and the NAPA functions more as a marketing tool than as a mechanism for steering development policies.

International foreland cooperation is also maintained at a bilateral level between ports through the signing of agreements, often formalised as Memorandums of Understanding (MOUs). In 2013, the ports of Hamburg and Los Angeles, for example, signed an MOU for the purposes of sharing best practices and strategies for enhancing competitiveness and environmental impact mitigation. MOUs can be broad, signalling a general desire to collaborate and share knowledge (as in the case of the MOU between Amsterdam and Mumbai, for example) or very specific, aiming to jointly target one policy area, such as environmental protection or maritime security (as in the MOU between Hong Kong terminal operator Modern Terminals and the Port of Los Angeles in 2003). Typically, they do not bind the parties in any mandatory or enforceable fashion, and are thus very popular communication tools for issuing statements of intent or joint policy positions.

This last example highlights yet another, path of cooperation: that of private-led coordination. Through mergers, acquisitions, joint ventures, and various forms of sub-contracting, the private sector shapes a de facto network of global port cooperation (Notteboom & Rodrigue 2012). For example, HPH has terminals in Hong Kong, Shenzhen and Guangzhou. This is also true for port community systems. MGI has now installed its cargo community system AP+ in almost all French ports, which provides the basis for heightened information exchange

In addition to such international mechanisms for inter-port coordination, there are a number of mechanisms that exist at more proximate scales that do not necessarily cross jurisdictions. Mergers at the metropolitan scale have been discussed above. Following Brooks et al. (2009), we can add to these: forms of joint promotion of one another's facilities (or even the establishment of joint marketing agencies); the joint application of new technologies and planning of port developments; joint investments in hinterland infrastructures that will be shared; joint regulatory efforts, in the domains of environmental protection, safety and security, for example; and all manner of information sharing instruments. Often, these more local forms of inter-port coordination constitute strategies that are turned towards inland ports, aiming to improve the hinterland connectivity of major gateways. A number of initiatives exist between the port of Hamburg and the other ports on the Elbe River, Cuxhaven, Brunsbüttel and Glückstadt, as well as with the Baltic Sea ports Lübeck and Kiel. Such inland port-to-port coordination increases the attractiveness of major gateways because it improves service delivery at several points in the supply chain. For this reason, many ports now employ a mix of different inter-port coordination mechanisms to enhance their competitive advantage, as is the case in the ports of the Yangtze River Delta (Box 1).

Box 1. Inter-port coordination mechanisms in Yangtze River Delta

The Yangtze River Delta is one of China's three major port regions, the other two being the Pearl River Delta and the Bohai Rim. The Yangtze River Delta includes major ports such Shanghai, Ningbo and Lianyungang. Since 2007, Shanghai is the largest container seaport in the world since 2011. The Yangtze River Delta regional port system involves three different jurisdictions, the Shanghai municipality and Zhejiang and Jiangsu provinces. Although regional port governance has for long been fragmented (Comtois and Dong, 2007), with intense competition between the main ports, Shanghai and Ningbo, current developments point towards more regional co-ordination, which takes the form of co-ordinated planning, common institutions, co-ordinated finance and co-ordinated operations.

An impetus for co-ordinated planning has been given by the national government. In the National Strategy for the Yangtze River Delta, approved in May 2010 by the State Council, a section on the regional port system lays out development directions and detailed plans for the ports' development and co-ordination. The plan positions Shanghai as the international shipping centre, Ningbo-Zhoushan as the regional hub, supported by other extension and feeder ports in the Yangtze River Delta. Moreover, development plan outlines have been detailed for individual ports, *e.g.* to accelerate general container port infrastructure in Shanghai port, to provide better port infrastructure in Ningbo port, in particular for iron ore and crude oil transportation. Such development outlines have also been applied to inland ports in the region, *e.g.* to develop several feeder ports and transit hubs in Jiangsu to provide connections between Shanghai and hinterland upper stream in the Yangtze River.

Although similar visions in the past have encountered implementation difficulties (Wang and Slack, 2004), there appear currently to be more institutional mechanisms to follow up on this strategy. All container port operations in the Yangtze River Delta are co-ordinated by a single entity, the Shanghai Port System Management Committee created in 1998. The committee is represented by the deputy minister of Communications, deputy mayor of Shanghai, deputy governors of Zhejiang and Jiangsu provinces, as well as senior government officials in charge of economic development and transportation from Shanghai, Zhejiang and Jiangsu. Moreover, since 2006, a Port Management Committee has co-ordinated administration of two nearby ports (Ningbo port and Zhoushan port) in the Zhejiang province. The two ports have subsequently been merged, as reflected in a new name – Ningbo-Zhoushan port.

This institutional co-ordination has been supported by financial participations of the main ports in the area. The two major ports in the Yangtze River Delta, the Shanghai Port and Ningbo Port, set up a joint ventue in 2010, Shanghai Port and Shipping Investment Co., Ltd., to invest in transport, shipping and ports, energy and related areas. Since each side holds around 50% shares of the joint venture, investment carried out by this joint venture is perceived to benefit both ports.[9] According to news sources, the two ports have started to discuss co-operation in more areas, such as co-ordination of future investments and operations.[10] Prior to that, Shanghai Port Group Corporation has invested since 2005 in several inland container terminals – Wuhan, Jiujiang, Nanjing and Chongqing, all upstream of the Yangtze River. As a result, container volume growth in cities such as Chongqing has been exponential (Notteboom, 2007). Closer links between the port of Shanghai and Ningbo have also been created due to the behaviour of private terminal operators. For example, the terminal operator Hutchison Whampoa has interests in Shanghai Container Terminals as well as terminals in the Ningbo Port.

Finally, coordination can even take place between different kinds of port, at the metropolitan or regional scales. Various mega-logistics regions in the world consider the presence of a large seaport and a large airport an advantage. O'Connor (2010) has observed that more diversified gateways (i.e. those possessing multiple airports and seaports within a radius of 70 km from the "core") generate larger traffic volumes and logistics clusters than those that specialise exclusively as air or sea gateways. Although air and sea cargo sectors are in most continents fairly fragmented (Ducruet & Van der Horst 2009), there are several cities, such as Hong Kong, Brisbane and San Pedro that have developed air-sea terminals where goods are shipped directly from one mode to another. A similar facility is available in Dubai Logistics City, aimed at increasing the possibilities for certain goods to be transported by a sea leg, followed by an air leg in order to reduce travel time. In 2009, Dubai's Port of Jebel Ali Free Zone joined forces with the

Dubai Aviation City Corporation to form one of the largest multi-modal logistics platforms in the world linking sea, land and air cargo.

In each case, inter-port coordination can be seen as a strategic response to a competitive environment, in which jointly led activities give participants an upper hand. In short, coordination between ports generates a whole that is larger than the sum of its parts. In most cases, inter-port coordination at varying degrees and scales improves information transfer, supply chain integration, and the effective allocation of infrastructure. Key to the success of these coordination mechanisms is to identify the areas of common interest between stakeholders as the basis for future action, and to make sure that these areas are enshrined in a clear blueprint for action from the very outset of collaboration.

3.3 Strong hinterland connections

Governance of port cities is increasingly influenced by the process of developing trade corridors. The goal is to integrate the port system in a multimodal transportation network in order to improve market access, fluidity of trade and the integration in an industrial network. In this context, a port must have interfaces between major oceanic maritime trade and economic activities of ports and inland terminals that provide intermodal structures and connections between the forelands and hinterlands (Klink and Geerke, 1998, Notteboom and Rodrigue, 2005). Obviously, business transactions require an adaptation to hinterland means. Conversely, the amplification capacity of transport modes may allow the expansion of trade. These bonds of mutual causality are now present in the traffic of port cities. The quality and capacity of hinterland modalities, roads and relays are essential to any expansion of trade.

Strong hinterland connections require certain provisions within the port. This includes direct rail access to the quays, smooth interconnections with the railway network outside the port and canals linking berths with inland waterways. These provisions are far from universally applied. In many ports, several moves would be required before a container (or other cargo) arrives on a train wagon or barge; the more moves are needed, the less competitive these modes of transportation get in comparison to truck transport. In other ports, there is no direct link with inland waterways, which means that barges would have to get to the port terminal by sea, which is not allowed for many barges and would require special vessels or changes in ship design. These examples are in many cases related to fallacies in port design, which are not always easy to solve. The ports that have realised sustainable modal splits have extensive railway tracks on port terminals and might have dedicated river terminals and short sea terminals. In some ports, such as Hong Kong, port feeder barges are used to directly transfer cargo from sea-going vessels to barges, without needing quay access.

In addition to these measures, regional approaches towards freight transport, e.g. distribution centres and extended gates, might be needed to create enough critical mass for non-truck transportation. Trucks generally have a competitive advantage for shorter distance transport; only as distances are longer does freight transport by train generally become a competitive transport mode. Large economies of scale can be reaped, but a certain logistical organisation is required for this in the form of distribution centres in which large amounts of containers and cargo can be grouped before being dispatched to individual destinations. Such a system of selective dry ports or distribution centres has made it possible for relatively small container ports such as Gothenburg to achieve high railway shares in total hinterland traffic. A related approach is that of extended gates, which basically re-located part of the port closer to the hinterland, by displacing cargo handling, customs and other procedures towards an inland port, allowing for a de-congestion of the port. Such a concept is well-developed by the port of Antwerp that has engaged in a large set of partnerships creating a network of inland extended gates. Ports have generally become more aware of the need to be better linked to hinterlands, with various ports taking stakes in inland terminals and distribution centres, creating dry ports, merging with inland ports and facilitating part of the hinterland transportation.

In some countries dedicated freight lanes and corridors are created. Such freight corridors facilitate fast and uninterrupted freight transportation, as it allows for limited intermingling of freight with urban passenger transportation. These corridors differ in length, with the Alameda Corridor being 32 km long, connecting the ports of Los Angeles and Long Beach to the transcontinental railways in the US (Box 2), to the Rotterdam Betuwe-line representing 120 km dedicated rail track to Germany (Box 3), up to the planned dedicated freight corridor between Delhi and Mumbai of approximately 1500 km. Although these dedicated freight corridors are neither guarantee nor necessity for achieving high railway shares in the total hinterland transportation, countries in which freight and passenger railways are mixed will have to find ways to accommodate their co-existence. In several countries, passenger rail gets priority, to the detriment of rail freight. Inland waterways are used in many countries to link seaports with inland destinations (Figure 21) and several seaports have financial participations in inland ports, in order to strengthen their hinterland connections (Table 26).

Box 2. Alameda Corridor

Alameda Corridor is a 32 km long freight rail cargo facility, connecting the transcontinental rail lines near downtown Los Angeles, California to the Ports of Long Beach and Los Angeles. The project is one of the largest public infrastructure works in the nation with a $2.4 billion investment. The operation of the corridor commenced in 2002. The centrepiece of the project is the Mid-Corridor Trench, which carries freight trains on triple track lines in an open trench that is 16km long, 10m deep and 15m wide. The corridor was built by the Alameda Corridor Transportation Authority (ACTA), which is a joint powers authority formed by the cities and ports of Long Beach and Los Angeles in 1989. It is a public-private partnership project that involved various stakeholders, such as the two ports, Los Angeles County Metropolitan Transportation Authority (LACMTA), Southern California Association of Governments (SCAG), private railroad companies Union Pacific (UP) and Burlington Northern Santa Fe (BNSF), as well as the eight cities that the corridor passes. Its funding came from a unique mix of public and private sources, including a federal loan, grants from the LACMTA, user fees paid by the railway companies, investments from the ports, and revenue bonds. According to the ACTA, the goal of the Alameda Corridor is to consolidate train traffic and eliminate at-grade conflicts, as well as improving the air quality in the Southern California basin through reducing traffic congestion at rail crossings.

As a dedicated intermodal railway designed to improve the efficiency of transporting container cargo from the two ports to the national rail system, there are a number of benefits generated by the Alameda Corridor. It has resulted in more efficient rail movement, with a reduction of train transit time from over 2 hours to 45 minutes, as well as increased train reliability. Moreover, it eliminated conflicts at 200 at-grade rail crossings that reduce traffic delays and emissions from idling automobiles and trucks. As of April 2012, which marked its 10-year anniversary, ACTA estimated that more than 150,000 trains and moved more than 20 million TEUs (twenty-foot equivalent units) through the Alameda Corridor, resulting in more than 13,000 tons of total emission reductions from the consolidation of freight rail operation and the alleviation of traffic congestion at rail crossings in the Southland. The ACTA also provided training to about 1,300 area residents and created more than new 1,000 jobs during its construction process. Currently, the corridor has average daily traffic of 43 trains and cargo volume of 12,359 TEUs.

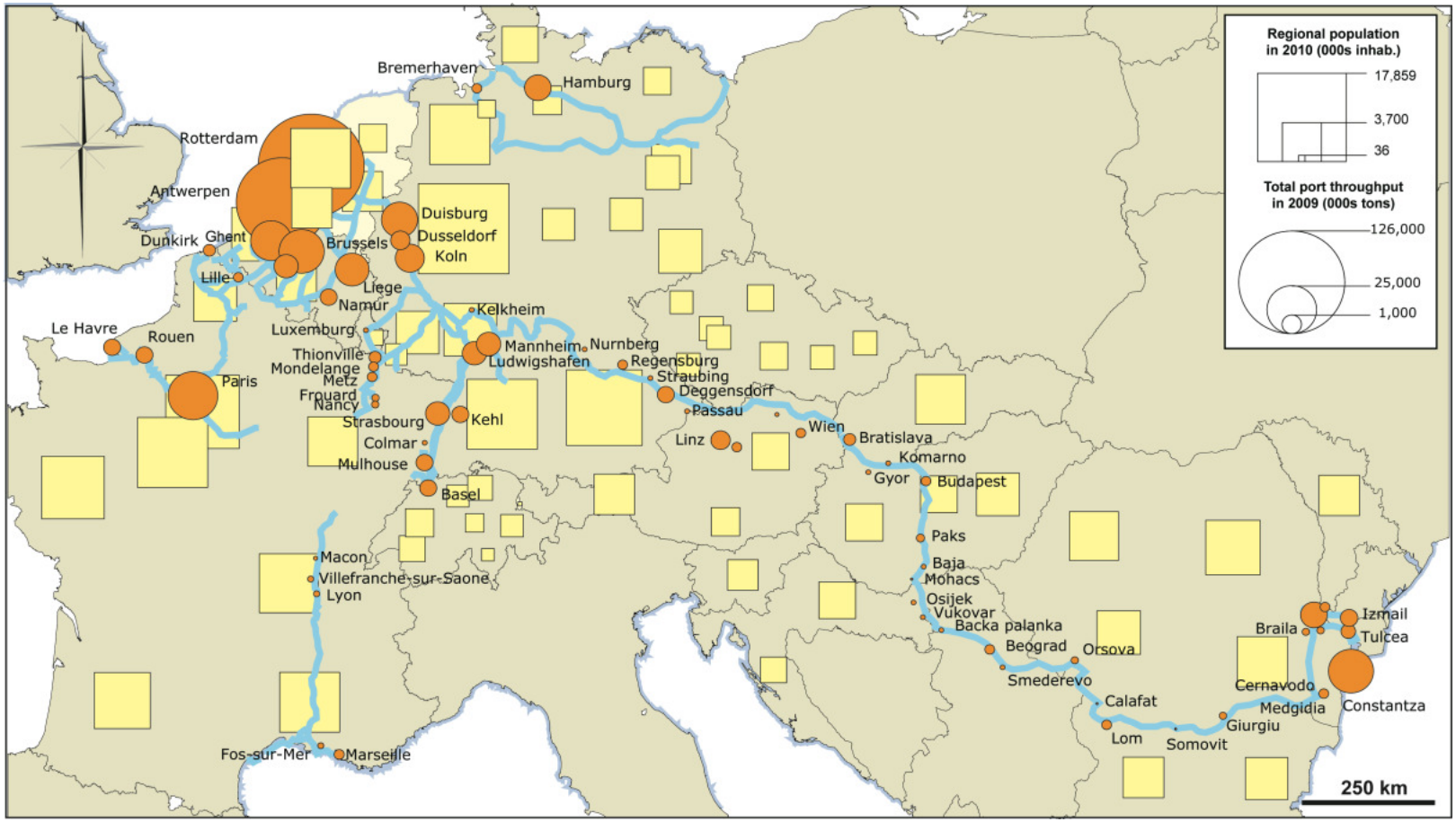
One key factor to the timely completion of the Alameda Corridor was the process to reach a consensus among various stakeholders from the public and private sectors. The ACTA was able to resolve conflicts of interests between stakeholders and created a publicly acceptable project by taking actions to accommodate their needs and concerns (Agarwal et al, 2004). The ACTA had negotiated settlements and signed memoranda of understanding (MOU) with each mid-corridor city, as well as to provide assistance in local economic development measures in order to secure their cooperation with project approval and construction.

Box 3. Betuwe line: dedicated freight rail link between Rotterdam and Germany

The Betuweroute is a double track dedicated freight rail track towards Germany and into Europe. For the section from Rotterdam to the large shunting yard at Kijfhoek existing tracks were reconstructed, but three quarters of the line is new, from Kijfhoek to Zevenaar near the German border. The rail part in Germany is referred to as the Hollandstrecke. Together they formed project no. 5 of the Trans-European Transport Network program (TEN-T). The first discussions on the dedicated freight track go back to 1985. Work on the Dutch part of the track began in 1998. Before and during its construction the route generated a lot of controversy in political and community circles. In 2000 the Court of Audit stated that promoting river transport should have been considered as a realistic alternative. In 2004 the Centraal Planbureau concluded that the construction would never pay its way. Delayed by two years, the railway was finished mid 2007, at a cost of 4.7 billion euro, more than two times the original budget.

The Betuweroute is managed by Keyrail. The shareholders of Keyrail are Prorail (50% - Prorail is the rail infrastructure manager in the Netherlands), Rotterdam Port Authority (35%) and Amsterdam Port Authority (15%). In 2010, rail traffic on the 120 km stretch between Kijfhoek and Zevenaar increased by almost 80% to 17,600 trains. The market share of the Betuweroute in comparison with the other border crossings for freight transport by rail to and from Germany has increased to more than 70% in 2010 compared to 45% in 2009. The main motor behind this growth has been active tariff policy and the electrification – at the end of 2009 – of the Port Railway Line, the stretch between the Maasvlakte and the Kijfhoek shunting centre. As a result of this, many carriers switched from the 'mixed network' to the Betuweroute. In addition, the Port of Amsterdam got connected to the Betuweroute in March 2011 via a railway connection to the Betuweroute near Meteren/Geldermalsen. As such the Betuweroute is now serving both ports. Keyrail expects the number of trains on the Betuweroute to increase to 500 a week by the end of 2011 or a market share of about 75%.

Figure 21. Inland port-cities in Europe



Source: Own elaborations.

Table 26. Participations of seaports in inland ports/terminals

Seaport	Inland port	Share (in %)	Other shareholders
Ningbo	Taicang, Wanfang Int. Terminal	100%	
	Nanjing, Mingzhou Terminal	100%	
	Jiaxing, Fuchun Terminal	100%	
	Wenzhou, Jinxin Terminal	45%	Wenzhou Port Group
	Taicang Wugang Terminal	55%	Hong Kong Wugang, Sino-Trans&CSC, BM Holdings
South Carolina	Greer Inland Port	100%	
Virginia	Virginia Inland Port	100%	
Shanghai	Chongqing Container Terminal	50%	Chongqing
	Jiujiang Terminal	50%	Jiujiang municipality
	Wuhan Container Terminal	49%	Wuhan municipality
	Nanjing Longtan Container Terminal	25%	Nanjing Port, COSCO
	Jiangyin Container Terminal	30%	Baohua Group, Jiangyin Port
	Wenzhou Container Terminal	20%	
Barcelona	Zaragoza Terminal	21.55%	Mercazaragoza, Aragon government
	Guadelajara Multimodal Terminal	49%	
	Perpignan St. Charles Terminal	5%	
Antwerp	Geleen Rail Terminal	33.3%	Ewals Intermodal, Meulenberg
	Beverdonk Container Terminal	20%	DP World
Le Havre	Paris Terminal Gennevilliers		
Marseille	Lyon Terminal	16%	Compagnie Nationale du Rhône (CNR), Compagnie Fluviale de Transport (CFT), Naviland Cargo
	Pagny Terminal	10%	Chambre of Commerce and Industry of Bourgogne and Saône and Loire

Source : own data compilation

More sustainable hinterland transportation also requires regulation and incentives that are supportive. Truck transport remains in many cases the cheapest hinterland transport option, at least for relatively short distances. This is partly due to limited internalisation of external costs of truck transport, to the larger number of moves that is generally needed when using other transport modes, but also to regulatory constraints. Several countries have maritime cabotage rules that prohibit foreign flag vessels to be active in national short sea shipping; as a result of such legislation and rules (e.g. the Jones Act in the US) short sea shipping remains undeveloped as a transport mode. Various countries have not yet liberalised their railway operations, which in effect limits the competition for rail freight. Such regulatory barriers would need to be tackled in order to stimulate more sustainable modes of hinterland transportation.

3.4 Guaranteeing the support of the local population

The support of a local population is essential for ports in order to keep their “licence to operate” and remain legitimate economic actors. Local support will evidently be facilitated if there are local benefits and if negative impacts are limited or mitigated, but long-term and sustainable support requires more. What distinguishes successful port-cities from less successful and more polarised port-cities is the sense of pride and “ownership” of the port by the population and business community. This pride is in many cases based on a sense of history, but maintained by deliberate policies of port and city authorities, e.g. by transparent port communication and activities or facilities that create links between the port-city population and its port, and refer back to the maritime heritage of the city.

Guaranteeing the support of the local population not only legitimises their operation, it is also an important part of innovative marketing communications that takes into account the challenges of seaports that are service-based businesses. Over the last years, port authorities have experienced a dramatic wave of changes in governance settings, in response to organisational, operational, and financial criticalities emerged in many ports (Parola et al, 2013). Leading port authorities pursue growth strategies aiming at exploiting business opportunities and expanding their international reputation and visibility; in order to achieve such objectives, they have adopted innovative governing strategies, which include innovative marketing and communication strategy for sharing a greater amount of information with major stakeholders. Accordingly, today's marketing communication strategies of ports are broader than attracting and retaining customers: they now include informing and educating other stakeholders such as employees and the local community about the benefits provided by the seaport (Cahoon, 2007). In re-shaping their relations with leading stakeholders, port authorities are targeting more effective forms of communication; the range of port authority actions may include international exhibitions, seaport days and direct business trips, school visits, and the creation of a seaport education centre, etc.

Furthermore, ports have been initiating more open and proactive approach in their annual reports: empirical findings revealed how port authorities emphasise innovative themes which go beyond the traditional contents of disclosure (e.g. operational and infrastructural data), shifting to economic and financial data and CSR information (e.g. social and environmental contribution and sustainability reports) (Parola et al, 2013); the research outcome has unveiled that the larger ports, or the ports which host a higher number of international terminal operators, are more inclined to initiate innovative information disclosure, aiming to strengthen the inter-relations with local actors involved in port-related activities, and to mitigate customer bargaining power.

The port can also be a defining element of city marketing; e.g. the city of Rotterdam promotes itself as a world port-city, identifying its port as a driving force of economy and also as a defining character of the city. Preserving the port-related heritages can also become an important tool for branding a port city: with its historic city centre and docklands, the port city of Liverpool has become the Maritime Mercantile City designated as a UNESCO World Heritage Site. In addition, the existence of international cruise terminals makes it easier for a port city to market itself as a global city, since cruise ships trigger international tourism and interaction with the outside world; Montreal, for example, claims itself as "a cruise destination par excellence" within the cruise terminal services at the Port of Montreal.

Port centres

Several ports apply open and active communication strategies to inform and engage local citizens and stakeholders. This can take the form of port centres, such as in Genoa (Box 4) and various other ports (Table 27). Port centres are built and promoted mainly by port authorities or city governments in order to making known the role and value of the ports, engaging local communities, students, children and the general public. In general, the key objective of these port centres is to improve the image of the port and place a stronger link between the port and the city, by providing accessible information on the port's operations, industrial area, and economic contribution.

Table 27. Overview of port centres

City, Country	Centre Name	Year	Number of visitors per year
Antwerp, Belgium	Port Centre Lillo	1988	42,000
Genoa, Italy	Genoa Port Centre	2009	14,000
Rotterdam, Netherlands	EIC Mainport	1994	22,000
	FutureLand	2009	100,000
Melbourne, Australia	Port Ed	2002	4,000
Busan, Korea	New Port Visitors' Centre	2011	n.a.
Groningen, Netherlands	Seaport Xperience Centre	2012	10,000

Port centres often target young people as their main audience, offering various kinds of educational programs and theme visits for students; for example, Port of Rotterdam (EIC – Education Information Centre Mainport Rotterdam) and Port of Melbourne (Port Ed – Port Education Centre) introduced special port education centres for children and students, which propose guided tours to operating ports, visits to cargo-handling/ship repairing companies, and training seminars. Their focus on young population can also be extended to the interests in developing future port-related professionals; Port of Groningen, through its Seaport Xperience Center, aims to develop future technical labour market by allowing the future generation to discover port-related professions.

Some port authorities see the port centres as a tool to advertise their new port or the construction of the new port. For instance, FutureLand, the visitor centre for the Maasvlakte 2 expansion project in Rotterdam, introduces the construction of the new port to the public through different activities using technologies, such as a virtual trip over the Maasvlakte as it will look in 2033 with the Future Flight Experience. Busan Port Authority also established Busan New Port Visitors' Centre, which aims to introduce the New Port, providing specific information and opportunities to experience the operating port to local community and the general public. In addition, a port centre can also be developed by private sector: Porto Lab, a school laboratory, is an initiative owned and designed by Contship Italia Group, intends to communicate the value of container port and intermodal transport activities by providing educational activities for primary school children.

Box 4. Port information centre in Genoa

The Genoa Port Centre was created in 2009 to promote the port and highlight the economic and social role of the maritime industry. As such, it attempts to stimulate strategic alliances between the port, businesses and the general public. The exhibition centre facilitates the discovery of the port, its present and future and its role in national and EU strategies. The centre plays an important educational role, and aims to attract students, teachers and parents. It organises guided visits, lectures and workshops and has developed educational material and other information. The Genoa Port Centre also has a role in broader communication through specific cultural projects (seminars, conventions and technical meetings) and exploration of the port of Genoa, such as visits to the port and the various areas of the port itself, in close collaboration with the port operators involved in the partnership. The initiative has been promoted by the Port Authority, the province, the university and the Porto Antico company, which is responsible for property development in the old port of Genoa, where the Port Centre is located. The Genoa Port Centre builds on the experience of the ports of Antwerp and Rotterdam, which created their port centres in the late 1980s.

Port education

Several port authorities offer different types of educational programmes through their port centres, their websites, the boat tours designed for school children, special visits to schools, and summer activities, etc. The general aim of these programmes is to support the social integration of port and city within the projection of making the future generations as employees, neighbours, and stakeholders of the port operations and related industries. When Port of Rotterdam and Port of Melbourne have their own port education centres, the port centres of Genoa and Antwerp also provides educational activities for children and students: Genoa Port Centre invites young students to discover which are the professions involved in the everyday operations through original devices and technologies such as webcams, simulators, touch screens; The Lillo Port Centre in Antwerp organises "Jonge Haven" (Young Port) project for young people in 5th and 6th year of primary education to give them information on port professions and industry in the port.

Port-related educational programmes can also be provided through the websites of the port authorities, which contain downloadable classroom materials and teachers' guides. For example, Port of Long Beach website offers "Port of Long Beach: Classroom", a series of lessons that combines real-world Port of Long Beach situations with content from the California state-approved curriculum; Port of Melbourne website also made it available to download teacher and student resources. In addition, other instruments, such as boat tours and visits, are often used in educational purposes. Port of Barcelona supports the educational activities on board of traditional boats, a Balearic cat-boat build in 1922, which allows young people to get in touch with the cultural and historical heritage; Port of Los Angeles provides free one-hour educational boat tours to school groups (fourth grade through college) to demonstrate the dynamics of world trade. Visits of the port authorities to the schools, on the other hand, demonstrates active initiatives the ports that attempt to increase their visibility as much as possible; Port of Naples organises the event "The Port of Naples Meets the Schools", which consists of a visit from the President of the Port Authority to the schools to explain to the children the different types of jobs that are performed in the port (Table 28).

Table 28. Port education programmes

Port	Programme Title	Target Age Group
Rotterdam	Programmes at EIC	Secondary schools, vocational institutions, up to university students
Melbourne	Port Education Program	Grades 5 and 6, Year 9 and 10
Genoa	Citizens of Port	8-18 Years Old
Antwerp	Jonge Haven (Young Port)	5th and 6th year of primary school, 1st and 3rd year of secondary school
Long Beach	Port of Long Beach Classroom	12th grade, middle school and high school
Los Angeles	School Boat Tour	From 4th grade to college
Barcelona	Around the sea	Not specific
Naples	Port of Naples Meets the Schools	Not specific
Bremen/Bremerhaven	Economics in the Port	Grades 8th – 10th and up
Reykjavik	Faxaports – Port of Reykjavik Youth Programme	11-12 year old, 14-18 year old

Source: own data compilation

These activities work might be more effective if they are not considered to be exclusively marketing exercises, but when coupled to transparency in information with respect to port activities and its impacts. Examples are the corporate sustainability reports of port authorities. Several port authorities in the United States have public harbour commission meetings and open access to its documents. In addition, several ports are active on social media and have a large range of followers that they inform and involve in port-related activities. All these activities can result in high local approval rates, especially if they form part of a consistent strategy of stakeholder involvement in port-city development. Many ports go further and try to create links with the local population, either through maritime museums, waterside leisure activities, cultural projects with port and global city brand marketing in which the port plays a visible role.

Maritime museums

Most large port-cities have a maritime museum, which can have an important role in shaping and maintaining the collective identity of a port-city and indeed a nation (Hicks, 2001). Some of these museums are national museums; e.g. the Australian National Museum in Sydney presents the National Maritime Collection, which mainly deals with the objects linked to Australian national history. The most recent example of such a national maritime museum is the China Maritime Museum in Shanghai, which was jointly built by the Ministry of Transport of China and Shanghai Municipal Peoples' Government in 2009: it is the first and largest national maritime museum which attempts to "carry forward the spirit of 'Patriotism, Good-neighbourliness, Friendship and Scientific Navigation.'"

Many of the maritime museums in port-cities have a more local character. The maritime museum of Rouen focuses on the preservation of the city's history as a port city, whereas the Port Natal Maritime Museum in Durban aims to offer an insight into the influence of maritime culture on local life. In addition, for a port city, maritime museums not only give the community an occasion to conserve the local port heritage and culture, but also become tourist attractions that contribute to the regional economic vibrancy: the opening of the Merseyside Maritime Museum in Liverpool, which was built with the support of Merseyside County Council, led the way in revitalising the Albert Dock area – the dock is now a major tourist attraction and home to many small shops, bars, flats, restaurants, hotels and other businesses.

A new wave of maritime museums not only focuses on the local port community and culture, but also on the current role of the port in the city (Navarro, 2012). Antwerp's MAS, Museum aan de Stroom, not only contains the objects demonstrating the history of the Antwerp port, but also presents MAS Port Pavilion where one can learn about the information on the operating port and the workings of the Antwerp port through a virtual port family guide. Maritime Museum Rotterdam also attempts to introduce the operating port which is now far away from the city centre through a special exhibition: "MainPort Live – Feel the Rhythm of Rotterdam Port" allows audience to experience the operating port in miniature and watch the ships in real time.

Involvement of port authorities in supporting maritime museums is fairly modest. Port authorities can be one of the initiators, such as in case of Antwerp with the MAS, and the Maritime Museum of Barcelona, which is a public entity, formed by the local council and the Port Authority of Barcelona – but these cases are quite rare. In some other cases, port authorities can be a financial sponsor of maritime museums, which is the case of Rotterdam and Amsterdam where the port authorities make financial contributions to the museums. However, in most cases, the link between the maritime museum and the port authority is absent.

Port events

Many ports also organise special activities in which the port acts as a stage, e.g. port days, maritime days, cruise days, port anniversaries; all activities in which the population is invited to the port and admire its variety of vessels, activities and people. The city attracts visitors for its 'maritimeness' which is derived from its maritime heritage, aggressively promoting the benefits of visiting their areas (Anderson and Edwards, 2001); it is by the creation of great events, which can take an international dimension, that the city governments attempt to attract a great number of tourists and to obtain a strong image of maritime city (Navarro, 2012). Port of Hamburg celebrates its Port Birthday every year in the beginning of May; Busan Port Authority and Busan Metropolitan Government organise the annual Busan Port Festival since 2008, which includes water leisure and sports activities as well as exhibitions on maritime culture and science.

Some ports try to improve their image and their relationship with citizens through opening up the port to the public. The port authority and municipality of Rotterdam present the World Port Days, whose main goal is to familiarise visitors with the port and to create a positive attitude towards the port and its surrounding maritime city. Marseille and La Rochelle host Open Port Days that invites the local citizens as well as the general public to discover the working port. Ports of Auckland also introduces similar event called "SeePort", which is a public open-weekend event giving the local citizens the opportunity to see their port in action.

The transformation of the port areas is in many instances also used to reconnect the local population with its port. Sydney harbour is no longer used for cargo handling and has been transformed in a leisure area, but has somehow kept its maritime character, thanks to marinas and old harbour buildings. The transformation of the old port of Genoa has reconnected the city with its port, via some of the new activities, such as cultural centres and an aquarium. The port can also be a defining element of city

marketing; e.g. the city of Rotterdam promotes itself as a world port-city. Such activities can help to create or sustain local goodwill for port activities.

Other than port-related events, several port authorities also support other cultural or community events, aiming either to attract tourism or to be engaged with local population. For example, Port of Las Palmas collaborates on a cultural event "Puerto de Culturas", which aims to celebrate and promote the cultural diversity in the Puerto Canteras area; classical concerts have also been organised in a container terminal in the port, where Symphony Orchestra of Gran Canaria performed Beethoven's Symphony on the occasion of International Festival of Theater, Music and Dance of Las Palmas. In addition, Port of Marseille-Fos actively participates in the city's cultural projects for European Capital of Culture, represented by the event "3 saisons d'exposition sur le Port" (3 seasons of exhibition on the Port) which is composed of three differently themed exhibitions. Another interesting example is "Rock on the Dock", an annual rock festival in the port of Antwerp, which contributes to the attractiveness of the port (Van Hooydonk, 2003). Port Metro Vancouver, on the other hand, is involved in supporting and participating in a number of community-level cultural events and initiatives, such as Children's Art Festival, Steveston Salmon Festival, and Richmond Maritime Festival, etc.

Social media

Social media has become an important communication tool frequently used by many port authorities. The most common is through Twitter account, where port authorities communicate their container traffic, the weather forecast of the port area, community events, and other initiatives. The ones with the highest number of followers are Incheon Port Authority and Port of Los Angeles (Table 29). With its Twitter account, Incheon Port Authority not only reports daily weather forecast and the port's contribution on local economy, but also draws attention on job opportunities in port-related industries, the historical factors of the port, and its environmental campaigns; Port of Los Angeles' Twitter account mainly informs on the community events and development projects happening in the LA waterfront. Facebook accounts are also often used, where pictures and videos can be more visible. Some ports utilise other internet-based communication materials: for example, Port of Portland runs a special blog called "PortCurrents", where the port publishes the articles on environmental and community issues; Hamburg Port Authority has its own channel on YouTube called "Hafen TV", which aims to introduce the work of the port authority and variety of business activities that are taking place in the port.

Table 29. Use of social media by selected world ports

Port	Number of Twitter followers	Number of tweets	Facebook subscribers
Incheon	8733	2214	4,040
Los Angeles	5702	404	12,471
Seattle	3311	719	1,999
Vancouver	2687	1602	-
Valparaiso	2436	972	-
Rotterdam	1531	857	-
Antwerp	1249	5	-
Gothenburg	747	924	-
Auckland	157	363	553
Cartagena	135	6157	-
Manzanillo (Mexico)	-	-	112

Source: own compilation of data

Public access to port

In addition to the "Open Days" when the public can have access to the operating ports, port authorities offer various ways to access to the port sites: free boat tours, bike paths around the port, port viewing sites, and port-city interface areas are the major examples. Offering free boat tours is one of the

most popular ways to access the port; with free boat tours, the public can observe the port sites more closely from the water. Port of Houston offers "Sam Houston Boat Tour" since 1958, a free leisurely 90-minute round-trip cruise ride along the Houston Ship Channel; during the tour, the passengers can enjoy passing views of international cargo vessels, and operations at the port's Turning Basin Terminal. Port of Long Beach also proposes free harbour tours from May to October, which are in very high demand. Port of Auckland provides free public boat tours on the Waitemata Harbour, giving the public an opportunity to view the operations from the sea; the hour-long tours take visitors alongside the container terminals where they can see the big cranes and other machinery at work.

Some ports introduce bike paths (cycle routes) around the port, through which the public can explore the port sites or have good views of the working port activities. Port of Hamburg introduces an extensive network of 45 km of cycle routes, and one can watch the loading and unloading of containers or cross impressive bridges along the routes; the port cycle route map is downloadable on the website. Port of Antwerp also provides bicycle maps that give an overview of the bicycle routes in the port, which include twenty sights in and around the port. Port of Melbourne, on the other hand, presents "Port Heritage Trail", which establishes a link between significant heritage sites and structures located around the port by placing easily identifiable markers at several locations; each site marker contains information and historical images, enabling visitors to explore the history of the Port of Melbourne as they walk or cycle along existing trail networks. Port of Auckland also launched "Red Fence Heritage Walk" in 2012, which introduces the historical wharves and the ways to access the port.

Public access to port areas has been also significantly increased through investments on building port-city interface or redevelopment of the spaces where the port and the city adjoin each other. Port of Valparaiso, for example, has been developing urban spaces such as Puerto Baron and Muelle Prat, attempting to better connect the port activities with the local population. Muelle Prat, built in 1850 with the purpose of transporting passengers, has become the area which allows the interaction between the port and people; the place is now frequented by tourists and the locals who would enjoy the existence of the promenades, craftsmen, and artists next to the sea. In addition, boat rides services are available in this area, with which one can observe the various movements of the port, cargo operations and unloading ships. Developing port-city interface has been often related with the rehabilitation of old port areas, referred as waterfront development projects; the examples vary, yet in general they aim to create a multi-functional district that stages commercial, recreational, and cultural activities.

The transformation of the port areas is in many instances also used to reconnect the local population with its port. Sydney harbour is no longer used for cargo handling and has been transformed in a leisure area, but has somehow kept its maritime character, thanks to marinas and old harbour buildings. The transformation of the old port of Genoa has reconnected the city with its port, via some of the new activities, such as cultural centres and an aquarium. There have been several creative initiatives to transform the old port infrastructure to cultural spaces. For instance, Hamburg's well-preserved Speicherstadt, a historical warehouse district located in Port of Hamburg, has become one of the most popular tourist attractions in the city since its transformation into several museums. "CRAFTED" at the Port of Los Angeles is another good example, which is a large-scale permanent craft marketplace in refurbished World War II-era waterside warehouses; the market hosts hundreds of individual craft-artists, designers, and artisanal food makers, and also organises cultural events. A very recent example is the "J1 site" in Marseille, an ancient warehouse renovated as a public cultural space by the Port of Marseille-Fos.

Goodwill projects

In order to improve the reputation or the image of the port perceived by the local population, port authorities can also lead goodwill projects such as compensation for negative impacts of the port, sponsorships, or volunteer work initiatives. Port of Valparaiso offers community social training

programmes; there have been three versions of the programme, with 130 beneficiaries who received training skills in hairdressing, plumbing, nutrition, food handling, and entrepreneurship. The Port of Houston Authority on the other hand sponsors local community programs, initiatives, and activities; Port Commissioners, Port Authority staff members, and representatives of external organisations may request Port Authority sponsorship of events or programs by submitting a sponsorship application form. Furthermore, the Port of Houston is also engaged in volunteer work initiatives – Port Authority volunteers, known as Port SupPORTers, participates in environmental programmes, helping bag sand for hurricane preparedness and cleaning up the Baytown Nature Centre. On the other hand, Port of Long Beach awards $60,000 in scholarships to Long Beach-area college students and high school seniors who are pursuing studies in related fields such as International Business, Global Logistics, and Trade and Industrial Technologies. As for the Ports of Auckland, it sponsors the 'Excellence in Exporting' Award, with which the port aims to support local businesses and help them grow the Auckland export sector.

For port cities, providing waterside leisure and recreation activities is not only a good way to attract tourism, but also to obtain public support through consolidating the city's maritime identity within the port. Several port cities have the public beaches not far away from the port, demonstrating the possibility of coexistence of the port, nature, and people. For instance, Hamburg's Elbe bank offers fine sand beaches overlooking the busy container terminals on the opposite bank of Elbe; restaurants, hotels, parks, green promenades, and natural beaches along the Elbe attract locals and tourists alike, and the view of the harbour and harbour cranes gives a unique character. Port of Los Angeles contains The Cabrillo Beach Recreational Complex, which presents various kinds of waterside recreation opportunities with its public beach, youth sports centre, marina, and aquarium.

The port and waterfrontage provide an arena for watersports and water sporting event to take place, and support services such as sailing schools, tour operators, yacht brokers, marinas bring regular income to the city and hinterland (Anderson and Edwards, 2001). Accordingly, several port cities engage in organising water sporting events or development of marinas. For instance, an annual yacht racing event such as Sydney-Hobart Yacht Race is considered to have a significant impact on tourism and national maritime identity; the event draws international attention and visitors, bringing life and vitality to the region. Southampton is another port city that enjoys positive economic benefits coming from watersports tourism; the Southampton Boat Show, which includes yacht racing events and free boating experiences, attracts around 110,000 visitors, 500 plus exhibitors and boosts the economy by more than £11m (Southampton City Council, 2013).

Indicators of effectiveness

The long term effectiveness of the measures described above has not been subject to systematic research. Specific programme assessments and evaluations are sometimes available which indicate the success of the particular measure, and the appreciation rate.[11] There is hardly any information on how a particular campaign or programme affects the overall public perception on ports. A Public Communications and Perceptions Survey Research Report on the Port of Long Beach was conducted with 1,000 registered voters in Long Beach, revealing that 68% of respondents were satisfied with the port's efforts to communicate with residents through newsletters, television, the Internet and other means. Other ports are known to have conducted public perception surveys in order to monitor their image among the local population, and hope to improve their ratings by applying some of the communication strategies described above.

4. HOW TO INCREASE LOCAL BENEFITS OF PORTS?

How can competitive ports be turned into engines of urban economic growth? What are the policy options for port-cities, what are the main policy instruments and what is their effectiveness? This section identifies three main models for port-based urban economies: maritime clusters, port-industrial development and port-related waterfront development. In addition, a side-option is presented which does not use the port as a source of economic growth but is based on diversification of the urban economy in order to decrease the dependence on the port economy. A non-regret option consists of increased cooperation between port-cities. These policy options are archetypical, as various port-cities have strategies that consist of parts of different models at once.

Table 30. Main policy options to increase local port benefits

Policy option	Related sectors	Instruments	Examples
Maritime clusters	Logistics Maritime services Shipbuilding/repair	Developmental support Fiscal incentives/grants Coordination/information Human capital matching	Singapore Hong Kong
Industries	Industrial ecology Renewable energy	Spatial planning Investments	Rotterdam
Waterfronts	Tourism/recreation Food Events industry	Master planning Project implementation Incentives/investments Synergies with port	Barcelona
Diversification	Non-port sectors	Similar instruments	London Liverpool Boston

Source: own elaboration

4.1 Maritime clusters

Over the last decades, economic development policies in many OECD member states have ceased to focus exclusively on single sectors, and have instead begun to concentrate on the linkages amongst firms within multi-sectoral 'clusters'. Such clusters are comprised of economic actors from diverse parts of the value-chain, and can include producers, customers, suppliers, labour markets, training institutions, intermediary services, industrial associations, and government actors (Porter 1998; Dayasindhu 2002; Porter 2003). Clusters are usually defined spatially, as regions or areas that feature higher than average concentrations of value-added activity within a given domain (IT, maritime, agriculture, textiles, etc.), but can be distinguished from industrial districts or simple geographic concentrations of firms in that they are linked through formal networking platforms, and usually benefit from some degree of cooperation and collective governance (Doloreux & Shearmur 2009).

Clusters are especially important to the maritime domain because the shipping and ports industries are highly dependent on sub-contracting and various kinds of services, and because they require a very specialised local workforce (De Langen 2002; Wijnolst 2006). For firms, participation in maritime clusters is said to generate increasing productivity through the creation of cost-reducing linkages between suppliers and customers, the formation of larger and more qualified labour pools, and through spillovers of

knowledge that work through inter-firm interaction (Brett & Roe 2010). Particularly for shipping, ports and maritime manufacturing, clusters can facilitate better interactions with a range of ancillary services (finance, brokerage, insurance), and can enable access to information and expertise that might open new markets and provide opportunities for expansion (Weissenberg 2006).

Importantly, successful maritime clusters enhance the port's positive contribution to its surrounding city and region. In cities such as London, for example, the growth of high-value added activities related to the maritime domain has been shown to contribute directly through employment, GDP increase, fiscal revenues and overseas earnings, and indirectly through the multiplier effects of wage spending and increases of demand in the supply chain (TheCityUK 2011). For this reason, the formation of maritime clusters has been seized upon as a policy objective in many parts of the world, and governments now have at their disposal a diverse range of instruments that might help embryonic maritime clusters to emerge and consolidate, and enhance mature clusters. However, many examples of cluster-formation policies that have met with mixed success exist (Doloreux & Shearmur 2009; Melançon & Doloreux 2011): the success of a given instrument for encouraging maritime clusters is context-dependent; clusters cannot be created ex nihilo through policy. In most instances clusters emerge through path-dependent and market-induced processes, meaning that not all maritime clusters can be encouraged in the same manner, and that not all port regions have the potential to form maritime clusters or should pursue such a strategy (Karlsen 2005). The role of policy is thus to respond to locally identified needs, and to encourage these tendencies only when this is logical in light of alternative uses of resources (Nauwelaers & Wintjes 2002). The instruments presented below, and the strategy of maritime cluster formation more broadly, should therefore not be interpreted as universally applicable panacea.

Cluster composition

A port cluster can be said to consist of "all economic activities related to the arrival of goods and ships" (De Langen 2004: 85). Depending on the context, the port cluster can thus be composed of very different sub-sectoral components. Table 31 below, based on data compiled by Lam & Zhang (2011) summarises some of the more famous examples of maritime clusters around the world, and illustrates the diverse compositions that are possible based on the comparative advantages of each cluster:

Table 31. Maritime cluster composition in main port-cities

	Hamburg	Hong Kong	London	NY / NJ	Oslo	Piraeus	Rotterdam	Shanghai	Singapore	Tokyo
Port	■	■					■	■	■	
Marine Insurance			■		■				■	■
Financial services	■	■	■	■	■	■		■	■	
Ship registry	■	■	■		■	■			■	
Shipowners, Operators & Managers		■	■		■	■	■		■	■
Ship classification			■		■					
Ship agency forwarding			■				■	■	■	
Ship brokers			■		■	■				
Legal services		■	■			■			■	
Ship building & repair	■	■					■		■	
Marine personnel				■			■	■		
Research, education & training	■	■	■		■		■	■	■	■
ICT services		■	■	■		■	■		■	
Maritime regulators			■		■		■			■
Maritime culture and heritage	■		■	■	■	■	■			

Source: Lam & Zhang 2011
Notes: Marked boxes indicate comparative advantage in a given sub-sector.

Port and logistics

The first and most obvious sub-sector of any maritime cluster is that of the port. The port often increases demand for a sub-cluster of firms that ensure that it performs well. Port-side logistics firms provide stevedoring services, including loading, discharging, and stowing, while other firms specialised in land-side logistics provide services such as transloading, warehousing and distribution. Various other firms ensure that the port's infrastructure and operations continue to perform at optimum levels through the provision of dredging, pilotage, mooring, berthing, and bunkering services. Of course, port-related logistics do not always necessarily constitute the core component of the cluster, as the cases of London, Oslo and Piraeus illustrate (see table # above).

A given maritime cluster could be composed entirely of firms fulfilling these logistical and port operations functions. An exclusively port-centric cluster would thus base its activities mainly around low value-added logistics activities such as cargo loading, discharging, storage and distribution, as is the case with Dublin, Ireland, for example (Morrissey & Dondoghue 2013). Alternatively, the port logistics functions component might be linked to an array of value-added transloading and cargo transformation activities (processing, packing, consolidation, etc.), which is the case in ports such as Antwerp or Osaka (Lam & Zhang 2011). To a large extent, the centrality of the port logistics component to the maritime cluster will be determined by local path dependencies. For example, the Drechtsteden cities, located on the Rhine–Meuse–Scheldt delta, have built up a significant dredging cluster in part due to their proximity to the Rotterdam port cluster (De Langen 2002), but also due to the years of traditional expertise in building levees for urban flood management. The differences in the development of West German maritime clusters also reveal divergences regarding the centrality of the port logistics sub-sector: in Hamburg, the growth of high-value added maritime service firms (insurance, banking, consulting) has pushed the traditional logistics firms further away from the high-cost areas in direct proximity to the port; while in Bremen, largely due to automobile value-added activities, ports and logistics firms remain tightly interwoven within the spatial confines of the city, with back-of-port logistics progressively taking on a central role in the cluster (Elsner 2010).

Shipping and maritime services

In the same way that the ports and logistics services are often tightly interwoven into one sub-sector, the shipping and maritime services sub-sectors often go hand-in-hand. Ship ownership and management play a key role in the health of the maritime cluster as a whole, increasing demand for a range of services and positioning port-cities such as Singapore, Rotterdam and London as international maritime centres. To an extent, the presence of shipping companies in a given maritime cluster is the product of historical path dependencies. Thus, in Japan for example, despite the formal dissolution of the Zaibatsu system in the post-war period, the historical privilege and power accorded to shipping companies involved in the Zaibatsu system has helped them to retain positions as key players in the Japanese maritime cluster (Shinohara 2010). With around 80% of world throughput carried by the top 20 shipping lines in 2010 (Notteboom & Rodrigue 2010), however, the horizontal integration of the global shipping industry – mainly through alliances, mergers and acquisitions – has made shipping lines powerful global actors whose operations are largely unbounded by any territorial constraints (Slack et al. 1996).

While the operational mobility of shipping can render maritime clusters vulnerable to sharp shifts in fortune, shipping companies are, however, somewhat constrained in their locational choices for their strategic command and control functions. Indeed, headquarters and regional offices where top-level decision-making and deal brokering takes place must be located in places that can provide the services without which the shipping industry could not function. Maritime services play many roles in for the shipping industry. Shipbrokers, for example, intermediate between ship-owners and cargo-owners that

need to charter a ship; they assist with the buying and selling of old ships and the building and acquisition of new ones; and they also play a key role for principles in the freight derivative market. The shipping finance industry includes investment banks, commercial banks, and more specialised equity firms, which lend substantial sums to the shipping sector. This is an especially important service due to the capital-intensive nature of shipping, but financial actors also provide a range of other services that are very important, such as equity and bond underwriting, merger and acquisition advice, cash management, and foreign currency exchange. Due to the risks inherent in the shipping industry, insurance firms also play a very important part in many maritime service clusters. Insurers provide protection against a range of liabilities including risks to hull and machinery, cargo, energy, and even piracy. The trust mechanisms that proximity enables may provide an incentive to locate headquarters in areas with such insurance services. London, for example, is the biggest centre in the world for protection and indemnity clubs, which provide mutual protection amongst ship-owners and –operators for risks that many insurers will not cover, including third party risks associated with cargo, collision or environmental pollution.

Due to its complexity, the shipping industry is also one that relies heavily on legal services. Often shipping HQs and legal firms will be clustered together, as is the case of Geneva, Hong Kong, and London. On the one hand, they provide solutions and contractual expertise related to a complex range of fields including salvage, pollution, shipbuilding, charterparties, insurance, cargo, energy and the environment. On the other hand, law firms assist in contentious dispute resolution cases. Many disputes in the shipping sector are international in scope, and thus require specific cross-jurisdictional expertise both on the side of the legal firm and on the side of the courts. The opening of the Rolls Building, the world's largest dedicated business, property and commercial court, in London in 2011, for example, was thus heralded as an important move in retaining the city's position as a leading maritime centre. Finally, other services within a typical maritime services cluster include accounting, ship classification and compliance, technical consultancy and research. Different forms of intervention will benefit different aspects of a given maritime services cluster, and it is therefore important to make sure that any cluster-support policies are based on a thorough understanding of exactly which services contribute to the comparative advantage of the cluster.

Shipbuilding and repair

For many decades and even centuries, traditional maritime nations in Europe, such as Britain, Norway, Greece, and Italy, built up important clusters connected to the shipbuilding yards that served the fisheries and commercial industries. Many traditional shipbuilding nations, however, could not keep apace with the rapid technological and economic changes that took place during the 1970's and 1980's, involving increasing capital requirements for exponentially larger container vessels, not to mention the competition from low-cost manufacturing areas. Consequently, the core of the shipbuilding industry has shifted from Europe to Asia. In 2011, China, South Korea and Japan dominated the contemporary market for shipbuilding, controlling 41%, 33% and 20% of the global shipbuilding capacity respectively, and 94% collectively (Clarkson Research Studies 2011). Nevertheless, shipbuilding is an industry that naturally lends itself to cluster formation, due to the regional character of shipyards: they are immobile, and must be located near to water and intermediate inputs (Weissenberg 2006). As a result, some European nations have retained maritime clusters based on shipbuilding activities. Regional specialisation away from large container vessel markets and towards niche markets has been one successful strategy of maintaining shipbuilding activities and putting years of expertise and regional networking to good use (Karlsen 2005). In Italy, for example, shipbuilding is highly concentrated and highly specialised: the Viareggio cluster remains one of the world's foremost mega-yacht centres, and is connected to an important network of subcontracting producers and service providers (Lazzaretti & Capone 2010).

Instruments

Governments are increasingly choosing to actively support and stimulate cluster growth. Table 32 summarises the instruments that have been employed in support of maritime clusters around the world. As mentioned above, policies should be tailored to suit the needs of the cluster's specific comparative advantages and needs. Therefore, not all of these instruments will be applicable to every context. Broadly defined, they can be grouped into four different types: *developmental support* instruments that support the emergence and maturation of embryonic clusters through the formulation of broad development strategies and the provision of basic facilitating infrastructure; *fiscal and financial incentive* instruments that seek to spur or renew growth in already-existing clusters by providing fiscal relief or financial transfers to strategic aspects of the cluster; *coordination and information-sharing* instruments that aim to improve cluster governance and overcome collective action problems; and *human capital matching* instruments that seek to better embed the cluster locally by improving matches between the local labour pool and the cluster's human capital requirements. Each type of instrument is assessed with notable examples below.

Table 32. Main maritime cluster policies

Policy instrument	Scale	Examples
Developmental support		
National maritime cluster strategy	National	Netherlands
National Excellency Programs	National	Finland, Norway
Incubators & research centres	Local	PortTech Los Angeles
Venture capital provision	National & Local	MCF Business development fund, Singapore;
Spatial planning	Local	Los Angeles, Durban
Fiscal incentives/grants		
Ship Registry Initiatives	National	See table 33, below.
Bilateral fiscal agreements	National	Most OECD countries.
Tax exemption for foreign flag ships	National	Singapore's (AISE) scheme
Anti-Piracy measures	National	Most EU countries
Tonnage Tax	National	Most OECD countries
Equity raising measures	National	KG financing model, Germany
Targeted wage subsidies	Local	Quebec, Singapore
Niche shipbuilding	National & Local	Italy, Norway
Coordination/information-sharing		
Consultative fora	National & Local	South Africa, Port of Brisbane
Voluntary National Associations	National	
Local Networking Platform	Local	Deltalinqs Rotterdam
Shipping Exchange	National & Local	Copenhagen, Shanghai, Japan; Baltic Exchange (London)
Human capital matching		
Maritime training and certification	Local	Rotterdam, Singapore
Workplace Initiatives	Local	SEVA-Port, South-East Virginia, US
Maritime scholarships and grants	National	Singapore
Research and Development Programmes	National & Local	Canada; Smart Port Rotterdam;

Source: own elaboration

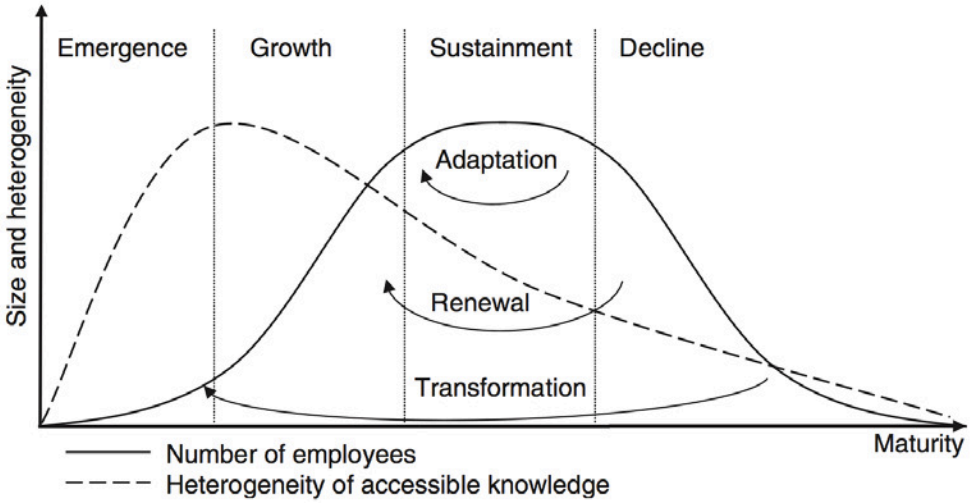
Developmental support

Any government strategy to support maritime clusters should take into account the cluster's stage of development, as the needs of the cluster evolve through time (Brett & Roe 2010; Shin & Hassink 2011). It is possible to distinguish at least four phases in the cluster life cycle. Van Klink and De Langen (2001) have referred to these as development, expansion, maturation, and transition, while Menzel and Fornahl (2010) have identified emergence, growth, sustainment and decline as the four stages of any cluster life cycle. Each stage implies different needs, and thus a different role for government (Van Klink & De Langen 2001): during development, the value chain and strategic relationships are still under construction, so policies should seek to provide information, foster relations and the exchange of know-how between firms, and create supportive infrastructure; during expansion, firms are specialising and seeking out new markets, thus the government should provide risk capital, stimulate outsourcing, and assist with

internationalisation; during the maturation phase, the cluster has an established set of products and supplier-producer relationships, and thus the role of policy should be to further professionalise suppliers and seek out links and synergies with other clusters, in order to avoid stagnation; during the transition phase, changes in the market have brought about decline, new market entries are low and a downward spiral is possible, hence policy intervention should aim to assist with the transition of firms into new configurations or domains, and should seek to retain and reapply local expertise and talent.

Crucially, a cluster does not proceed through these stages in a linear fashion. As illustrated on figure 22 below, policy intervention might facilitate cluster adaptation, allowing it to escape decline and sustain its markets, it might renew a declining sector by re-invigorating growth (as ship registries helped to achieve in many maritime clusters, described below), and in rare cases, the local know-how and expertise from a no longer active cluster may be transformed to create new markets and products.

Figure 22. A stylised representation of the cluster lifecycle



Source: Menzel & Fornahl 2010

During developmental stages of a cluster, the formulation of a broad set of strategies and policies can be a crucial factor in chartering the most optimal growth trajectory. These policies set out a vision and a broad, multi-sectoral set of orientations for the implementation of specific sectorally focused policies and instruments. In Finland, for example, the national government has sought to provide a broad framework for maritime cluster development through its National Maritime Cluster Programme. The programme aims to provide support for all stages of cluster development. It seeks to provide the conditions for the emergence of new clusters through funding innovative initiatives, and helps the cluster identify and pursue new business opportunities (Merk et al. 2012).

The Netherlands presents a good example of how national policies can support the growth and emergence of maritime clusters. Importantly, the Dutch state was able to tailor policy interventions to suite the requirements of the cluster throughout the consecutive stages of its maturity. Throughout the 1980's, the 'mainport' strategy constituted the central guiding principle for maritime cluster development (Merk & Notteboom 2013). Under the mainport strategy, the port of Rotterdam and the airport of Schiphol were promoted above other ports as the key drivers of the Dutch economy. The strategic vision for a "Netherlands, distribution country" (Nederland Distributieland) was enshrined in an overarching policy framework by the same name. In line with this vision, investments in supportive infrastructure were highly concentrated onto the mainports business environment, and various commercial initiatives sought to attract the headquarters of commercial and logistics firms to the mainport areas. This vision succeeded in growing the Dutch maritime cluster, which underwent considerable expansion in re-exporting activities and

managed to attract a large number of European Distribution Centers (Kolk and Van der Veen 2002: Erasmus University Rotterdam – RHV 2010). As the Dutch maritime cluster has become increasingly more complex in its composition and thus in its needs, however, the strategic orientation of the government has shifted away from an exclusive focus on mainports, to one that aims to enhance the competitiveness of the metropolitan region Randstad Holland. This new turn in the Netherland's maritime cluster policy has sought not only to enhance connectivity through information and transport infrastructure, but has also focused on quality of life aspects in the region. This latter aspect of the new policy orientation can be seen as a response to the complexification and maturation of the maritime cluster: it became necessary to seek high-level headquarters and a high-quality labour pool. The mainports are now acting as facilitators for the competitive development of Randstad Holland. This new strategic direction is also echoed in several central government documents including the National Seaports Policy 2005-10 (Ministry of Transport, Public Works and Waterway Management, 2004), the economic vision on the long-term development of Mainport Rotterdam (Ministry of Economy, 2009), but also the Peaks in the Delta programme (2004-2010), the Randstad 2040 vision and the Randstad Urgency Programme (2008).

Provided that it is attuned to the lifecycle of the maritime cluster, broad national policy support is an essential component in fostering cluster emergence and maturation. Local-level instruments also have an important role to play, however. In clusters concentrated around ports, local government and port authorities can stimulate new cluster growth through the provision of basic infrastructure, such as business premises in proximity to the port. The Port of Los Angeles has implemented rather successful support instruments through its PortTechLA program. Created in 2010 in direct proximity to the ports of LA and Long Beach, PortTechLA is a large complex that functions as a business incubator for hundreds of port-related companies and start-ups. It is linked to the Technology Advancement Program, which funds programs in support of the port's Clean Air Plan and Clean Truck Action Plans. Start-ups that provide innovative forms of environmental port technology are thus supported financially by the port, further embedding the growth of the cluster within the specific local needs of the port community. The success of the program's cluster-building objectives can be read in the business demography: in 2013, 87% of the incubated start-ups begun in 2010 were still in business. This success rate is perhaps in part due to the enhanced access to venture capital that the incubator facilitates, both through events such as the PortTechEXPO Pitch Competition, involving local venture capitalists, and through the various business mentoring programs set up by PortTechLA.

In Europe, such local-level maritime cluster instruments are increasingly undergoing a process of policy transfer, in part driven by EU-level networking initiatives such as the European Network of Maritime Clusters (ENMC). In Sibenik, Croatia, for example the Norwegian Ministry of Foreign Affairs has sponsored the creation of a Maritime Innovation Center named CroNoMar, which is meant to function as an incubator for start-ups and development projects in the Croatian martime sector. Norway, which has extensive experience in the field of maritime cluster development, has thus been able to transfer some of its local-level know-how to its Mediterranean partner. The model of the project seeks to foster the emergence of a local maritime cluster specialised in the ship-building sub-sector. Half of the incubator is reserved for 'established' companies, with 25% for services and the remaining 25% intended for use by start-ups. After two years of operation, three ship-building firms had begun business there.

Port authorities can also use a number of spatial planning instruments to foster their maritime clusters at the local level. Such instruments rely on the landlord function of the port authority, used to plan and develop new infrastructure as well as regulate and steer land-use patterns within the port. Port-based spatial planning instruments can encourage maritime clusters in two main ways.

Firstly, they can optimise land-use *within* the port. This involves land acquisition and the reservation of space within the port for future use in strategic sectors of activity. For example, demand for ship repair and

maintenance has increased greatly over the past years concomitantly with the expansion of the world fleet (OECD 2008). When coupled with other shipyard activities, such as conversion or shipbuilding, ship repair facilities can generate economies of scale within the port, and thus contribute to the growth of maritime clusters. However, such facilities present enormous land-use requirements that must be planned for. By reserving space for such facilities, ports such as Dubai and Singapore have enabled the growth of strong shipyard clusters. Furthermore, land-use planning within the port can also involve the clustering of complementary activities. Authorities in the port of Los Angeles, for example, created a new Port Master Plan in 2013 that aims to diversify and expand the commercial and academic uses of port-land so as to encourage innovative collaboration between port logistics firms and research centres. The plan further aims to reduce the presence of non-water dependent activities on the waterfront, mandating a 50% decrease in the acreage of such firms on the waterfront by 2017. Port authorities can and should provide spatial frameworks that make the most of the cluster's particular strengths, and that facilitate growth in its most important sectors.

Secondly, port authorities can also foster the maritime cluster by optimising land-use *at the interface* between the port and its immediate hinterland. In many ports there is room for improvement in terms of inland depots and distribution centres for value-added logistics, which would better suit the needs of the firms that cluster in the immediate hinterland of a port (transloading, warehousing, road haulage, etc.). In Durban, for example, a lack of coordinated planning between the port authority and the city has led to the creation of an informal logistics cluster in the residential neighbourhood of Clairwood. The co-habitation of such incompatible land uses generates many negative externalities, both for the quality of life of the residents, and for the health of the maritime cluster, which is spatially fragmented. In response to these trends, the port and city have collaborated on a Back of Port masterplan, which will create new categories of land-use better suited to the existence of a maritime cluster in the city, and will allow for the progressive rezoning of the back of port area towards an inland depot model. Other ports have taken the principle of interface planning for the maritime cluster beyond logistics, and are using the proximity of the port to the city in order to benefit from the positive externalities that urban agglomerations represent in terms of human capital and infrastructure (Hall & Jacobs 2012). In the Kop van Zuid and RDM campus areas of Rotterdam, the Speicher-area of Hamburg, and the Euro-Méditerrannée area of Marseille, for example, the port-city interface has been zoned for hybrid uses that allow for the co-location of maritime services, educational facilities, and port-related firms.

Fiscal incentives and grants

Once the maritime cluster has been successfully supported and the precedent for further growth has been set, fiscal and financial instruments can provide strong levers for encouraging maritime cluster expansion, and in some cases can help to renew ailing clusters. The global nature of the maritime industry now makes it possible for market actors to relocate their activity to the business environments that are most amenable. In order to foster their maritime clusters, governments must encourage market participation, which often means providing competitive tax regimes. A key issue thus resides in ensuring that tax reductions are offset by net gains for the national GDP and labour market.

Fiscal initiatives aimed at encouraging registration in the national fleet have become popular instruments amongst central governments seeking to provide a boost to their maritime cluster. In many states around the world the problem of declining registered and owned fleets grew severely from 1970-1990, as states running open registries with low tax rates ('flag of convenience' states) increasingly attracted ship-owners from around the world (Carlisle 2009). One of the first maritime cluster policies implemented by central governments has thus been to create low-tax, second registers open to foreign-owned ships, capable of competing with flag of convenience tax regimes (see table 33). The creation of the

Norwegian International Ship (NIS) registry in 1987, for example, was considered 'instrumental' in the turnaround of the Norwegian shipping cluster during the 1990's (Benito et al. 2003).

Table 33. Opening of second ship registers 1984-1998

Year	Registry	Primary User
1984	Isle of Man	United Kingdom
1987	Netherlands Antilles	The Netherlands
1987	Norwegian International Ship Register (NIS)	Norway
1989	Kerguelen (French Antarctica, to 2003)	France
1989	Danish International Register (DIS)	Denmark
1989	Luxembourg (for Belgian ships, to 2003)	Belgium
1989	German International Register (GIS)	Germany
1990	Madeira (MAR)	Portugal
1991	Canary Islands	Spain
1992	Marshall Islands	United States
1998	Italian Second Register	Italy

Source: Carlisle 2009: 322

Besides the low tax rates, which constitute a direct fiscal incentive, the comparative advantage of OECD states with open second registers usually resides in their reputation and credibility with regard to international rules, standards and regulations in the domains of maritime safety, labour laws and environmental protection. Due to the comparatively stringent oversight mechanisms of OECD states, ships that are registered with them are often seen as less risky by insurers, which in turn results in lower premiums for such ships. Thus, because compliance with international standards such as those published by the ISO, the IMO, the ILO increases the attractiveness of the state register, adoption and enforcement of regulations can in fact constitute an important pro-cluster mechanism. In its attempt to increase its reputation and thus its registrations, Singapore, for example, has adopted all major IMO conventions on ship safety and marine pollution, maintains a 'white list' status on most port state control regimes, and is host to no less than nine separate classification societies. Hong Kong has likewise endeavoured to comply with international safety, labour and environmental norms as a way of decreasing credit costs for its registered shippers (CUHK & OCTSRI 2013). Furthermore, both countries have undertaken a range of measures to make registration more attractive. In Hong Kong, these include the removal of registration fees, the introduction of flexible rules for crew nationality, the creation of a 24-hour registration service, free vessel inspections, and the creation of a public relations group for the register. Hong Kong and Singapore's registries respectively occupied the 4th and 6th places on the list of the top merchant fleets by tonnage in 2010, according to the IHS Fairplay data.

In addition to compliance with international norms on safety and the environment, some states with large maritime clusters have seized upon the issue of maritime piracy in order to attract and retain ship-owners. As the instances of piracy in hi-risk areas off the coast of Somalia and West Africa have increased, so too has the demand for new security measures to insure the transport of cargo. However, major flag states diverge with regard to the anti-piracy measures they provide to their registered ships, with some placing restrictions on the ways in which ships can be protected. As concern over ship security in at-risk areas grows, states that offer more leeway on security measures may appear as more attractive flag states to ship-owners, particularly to those operating in piracy-prone areas. To enhance anti-piracy capabilities in their shipping sector, governments use two main instruments. Firstly, the flag state can provide protection

at its own cost through Vessel Protection Detachments (VPDs). VPDs are small teams composed of guards from the government military or navy, and are currently provided by France, Israel, Spain, Belgium and Italy, amongst others. Secondly, states can allow shipping companies to employ Private Security Companies (PSCs). This second measure has proven controversial, resulting in protracted debate in the German parliament in 2013, for example, about the oversight of such PSCs, and whether their operation poses a threat to the exclusively sovereign power to make decisions over the use of force. While PSCs may present issues of training and oversight (Ginkel et al. 2013), allowing them might also bear several advantages, such as cost-effectiveness and flexibility for ship-owners. In nations that allow PSCs, issues of oversight and training should be addressed through the introduction of stringent operational criteria. In Norway, for example, PSCs can only apply for temporary firearms licenses, and cannot engage in the use of force without the approval of the shipmaster. Norway also requires reporting on vetting procedures for any shipping company wishing to use a PSC, including background checks of the staff. Few public accreditation standards for PSCs exist however, and it appears important to move toward the formulation of such standards in order to harmonise best management practices across the global private security sector. As of 2013, major European maritime states that allow or were debating approval for PSCs included Italy, Belgium, the UK, Denmark, Norway, Greece, Spain, Cyprus, Germany and France

Various fiscal measures can be taken to discourage deflagging. One such measure that has been used with success in many states is the tonnage tax. The tonnage tax not only seeks to encourage registration in the state's fleet, but it also seeks to spur employment and productivity in the already-present maritime cluster. Under the popular 'Dutch model' – introduced by the Netherlands in 1996 and implemented by over 20 states around the world – the normal corporate income tax rates are still applied to ship owners' profits, but their profit itself is calculated differently. The tonnage tax under this model sets a given daily profit per ton, which is applied to the total tonnage capacity of the fleet owned by the company and calculated for a full year. The profit thus calculated is then taxed at the country's corporate tax rate, meaning that ship-owners are taxed at a flat rate, irrespective of the company's actual profit or loss. When business is going well, this tax regime often translates into an effective tax rate of <1% for participating companies (PWC 2009). However, when business is going poorly, the tonnage tax can also constitute a drain on participating companies, who must pay taxes even in situations of negative net income (many tonnage tax regimes require a minimum 10-year participation in the scheme with no opt-out option). While the tonnage tax played an important role in slowing the decline in flag registers amongst traditional maritime states in the preceding decades, it has since become something of an international norm, and may no longer be sufficient in and of itself to meaningfully contribute to the maritime cluster. Some states, however have tailored tonnage tax schemes to suit their own national requirements in ways that push the potential of the tax further than simply attempting to reduce deflagging rates.

In the UK, for example, eligibility for the tonnage tax involves two main requirements. On the one hand, ships must be "strategically and commercially managed in the UK". Several factors are assessed as part of this definition: headquarters and decision-making operations of the company should be located in the UK; activities such as route planning, cargo booking, personnel management, technical vessel management, and direction of foreign offices should be carried out in the UK; the overall share of work, and number of employees, in the UK should outweigh that done elsewhere, vessels should be flagged, classed, insured or financed in the UK, and so on. This ensures that the loss of potential taxation through the implementation of the tonnage tax regime is amply compensated through increased activity in the UK maritime service cluster. On the other hand, the UK tonnage tax regime includes a "training commitment", which requires participating companies either to train officers and cadets (who must be British or EU nationals), or to transfer funds to the Maritime Training Trust. This requirement effectively builds a human capital matching mechanism into the tonnage tax regime, ensuring that the maritime cluster remains embedded in the UK labour market. Since its introduction in 2000, the UK tonnage tax has been credited with reversing the decline in ship-owners and operators in the UK, and contributing to threefold and six

fold growth in the UK-owned and UK-registered fleets respectively during the 2000-2009 period (MaritimeUK 2012). The policy has furthermore been credited with contributing an extra 189,700 jobs to the UK economy (direct, indirect and induced), and with more than doubling the shipping industry's GDP contribution compared with what it would otherwise have been (OE 2013).

In addition to the regimes described above, governments might undertake bilateral measures to increase opportunities for firms within their maritime cluster. These include reciprocal tax exemption agreements (RTEs), agreements for the avoidance of double taxation (DTAs), and comprehensive DTAs (CDTAs). The logic behind such bilateral agreements, in which the parties agree to reciprocally exempt ship operators from certain taxes in both countries (RTEs) or in one only (DTAs & CDTAs), is that they foster trade relationships, improve the competitiveness of the maritime cluster, and enhance its attractiveness for ship operators. Maritime and trade-dependent countries often form such agreements. New Zealand, for example, had 37 DTAs in force in 2013, with five signed not yet in force, and seven more under negotiation. Additionally, section CV 16 of New Zealand's Income Tax Act 2007 allows for income exemptions for any state in which reciprocal exemptions are made for NZ ship operators, meaning that most of its DTAs can also effectively function as RTEs.

Finally, clusters can be fostered through a range of targeted fiscal exemption schemes. Exemptions can target a specific sector, such as Singapore's Approved Shipping Logistics scheme for ship agencies, ship managers, international logistics operators and freight forwarders of shipping groups that provide freight and logistics services from Singapore. Or, they might deliberately target foreign vessels, such as the opening of Singapore's Approved International Shipping Enterprise scheme in 1991. A review of the specific mix of pro-maritime cluster instruments that have helped transform Singapore into one of the world's leading maritime clusters is given in box 5 below.

While developmental support, easing of flag registration, and fiscal relief mechanisms remain key instruments that can be deployed by central governments to support their respective maritime clusters, the legitimacy of sectorally-focused direct subsidies has been brought into question in recent years, due to concerns over market distortion and trade disputes. Today, governments risk violating international and national trade laws through direct transfers to specific sectors of the economy, and in certain domains must seek alternative policy solutions. The shipbuilding sector presents a notable example of such trends. While output from the shipbuilding sector grew enormously during the late 1960's, the oil crisis of 1973 severely diminished its global output, with supply outpacing demand. Throughout the 1980's and 1990's, this overcapacity lead to a drop in profitability that developed countries in Europe and Asia dealt with in part through rationalisation policies (caps on capacity increases) and in part through subsidies (FMI 2003). The rationale behind subsidisation was to retain capacity and competitive stance whilst awaiting a new upswing in activity. In 2004, for example, EU-wide subsidies to the shipbuilding sector were in the vicinity of € 100M. However, while the shipbuilding sector did pick up again, profitability did not increase in kind. Furthermore, concerns over the cyclical tendencies of the shipbuilding sector coupled with several trade disputes – such as that between Korea and the EU, over which the WTO ruled in favour of Korea in 2005 – have spurred a global effort to reduce subsidies in the global shipping industry, which has succeeded in the removal of many (if not all) forms of subsidy. In 2013, for example, the European Commission ruled that that tax advantages received by Spanish shipbuilders were unlawful and should be repaid to the Spanish state. While various alternative options for direct and indirect subsidies remain open to the shipbuilding sector in different nations around the world – including the EU, with the non-selective tax scheme approved by the commission in 2012 – other intelligent policy solutions remain open to developed nations seeking to preserve the know-how and sunken capital tied up with their shipbuilding sectors.

Box 5. Maritime cluster building in Singapore

In the past, Singapore had been over-reliant on the conventional port functions of providing cargo handling, ship-related services and storage. However, in light of the need to diversify its business operations and thus maintain its position as a logistics hub, the government of Singapore has embarked on establishing Singapore as a maritime logistics hub. Singapore is now a home to more than 5,000 maritime establishments, with S$ 28 billion gross receipts, employing a workforce accounting for 5 per cent of Singapore's national employment and whose output account for 7 per cent of Singapore's GDP. Singapore has attracted a number of shipping groups to register in its Registry of Ships.

To increase the value-added of the port of Singapore, the Singapore government has undertaken a number of fiscal measures and other incentives to attract advanced logistics companies to locate around the port of Singapore and form a maritime cluster. The strategy is to build a maritime business cluster to enhance position as a logistics hub: a clustering of port and maritime-related activities complementary to the trade in goods and services (linking port operations to international trade) and a one-stop service for customers by providing an integrated maritime logistics services and attaining the economies of scale and scope. Apart from maintaining transparency of regulations, provision of world class infrastructure, provision of adequate supply of skilled logistics professionals and provision of a foreign-friendly environment, fiscal measures and other generous incentives have played a major role towards attaining a maritime logistics hub status. The major tax incentives include the Approved International Shipping Enterprise (AISE) scheme, Approved Shipping Logistics Enterprise (ASLE), tax benefits for Ship Registration and Business Development Support. The AISE offers income tax exemption for 10 years for foreign flag ships provided that the owner or charterer controls a significant amount of ships and have a significant operation in Singapore. In the past only Singapore flag ships were given income tax exemption, and this exemption assisted in the substantial expansion of Singapore fleet in the 1970s and 1980s. However, in many cases there was very little further benefit for Singapore and its economy since a large of that fleet was operated, commercially and technically, outside Singapore. To increase the use of Singapore as a base for the management and control of their shipping operations, Singapore introduced in 1991 a tax incentive under the AIS incentive scheme to exempt shipping lines awarded a AISE status from tax on the income from vessels operated by them, whether registered under Singapore flag or elsewhere. The ASLE provides a concessionary income tax on qualifying incremental income for established ship management, ship agencies, freight forwarders and logistics operators.

To encourage foreign vessels to register with Singapore's Registry of Ships, profits of a shipping enterprise derived from the operation of a Singapore-registered ship are income tax exempt. This applies to income derived from the carriage in international waters of passengers, mails, livestock or goods or from towing or salvage operations carried out in international waters by Singapore ships, and includes charter of Singapore ships. It also exempts shipping companies registered with Singapore from withholding tax on interest payments with respect to offshore loans to finance ships. Under this incentive scheme there is also no tax on gains from vessel sales. The government also exteds business development support to ship-owners and maritime auxiliary service providers by providing grants and defraying expenses at initial development on reimbursement basis.

To foster innovation within the maritime industry, the government has established since 2003 the Maritime Innovation and Technology Fund (MITF) and to address the shortage of supply of skilled logistics professionals, the government has established since 2002 the Maritime Cluster Fund (MCF). The MITF includes the Maritime Industry Attachment Programme, the Joint Tertiary & Research Institutions and MPA R&D Programme, the Maritime Technology Professorships and the Platform for Test-bedding, Research, Innovation and Development for New-maritime Technologies (TRIDENT). The MCF was established by Singapore's Maritime and Port Authority to support the maritime industry's manpower and business development efforts.

One option involves so-called industry shifts, whereby know-how and capital from traditional shipbuilding regions are retained and put to new uses. In their analysis of activities at existing and former shipyards throughout Europe, Giovacchini & Sersic (2012) have identified the development of offshore renewable energy sources as a very common and successful industry shift that has been brought about in many Northern European states due to concerted policy interventions. In effect, the development new offshore wind power facilities – not to mention experimental tidal energy generation equipment – has drawn significantly on the expertise of shipbuilders.

Yet, while industry shifts have allowed some port cities to retain and reuse the capital and know-how tied up with traditional shipbuilding activities, this strategy often represents a move away from – rather than a strengthening of – the rest of the maritime cluster. Alternatively, focusing on 'niches' constitutes another strategy that attempts to maintain shipbuilding activities in connection with the broader maritime cluster. The promotion of niches involves focusing investment into research and development on highly innovative and customised products. In comparison to the large-scale and standardised outputs typical of Asian shipbuilding, specialisation and customisation remain competitive advantages of the European shipbuilding clusters. Niches include luxury yachts, offshore support vessels, cruise ships, and naval ships. As noted above, Italy has managed to maintain many of its shipbuilding activities through the specialisation in cruise and luxury ships, mainly in the shipyards of Monfalcone, Marghera and Sestri Levante (Giovacchini & Sersic 2012). Norwegian shipyards, on the other hand, have specialised in a variety of small vessels, ferries and offshore support vessels. The Norwegian state has assisted in the outsourcing of certain high-cost aspects of the production process to Eastern European countries (such as hull-building), which has supported niche specialisation by enabling the Norwegian shipyards to retain the key value-chain activities while operating at a relatively low cost. Targeted out-sourcing policies might therefore present a viable option for reductions in typically high-cost niche activities, without recourse to subsidies. However, the reality is that such cost reductions are often achieved through reduction in the labour intensity of production, which translates to a drop in employment in the maritime cluster. Retention of niche activities through selective outsourcing is therefore an instrument that is not without its risks, and should be weighed against alternative development strategies focusing on high-growth, non-maritime sectors, such as offshore energy. Niche strategies are best pursued when few alternative options exist, or where retention of the activity in question is particularly important due to highly-dependent supplier industries.

Coordination and information sharing mechanisms

Clusters that are able to coordinate interests among participants are better placed to overcome collective challenges and achieve common goals. De Langen (2004) has argued that coordination can lower inter-firm 'transaction costs' within the cluster (associated with searching for partners, time and travel expenses, performance monitoring, contract specification) as well as increase the 'scope' of cooperative efforts (from investments in the labour pool to collaboration on innovative projects, collective marketing and expansion efforts, and knowledge sharing). In spite of these benefits, however, coordination does not come 'naturally' to firms within a cluster, for at least three reasons (Olson 1971; De Langen 2004): the risk of 'free rider' behaviour by firms who benefit from the cooperative environment without committing their own resources constitutes a disincentive; under situations where benefits from coordination will be unequally distributed, worse off firms will seek to inhibit cooperative development; and finally, the uncertainty of coordination can constitute a risk, disincentivising coordination amongst risk-averse firms.

Without any form of external intervention, coordination between firms within a cluster is thus generally more limited than the optimal level. For this reason, it is often necessary for government or 'leader firms'[12] (De Langen 2004; Nijdam 2010) to intervene in order to structure better governance outcomes. Instruments for better cluster governance can range in scope, from the local to national levels.

Governments have used several instruments to introduce better cluster governance, particularly with regard to relations between the port authority and the port community. These may include statutory consultative mechanisms. In South Africa, for example, where ports are nationally-owned, the National Ports Act created a port consultative committee (PCC) for each port. The PCCs serve as an interface between the authorities, local government, unions and industry representatives, and help to provide better alignment between the key stakeholders of the ports cluster.

Various public actors in port cities around the world have also created voluntary networking platforms that bring together representatives from the industries that make up the maritime cluster (shipping associations, import-export associations, cargo handlers, maritime agents, unions, etc.) and from the local institutions (chamber of commerce, municipality, port authority, regional authorities, etc.). In Brisbane, the Community Consultative Committee is run by the port authority, while in Durban, the Port Liaison Committee is run by the chamber of commerce, and in Mississippi, the River Trade and Transport Council runs the local networking platform, the Lower Mississippi Port Cluster. The Community Consultative Committee in Brisbane, similar to many other platforms of this kind, brings together local environmental groups, the Manly Chamber of Commerce, terminal operators (DP World), and several private actors in the port community. Through this mechanism, stakeholders are able to provide input into the ports plans, enhance cooperative efforts and share information.

Associative initiatives led by the private sector are also important cluster governance instruments, and should be encouraged by policymakers. The Dutch employers' association, Deltalinqs, is a significant example of such a structure. The Deltalinqs association brings together some 700 firms, mainly of the Rotterdam maritime cluster. Individual firms can be members, and are grouped by industry field (ship's agents, bulk and container stevedores, forwarders, pilots, transport and logistics, and so on). But Deltalinqs also features many associative members, such as the Association of Rotterdam Shipbrokers or the Association of Rotterdam Terminal operators, and thus serves as an umbrella-organisation for sub-clusters. Deltalinqs not only lobbies for the interests of the maritime cluster, it also maintains a series of important partnerships with the Port of Rotterdam, the City of Rotterdam, and several educational institutes. Notable joint projects that such partnerships have enabled include: Port Base, a joint initiative of the PAs of Amsterdam, Rotterdam, Deltalinqs and the customs, which serves as a comprehensive information exchange for hundreds of customers and the authorities; Delta Port Donation Fund, jointly-funded by the Rotterdam PA and Deltalinqs, which invests in NGOs working on welfare, culture and sport in the vicinity of the port and industrial area, in order to improve the positive impacts of the maritime cluster; and a series of educational and research programmes aimed at responding to the needs of the maritime cluster through workplace training and new certifications (detailed below).

It is also important to note that transnational cluster networks are growing importance. In Europe, for example, the European Network of Maritime Clusters (ENMC) brings together fifteen national clusters. The EMNC currently serves two main ends: internally, it serves as a forum for the exchange of good practices; externally, it serves as a platform for lobbying for the interests of the EU maritime sector. Other examples include the LeaderSHIP 2015 and 2020 initiatives, which have sought to connect various shipbuilding clusters throughout Europe. The initiative brought together several industry leaders to agree on a strategy for lobbying for improved access to finance at the European level.

Finally, shipping exchanges can also constitute private-led, government-supported ventures that enhance the competitiveness and coordination of the maritime cluster at national and regional levels. Shipping exchanges provide important information-sharing mechanisms, especially for those clusters that have strong maritime finance components. For many years, the Baltic Exchange has helped to spur growth in the UK and London maritime clusters, and contributed to the city's transformation into an international maritime centre. The Baltic exchange is an international source of information on the maritime markets. In addition to its global role, it is a large contributor to the UK ship broking industry. Some 600 companies were members of the Baltic Exchange in 2013, 400 of which were based in the UK. In light of the success that the Baltic Exchange has brought to the UK maritime cluster, it is little wonder that Denmark, Japan and China are now host to their own shipping exchanges. The Shanghai shipping exchange, founded in 1996, plays several coordinating and information-sharing roles within the Chinese maritime cluster: it helps to adjust freight rates; facilitate trade between the shipping elements of the cluster; collect and

publish information on the maritime markets; and standardise transactions. The exchange has helped to improve the international standing of the Chinese maritime cluster: some 300 firms were members of the Shanghai Shipping Exchange in 2013, and major shipping firms such as Hapag-Lloyd, Maersk, Pacific Shipping Company, Kawasaki, and CMA-CGM have subscribed to its shipping index.

Human capital matching mechanisms

As the firms that compose a given maritime cluster are usually highly specialised, they require specific skills that are often in short supply. Increasingly, governments are seeking to better match their local labour pools with the needs of the maritime cluster, as a way of simultaneously promoting job creation and contributing to the value-added of the port.

Many maritime clusters now feature partnerships between universities, local government and maritime firms. These partnerships help to better match the local labour pool with the maritime cluster in three main ways. First and foremost, they give rise to new degrees and certifications that enable local students to develop skills needed by the maritime cluster. Such mechanisms can serve long-term aims of the maritime sector, especially in areas that are experiencing shortages of labour in strategic sectors. In the Rotterdam maritime cluster, for example, the Deltalinqs association has created the Maintenance College, in partnership with Albeda College, and the Process College, in partnership with ROC Zadkine and the Shipping and Transport College. The curricula of such programs are conceived in tight collaboration with the maritime cluster, and respond directly to its labour demands.

Secondly, they provide an avenue for apprenticeships and internships with participating maritime firms. This instrument can provide a very direct mechanism for embedding the maritime cluster within the local context, as it increases the likelihood that skilled workers are retained locally. Such workplace schemes can be especially important in areas that are undergoing changes in their economy and require workforce transformation, and where risk of human capital flight is strong. In South-East Virginia, which has undergone such challenges, the The Seva-Port Partnership between community colleges and the port authority aimed to create a local workforce skilled in the warehousing and distribution sector through such workplace internship schemes. Crucially, this program also targeted young talent through summer programs with local high-schools, that included hands-on internships with participating logistics firms. The YoungShip program in Møre, Norway, has adopted a similar approach, fostering informal contact between young students and key firms of the Norwegian maritime sector. The program, which includes mentoring and aims to increase female participation in the Norwegian maritime cluster, has met with considerable success, and as of 2013 was active in a number of Norway's port-cities.

Thirdly and finally, educational partnerships in maritime clusters often provide scholarships and grants for maritime education programs, which extend the breadth of the labour pool by providing greater access to education, and include the added benefit of attracting international talent. The Maritime and Port Authority (MPA) of Singapore offers a host of scholarships in the maritime field, which often lead to career paths within the maritime cluster. Under the Tripartite Maritime Scholarship Scheme, for example, talented high-school graduates are granted scholarships of up to $50,000 to complete the Diploma in Nautical Studies or in Marine Engineering at the Singapore Maritime Academy or Singapore Polytechnic. Scholars are co-sponsored by the MPA and a participating shipping company or union, with whom they must spend at least three years as a Marine Engineer Officer in fulfilment of their return of service obligations. The program thus ensures that students are being trained for specific positions within the maritime cluster and that talent is retained in Singapore.

An offshoot of these forms of collaboration is that the local institutes do not simply provide better-skilled workers to the maritime cluster, but increasingly also R&D services for ports and connected SMEs.

The Maritime Institute of Quebec, for example, has created its Innovation Maritime research centre within the framework of just such a partnership. Innovation Maritime is recognised as a College Centre for Technology Transfer by Quebec Minister for tertiary education, research and technology sciences, which enables it to benefit from government research grants. For example, any individuals or companies that request research and development projects from Innovation Maritime can apply for tax credits from the Quebec and Canadian ministries of science and development, and the centre is further eligible for grants from the Natural Sciences and Engineering Research Council. In 2013, Innovation Maritime had successfully carried out more than two hundred research and development projects for various fields in the maritime cluster. Similarly, the port of Rotterdam has actively engaged in such R&D development initiatives through its partnership with the Erasmus University. The Smart Port research centre thus aims to meet a growing demand for maritime research and expertise, and collaborates with the port to produce research of direct relevance to the maritime cluster. Such collaborative R&D efforts between universities and ports are increasingly taking on a global dimension. The Singapore Maritime and Port Authority has not only signed MOUs with three of the leading universities in Singapore (NUS, NTU & IHPC), but has also begun to invest in joint R&D with the Research Council of Norway – which provides the scope for a range of collaborations between industry and universities in both countries – and jointly organises the International Maritime-Port Technology and Development Conference with the Port of Rotterdam.

4.2 Port-industrial development

In many port-cities, industrial development and port development have traditionally gone hand in hand. These forms of port-city industrialisation were more or less spontaneous, occurred during various stages of port-city development and were in many cases determined by urban specificities and land site conditions and availability. E.g. in the western Mediterranean before 1919, there were industrial zones growing spontaneously in the ports of Marseilles, Taranto, Naples, Barcelona, Genoa, Valencia, La Spezia, Piombino, Savona and Palermo (Verlaque, 1981).

Since the late 1950s, a wave of planned industrialisation related to ports takes place. These policies were in most cases driven by national states supporting national champions as a means of developing economically disadvantaged areas, by restructuring industries and creating new growth poles. The fundamental reasons for their development lie within the sphere of maritime transport, namely the development of very large bulk carriers, which have dramatically reduced the costs of long-distance ocean transport (Vigarié, 1981). This heavy industrial development in coastal areas, frequently referred to as Maritime Industrial Development Areas (MIDAs), was very land intensive with requirements for sites of at least 2000 hectares. Major MIDA projects in Europe, US and Japan, all took place in the late 1950s. The Botlek scheme in Rotterdam became operational in 1958, later extended with the development of the Europoort and the Maasvlakte, which created an area of over 10,000 hectares devoted to oil, chemical and shipbuilding industries. Antwerp developed at the same time a large site for heavy chemical industries, whereas Amsterdam and IJmuiden introduced a major iron and steel complex. Other European examples of MIDAs include Dunkirk, Fos-sur-Mer, Le Havre, Hamburg and the Weser ports, Teeside in the UK, and Livorno in Italy. Also in Japan, ports were considered the lynchpin of regional development in their port policies; the regional development impact of port development projects was considered a sufficient return on port investment. In 1964 An Act on the creation of Special Areas for Industrial Development was approved in which ports served as hubs of development. In line with this, « developer ports » were created in depressed regions as a catalyst of industrial and urban development, e.g. in Kashima and Tomakomai (Olukoju, 2003).

Originally concentrated on heavy industries, policies gradually shifted to lighter industrial activities, after the economic crisis of mid-1970s. New oil refining capacity and production of primary chemicals and

steel in developing countries meant a rationalisation of the industries that underpinned MIDA development, with a re-focusing of port development projects. At the same time, there was an increased pressure of the population of port-cities such as Rotterdam, Hamburg and Yokohama, to limit pollution and diversify economic activity. Larger areas in ports became devoted to warehousing, commercial activities and development of light industries. An example is the port of Gioia Tauro in southern Italy, perceived in 1970 as a future MIDA, but transformed into a container transhipment port in the mid-1990s after decades of non-existing industrial development and non-realisation of projected steel plant and electrical power plants (Dunford and Yeung). Policies related to MIDAs are special economic zones, often located in or close to ports, which are provided with attractive conditions in order to attract industrial development.

Port-industrial planning projects like these have had mixed success rates. In many cases, they have led to rapid increases of population, employment and economic growth. They have in some cases increased the industrial potential of nations and facilitated the restructuration of post-war economies. The "developer ports" policies in Japan have facilitated rapid transformation of agricultural areas into industrial and commercial zones, with spectacular growth rates in Kashima (Vigarié, 1981; Olukoju, 2003). At the same time, there have been many partial failures as a result of over-ambitious projects or of a lack of continuity in planning. In southern Italy, no effective MIDAs were developed apart from Taranto (Vigarié, 1981).

One of the main challenges related to port-industrial development is the creation of linkages with the local economic tissue. This is challenging because most of the industries that have invested in MIDAs are multinational companies whose development strategies that are often not aligned to those of regions and cities. As was illustrated before (in the chapter 2.1), industries within port clusters are not always strongly inter-related and there are many economic spillovers to other regions in the same country – or other countries. A related challenge is the bottom-up character of these projects that in many cases ignored the existing regional assets in terms of skills and competencies. E.g. in Dunkirk, the arrival of heavy industries has meant a transformation of employment representing diverse competencies related to the textile and port industry (such as fishing nets, sails and other artisanal activities), into low-skilled industrial work with hard labour conditions (Boutillier et al. 2011).

This lack of economic linkages within the region might enforce vulnerability of regions related to one-sided economic development and path dependency. Port activity in large industrial ports can be largely focused on industrial activity at the detriment of commercial port activities. This is the case in large port-industrial complexes, but also in other ports with strong industrial orientations. In Antofagasta (Chile) all port activity is focused on the copper mining industry, creating vulnerability due to specialisation and missed opportunities in terms of the creation of an urban logistics sector (Merk, 2013). Various ports with industrial character have tried to develop other port functions, such as container terminals, but have not always succeeded (Amsterdam, 3% of total traffic in Dunkirk). Such one-sided port-related development might increase economic vulnerability, because of one-sided economic orientation, but also constrain future development perspectives, because it could enforce economic locked-in-effects. In the case of Dunkirk, the emergence of entrepreneurship is blocked by the dependence of the region on industrial activities that have led to an accumulation of specific assets that favoured heavy industrial development according to some authors (Boutillier et al. 2011).

Some port cities have tried to synergise new and emerging sectors with the port as a way of tapping into the human capital and knowledge resources otherwise 'locked into' the port and logistics sector. By building institutional linkages, local governments hope to transform their labour markets and reduce the local costs of business. This is precisely the aim of the South-Eastern Virginia Partnership for Regional Transformation (SEVA-PORT) (Box 6).

Box 6. South-Eastern Virginia Partnership for Regional Transformation

Through the SEVA-PORT partnership, Virginia aims to tether its well-developed port cluster – and especially the industries involved in transportation, warehousing and distribution – to the sector of computer modelling and simulation, which specialises in the creation of sophisticated models for use in the fields of gaming, engineering, and medicine, and is also crucial to the operational aspects of logistics. In addition to creating this economic synergy, the policy is also intended to work as an inclusive employment mechanism, and to this end has implemented a diverse array of training programs targeted at the youth and dislocated workers. The first step in the project was kick-started in 2007, when the SEVA-PORT partnership was awarded a 5 million USD grant, created to support regional transitions from traditional industrial or agricultural sectors to innovative information-based sectors. Key to obtaining this funding was the creation of a broad regional partnership, which brings together 24 cities and counties, a number of business and industry representatives, over ten different educational institutions, and several economic development agencies from state and local government. The key mechanisms of the policy focus on upgrading the educational opportunities that will create a labour pool at the nexus of these two industries. This involves integrating certificate programs for warehousing and distribution, truck driving, and modelling and simulation into the degrees offered by community colleges, and the expansion of internship opportunities in these same sectors through links with the private sector.

The economic vulnerability of industrial development in ports is underlined by the current global industrial restructuring. Ongoing outsourcing of heavy industries from developed economies to emerging economies has led to the closure of many industrial plants on port sites and the need for industrial reconversion. E.g. the petro-chemical cluster on the port site of Marseilles-Fos is struggling, with various closures of refineries and further closures in sight (Merk and Comtois, 2012). The port of Rotterdam foresees a large-scale restructuring of the refinery industry and aims at bundling forces with the industrial complex of the port of Antwerp in order to be the only European location of refinery activity in 2030 (Port of Rotterdam, 2012). Although there is increasing talk of near-sourcing, indicating a reorientation of industrial activity closer to consumer markets instead of low wage regions, there are few empirical data that seem to underpin this trend (Drewry, 2013). With this perspective of looming industrial rationalisation, many ports and port-cities are assessing new industrial opportunities that could build on existing assets and infrastructure to be developed. These opportunities include industrial ecology and renewable energy, two new port-industrial options that will be explored below.

Industrial ecology

Industrial ecology, also referred to as circular economy, aims to provide systematic management of material and energy flows, using waste from one process as an input to another process. Where this cascading of materials or energy is achieved through collaborative relationships between normally unrelated industries, it is referred to as industrial symbiosis. Following the first widely acknowledged example of Kalundborg in Denmark, experience has been accumulated in various industrial ecology cases around the world. Basic condition for cases is the physical proximity of the firms between which interrelations exist or could be created.

Port sites have large potential for industrial ecology projects. Many ports are large industrial estates where various industrial firms are clustered. This physical clustering provides many opportunities for synergies. What is more, ports can have substantial influence in co-siting of industries that could engage in industrial ecology projects. Various ports all around the world are engaged in on-going industrial ecology-projects; among the various initiatives of industrial ecology in port areas, a recent overview analyses in detail 31 initiatives in 23 different ports (Mat and Cerceau, 2012). An assessment of these initiatives illustrates that various motives lay behind these projects, ranging from pollution prevention, process

optimisation, waste management, internalisation of environmental costs, local economic development and competitiveness.

While initiatives analysed in North America appear to be driven by environmental motives such as pollution prevention and environmental protection, industrial ecology in Europe and Asia is mainly understood as a driver for economic development in port-cities. Initiatives in Dutch ports, including the port of Amsterdam, Zeeland Seaports and the port of Moerdijk, aim at developing industrial ecology in order to attract and sustain businesses. For instance, since the 1990s, industrial ecology is developed as a lever for competitiveness and attractiveness in the port of Rotterdam. The OCAP-project[13] supplies horticultural businesses with residual CO2 from Shell Pernis located on the port site, using a disused pipeline and a new distribution network of 130 km of smaller pipes. Fostering local economic development was also at the core of projects performed in Antwerp, Ghent and Brussels. Several Japanese ports, such as Osaka, Kawasaki and Kitakyushu transformed themselves into recycling hubs (OECD 2012), while eco-industrial parks have been developed in various Chinese and South Korean ports, including Tianjin, Ningbo and Ulsan.

Among the 31 case studies, the main economic sectors in which port industrial ecology projects are implemented are energy, waste, chemicals, petrochemicals, water management, construction materials, maritime industries, metallurgy and the agro-food sector (Mat and Cerceau, 2012). However, this study does not pretend to be exhaustive and there are many more synergies in port-industrial clusters to be reaped. In France, for instance, a national workshop gathered, in 2013, stakeholders of the 7 main French port-industrial complexes in order to highlight the industrial ecology dynamics in progress in these areas and pave the way toward further networking in order to share best practices and expertise.

There can be various drivers for industrial ecology on port sites. Initial drivers are in many cases, governments' pressure for more environmental responsibility. E.g. one of the drivers of the continuing effort to push forward the economic use of waste heat capacity in the port of Rotterdam was the pressure from the regional water board, which made it clear that they would no longer accept the emission of heat into the surface water (Baas and Huisingh, 2008). Many of the Asian projects are top-down driven, based on national strategies such as the Circular Economy Law (China), the Green Growth strategy (South Korea), Recycling Ports plan (Japan) and the Eco-town program (Japan). Important facilitators are knowledge institutes that have helped delivering technical expertise and innovation; and facilitating exchange of information and best practice; e.g. the University of Delft conducted a study in collaboration with the port of Rotterdam to explore the possibilities of a methanol-based industrial cluster in the port area (Herder and Stikkelman, 2004). This example of port industry and university collaboration fits into a larger picture of cooperation in this field (Box 7).

Co-siting and clustering can support these exchanges and utility sharing. Ports have possibilities to influence this by their zoning regulations in their port master plan by which they can cluster industries, give them water access or access to railway or inland waterway connections. In addition, they dispose of incentives to attract certain industries, e.g. through their concessions for port land sites. Although port authorities can have an important role in co-siting, but much depends on whether the industrial activity takes place on the port area; e.g. both the port authorities of Rotterdam and Antwerp act as landlords not only of port terminals but also of large industrial estates hosting the world largest chemical clusters; this gives them more room to organise synergies via co-siting or utility sharing than for example the port of Tarragona, that is related to a large chemical cluster on land that is owned by the chemical companies themselves (EPCA, 2007).

Box 7. University initiatives on behalf of the port of Rotterdam

Although it has its sights firmly fixed on a global role, the Erasmus University Rotterdam has shifted its strategy in recent years and is now clearly committed to local and urban development. The economics department recently created a "Smart Port" Centre, bringing together training, research and consultancy services linked to the port's activities. Erasmus has also joined the "Generation R" Programme and the Rotterdam Climate Initiative, or RCIP (with financing for start-ups in the energy and climate sector). The university has been in charge of many impact studies for the Maasvlakte 2 programme and the westward move of the harbour. The university's Institute of Urbanism promoted the idea of the floating city, which is now in place in the downtown area. Similarly, the Technical University of Delft (TUD) has co-operated with the port authority in the field of computer modelling. It has a common interest with the city and the port in safety and security and transportation analysis. In this sense, the metropolitan area and the port can be considered a laboratory for research activities. The port of Rotterdam has developed on the strength of traditional activities, in particular chemicals and petrochemicals. The port industrial cluster has expanded with new international services, forwarding agencies and multinational company head offices. The fact remains that the majority of small and medium enterprises active in the port are engaged in logistics, transportation and trade, and involved primarily in the carriage of cargoes to and from their port of shipment. These firms have little interest in innovation. It is estimated that only 1% to 2% of the turnover of the port and industrial cluster is devoted to R&D. These are in fact mature industries that show clear signs of becoming ossified in routine activities.

To deal with these risks of "cognitive lock-in", local leaders have sought to reconfigure the city-port interface. Rotterdam University (university of applied sciences) has established a new campus for research, design and manufacturing (RDM) in one section of the old port. An incubator managed by the Technical University known as "Yes! Delft" has been established there. RDM Innovation Dock is part of the campus, Its goal is to connect practical research and entrepreneurship, by creating a degree of integration between higher education institutions, services and private industry. All these initiatives take place within an ambitious plan promoted by the city (City of Rotterdam Council) and the Port Authority, the goal of which is to redesign "Stadhavens Rotterdam" and make it a showcase for water management, by exploiting Dutch expertise in flood control and extending this know-how into the area of climate change. Beyond the RDM, the strategy relies on three other broad objectives: re-inventing delta technology in the context of the Rotterdam Climate Initiative, developing floating communities, and sustainable mobility programmes (the object being to halve lorry traffic). Rotterdam intends to become a knowledge port.

In the absence of these drivers, the development of industrial ecology in ports is more complicated. Royston (2011) explains the moderate adoption of industrial ecology on port sites in the UK by more private ownership, smaller land holdings, hands off government policy and the absence of business associations that could have created a facilitating environment.

Renewable energy

Synergy strategies in ports' long-term strategic visions increasingly focus on renewable energy. Such visions, which set out a long-term blueprint for the port's strategic development on a 20 – 50 year timeframe, are increasingly being used as a mechanism for encouraging policy alignment with industry representatives and local government, and they are also integral to contemporary marketing and promotion strategies of ports. Rotterdam's Port Vision 2030, for example, published in 2011, is based on a synergy strategy that would see the port linked to its emerging sustainable energy sector. Similarly to the SEVA-PORT partnership, the Rotterdam Port Vision 2030 envisions this cluster synergy to be an agent driving deeper industrial transformation. Accordingly, as the port of Rotterdam increasingly switches to the use of clean fuels and bio-based energy, and integrates energy recycling and carbon capture policies into its operations, this should drive demand for transformation in the adjacent energy clusters from the present-day dominance in petro-chemicals, to sustainable forms of energy production. Already Rotterdam is one of the largest European importers of LNG, and the port is equipped with an advanced set of liquid bulk refineries that could be used for bio-fuels. To oversee and encourage this transition, the port has invested

into the development of a synthesis gas (syngas) cluster, and has begun construction on carbon capture and storage infrastructure.

Driven both by forecasts for increasing oil prices that may diminish imports going forward, and by the increasing stringency of environmental regulations that are causing many ports to consider onshore power and renewable energy generation, similar sorts of synergy strategies between the maritime and new energy sectors appear to be growing in popularity. In addition to Rotterdam, several Dutch cities and ports have based their growth strategies on such links. Groningen port hopes to develop into the Bioport Eems Delta, which would be the main importer and transhipper of biomass. To this end it has developed several partnerships with industry and local authorities, including a shared roadmap with the Northern Netherlands region. Furthermore, the port-city region of Zeeland, between Antwerp and Rotterdam, for example, has a well-established agricultural and chemical sector and a set of policies aimed at fostering synergies between the emerging bio-mass activities of these two clusters and that of the port. As part of these policies, the port of Terneuzen has implemented a project with two local renewable agriculture companies, which combines horticulture with carbon-capture.

The fast boom of marine and offshore wind energy (OWE) development in recent years, especially in European waters, presents significant potential for port cities to develop new and green industry sectors that can generate substantial economic benefits in a sustainable way. With almost 3,000 megawatt (MW) of offshore wind capacity installed in 2010, offshore wind energy is one of the essential strategic elements for the European Union (EU) to meet the ambitious goals in its renewable energy agenda, which targets installing 45 gigawatt (GW) offshore capacity and investing about EUR14.4 billion by 2020. Within the EU, the United Kingdom and Germany are two of the leading countries in terms of OWE deployment. The UK aims to have 18 GW installed by 2020 and 40 GW by 2030, while Germany is targeting for 10 GW by 2020 and 25 GW by 2030, respectively (EWEA, 2012). According to the European Wind Energy Association (EWEA, 2013), an offshore wind turbine with a capacity of 2.5-3 MW can produce electricity to supply 1,500 average EU households. As the largest offshore wind farm of the world, the London Array project was recently complete, which is expected to generate enough energy to power nearly half a million homes for England with its 175 massive wind turbines (LondonArray, 2013). The expansion of the OWE industry also extends to the worldwide market, such as Asia and North America. Having the most remarkable progress, China finished the first OWE project in 2010 at the Shanghai Donghai Bridge, which has a capacity of 102 MW. The China Wind Energy Development Roadmap 2050 further foresees that the country would have 1 terawatt (TW) of wind energy installed by 2050, of which the offshore energy potential is estimated as 500 GW (IEA and ERI, 2011). In the United States, although no construction has started yet, thirteen OWE projects in ten states are in place, representing more than 5 GW of capacity (NREL, 2010).

As one of the key growth sectors of renewable energy, offshore wind energy is envisaged to bring employment and value added to the ports, by constructing future power supply systems, clustering related industries to the port areas and hence revitalising the economy of port cities. In the EmployRES study that assessed the impact of renewable energy policy on economic growth and employment in the EU, it estimated that the gross employment in the offshore wind energy sector in selected North Sea countries can be 115,000 jobs, given the assumption that the EU renewable energy targets are met by 2020 (Ragwitz et al, 2009). In addition, a number of studies have also been conducted to provide the figures on potential employment in the OWE sector in the U.K. by the end of 2020 (Carbon Trust, 2008; Boettcher et al 2008; RUK, 2011; and CEBR, 2012). Although the methodologies could vary among different reports, all studies assumes that the number of jobs per MW is inclined to increase as the new installed capacity goes up as the benefits within the supply chain and export potential would grow with scale (McNeil et al, 2013). For instance, 18 GW installed by 2020 could generate 22,900 to 43,400 jobs and having 40 GW installed by 2030 could raise that number up to 96,400 jobs (ibid.). Ports are the decisive nodes on the logistics chain

for both construction and installation of the Offshore Wind Energy Plants (OWEP), as well as operation and service which includes maintenance and repair of the Offshore Wind Farms (OWF) and OWEP (Uniconsult, 2013).

Depending on the associated activities and functions, there are mainly two types of ports, namely base ports, also called as major components ports which cover the manufacturing and construction activities, and service ports, which include the operation and maintenance aspects. To be more specific, four main functions can be distinguished for ports to engage in OWE. They are fabrication and installation; operations, maintenance and service; research and development; and lastly, import and export of onshore and offshore wind energy plants and components (Uniconsult, 2013). Besides the traditional logistics tasks as storage, stowage and transhipment for the components, there are also multifaceted opportunities for ports to benefit from engaging in the business, such as related industry clustering, further development of infrastructure and research facilities (Uniconsult, 2013). On the other hand, market players in the industry, including OWF developers, component manufacturers and designers, ship-owners, operators and energy providers, are also evaluating ports in terms of their handling capabilities and capacities when making choices on location. Therefore, it is critical for ports to be aware of the requirements for the OWE industry and then strategically position themselves to meet the industry needs.

Whether for a base or a service port, there are some shared preconditions that are extreme important for the ports to be able to meet. For example, the high quality of location factors, meaning the availability for expansion and qualified labour force, and excellent connectivity of the port to its hinterland for logistics transport (Uniconsult, 2013). Because the fabrication of OWE turbines is often decentralised, meaning that the components are produced in different sites – in many cases in the hinterland, and then transported to the storages areas near the ports. Therefore, not only having sufficient storage space to carry out the pre-assembly or pre-store activities is important, an efficient hinterland connection for transporting the heavy-lift cargo is also imperative, especially for ports that serve as the consolidation ports in this supply chain, such as the Port of Belfast in Northern Ireland (ibid.). A study conducted by the ORECCA (2012), described the further detailed technological requirements for ports and vessels to be able to handle the OWE operations. It pointed out that the keys to become service ports include easy accessibility, the ability to accommodate service vessels and sufficient storage space for spare parts. Another study (Guillen et al, 2011) analysed the port infrastructure requirements by comparing OWE developments at different stages in the EU and in the United States. From receiving inbound cargo via intermodal systems, to handling and assembling the materials at ports, to staging components for transporting to the offshore wind farms, and lastly to outbound logistics including moving components elsewhere and transmitting the power to the grid, the entire logistic chain is developed and the required criteria for each element is established in the study.

In spite of the location and infrastructure requirements, the strong political commitment from the government is also of critical importance to the developers to determine whether to make their investment in a particular port. Offshore wind energy is not only capital intensive, it also requires significant technological resources. Compared to onshore wind energy, the capital cost for offshore wind projects is twice as much as that of onshore, with the operation and maintenance costs could even go up to three times (World Bank, 2010). The accessibility to the wind turbines, which is not an issue for onshore wind, could become a barrier in offshore wind farms. In some countries with high population density in Northern Europe, the limit of space for developing large-scale onshore wind power farms, actually stemmed the OWE development to become an important element in the national energy mix. In addition, the wind speed is often higher in the coasts than onshore in these countries. Therefore, the improved power production resources can, to some extent, offset the high capital costs and additional operational costs for offshore wind projects. On the other hand, some countries in southern Europe, the United States, and China, enjoy abundant land resources for onshore wind energy production, and thus onshore wind is a more competitive

option for renewable energy development with its lower costs. In this sense, the support from the government in terms of policies, strategies and incentives, is of particular importance to boost the confidence of the industry and foster the development for OWE farms. Investment in infrastructure and technology, facilitating effective stakeholder management and stable policy drivers are critical to the success of kick-start a virtuous spiral of cost reduction and efficiency (Wiersma et al, 2011). National and regional governments can play a key role in this respect to stimulate the growth of the offshore wind market and harness the development of the OWE industry through taking pro-active and enabling actions.

In practice, a competitive institutional framework provided by the national government is necessary to support the development of the OWE industry, as any other renewable energy industries, with general policy instruments and approaches like tariff feed-in, quota and tax incentives. As a windy island set in shallow waters, the U.K. has a natural advantage to develop OWE technology (McNeil et al, 2013). The U.K. government has introduced a feed-in tariff for renewable energies since 2010. While this feed-in tariff is only permitted for energy plants that are smaller than 5 MW, the OWE is mainly subsidised through a regulation called the "Renewable Obligation" (Uniconsult, 2013). It determines an obligatory minimum share of renewable energy in the total energy mix and the Renewable Obligation Orders commit the electricity suppliers in the U.K. to abide the defined quota. For supplier that cannot fulfil the quota, then a "buy-out" penalty is going to be implemented as they need to pay the fines for every MWH that is missed for their target set by the government. Subsequently, the collected fines will be put into a fund and distributed among the suppliers who have achieved their quota. In France, the strategy of attracting offshore wind manufacturers lies in government strategy and ministerial activism through its approach to procurement and by providing state finance to firms in the private sector (McNeil, 2013). In Asia, the Chinese government is also catching up to develop its OWE system and provides supporting schemes such as a discounted corporate income tax or value-added tax as well as feed-in tariffs or funds (KPMG, 2011). Japan and South Korea also have announced the plan for investment in OWE farms and approved feed-in tariffs regulation that will boost their OWE production. In the U.S., production tax credit (PTC) and investment tax credit (ITC) are the main policy tools used to subsidise renewable energy.

The policy certainty over a longer period of time is also of critical importance to give the developers and suppliers the ability to plan for the long term and ensure the continuity for port infrastructure upgrades. In Germany, the law of "*Erneuerbare Energien Gesetz*" (Renewable Energy Law) is the major legislation that provides subsidies to support the development of the wind energy industry. German ports are not only being adapted to meet the domestic industry demands, but also to facilitate export to foreign markets (McNeil et al, 2013). Local municipalities, who own and manage the ports, can hence make long-term investment decisions that will take into account of the potential economic benefits brought to the local economy. Around €200 million was invested by the Bremen state government in OWE infrastructure and incentives on the banks of the Weser. Besides having a skilled work force and the strategic location, a strong pro-active approach by political and regional authorities also contributes to the success of Bremerhaven's integrated development as the OWE hub in the North Sea. For instance, the approval for wind turbine construction permits is rather efficient. Moreover, lower investment rates are provided and short-term leases are also available to the developers and operators. Such strong support brought substantial outcomes to Bremerhaven, with 5,000 workers being employed in OWE, which is approximately one-third of all employees in the OWE sector nationwide (Azau, 2012). Not only major offshore wind turbines manufacturers and rotor blade manufacturers have established production bases in Bremerhaven, steel foundations and offshore construction companies have also come to locate within the port, as well as research institutes. Striving to become a prime construction port for the German offshore wind farms and the base port for *Nordsee Ost* project, the OWE cluster is growing strongly as the port-city is further upgrading its specialised infrastructure and developing more available land space for expansion of the supply base within its complex (Guillen, 2011). The government of Denmark has given continuous financial support to the OWE market since the late 1970s, along with policy certainty and a stable

regulatory environment to bolster the domestic industry. The strong focus on building onshore wind power supply chain and driving down the energy cost has resulted a very matured supply chain, whereas no overseas-built wind turbines are imported to meet the needs of the domestic market.

In view of the increasingly rigorous environmental standards applied on maritime operation, ports are also exploring the diversification in its industry portfolio, such as tidal, wave and marine current energy. Tidal energy projects use tidal amplitude caused by the gravitational forces of the moon to generate power while wave energy is generated by the movement of a device either floating on the surface of the ocean or moored to the ocean floor. The constant movement of the marine current can be used to drive the rotor blades with wind turbines, thereby capturing the kinetic energy to generate electric power (FEMP, 2009). Such ocean energy is highly dependent on the feasibility of physical environments, which can be very challenging in terms of the required marine engineering technology such as tidal turbines and wave devices. Although none of the technologies is widely deployed for commercial use yet, the potential of ocean energy as a credible alternative low carbon energy resource is still significant, with the global potential capacity by 2050 being estimated at 748GW (ORECCA, 2011).

Currently, the ocean energy industries are still at an early stage of development, with a limited number of operations being exist worldwide, albeit the rapid technological improvement is expected to drive down the high production costs. The tidal resource produces variable, but highly predictable energy, although these resources are also highly localised in sites that have particularly strong ocean currents. The technology of tidal barrages is relatively more mature than others, but only four tidal power plants are in operation, notably the 240 MW La Rance barrage in France, which has been generating power since 1966 (IEA, 2011). The largest tidal power plant was brought into commission in South Korea in 2011 with a capacity of 254 MW. There are also two other smaller scale systems built in Canada and China. Although most of the technologies for wave energy are still in the research or early development stages, it holds substantial potential with an estimated worldwide potential at 29,500 TWh/year (terawatt hour per year) by the Ocean Energy System (OES) (IEA-OES, 2011). There are several prototypes being developed in a context of proliferating technological development (Ernst&Young, 2012). However, the diversity of systematic concepts and the uncertainty of marketisation make it difficult to assess the costs and schedule for large-scale commercialisation of wave energy projects. In addition, the engineering challenges associated with intercepting energy from wave or tidal power efficiently are also affecting the growth of the industries.

In order to achieve their respective goals in renewable energy portfolio, some countries are also undertaking feasibility assessment to seek the potential for ocean energy development. As one of the leading countries for ocean energy production, France has natural advantages in terms of having some of the strongest currents in the English Channel. The ports of Cherbourg and Caen-Ouistreham in Normandy are undergoing some extensive expansion in order to accommodate the expected tidal energy project with a full-scale deployment of 300MW. By targeting to reach the 15% renewable energy share by 2020 and to reduce GHG emission by 80% by 2050, the U.K. government is actively increasing the deployment of renewable energy, with marine energy being one of the strategic priorities for its abundant resources in tidal and wave streams (UK Renewable Energy Roadmap, 2011). The potential benefits of wave and tidal energy development to the UK are also substantial. According to RenewableUK (2013), the marine energy industry has been forecast to be worth £6.1 billion to the UK economy by 2035, creating nearly 20,000 jobs. Recently, the Port of Milford Haven has partnered up with a marine renewable energy company based in Cardiff (Whitlock, 2013). The port agrees to provide facilities for the storage, assembly, deployment and maintenance of the DeltaStream tidal generation unit and for an operations centre during the demonstration programme. In the U.S., the Department of Energy has commissioned several studies to calculate the maximum kinetic energy available from waves and tides off U.S. coasts that could be used for future energy production, which represent largely untapped opportunities for renewable energy

development (EPRI, 2011; Georgia Tech Research Corporation, 2011). Another study was conducted to provide the Chilean government on the potential strategies to develop marine energy in Chile, as well as the required regulatory framework in order to achieve the desired benefits (University of Edinburgh et al, 2013). The Port of Valparaíso (Chile) is working as a sponsor with different local universities and companies, to promote development in the research of maritime power, especially the wave and tidal power. These institutions will be allowed to test their prototypes in the port maritime areas, and in the future, might feed with electrical power some of the public spaces of the port.

The capacity of ports is essential in terms of the layout design and facilities that are required for installing wave and tidal power arrays, which is often complicated and needs a dedicated location for deployment of specialised vessels, components and equipment. Supporting infrastructures and grid connections are also critical to ensure the successful and cost-effective transport of electricity output. Moreover, ports also need to be aware of other issues resulted from ocean energy development, such as the ecological impacts to marine life and the marine environment, as well as to other marine users like shipping and fishing industry.

4.3 Port-related waterfront development

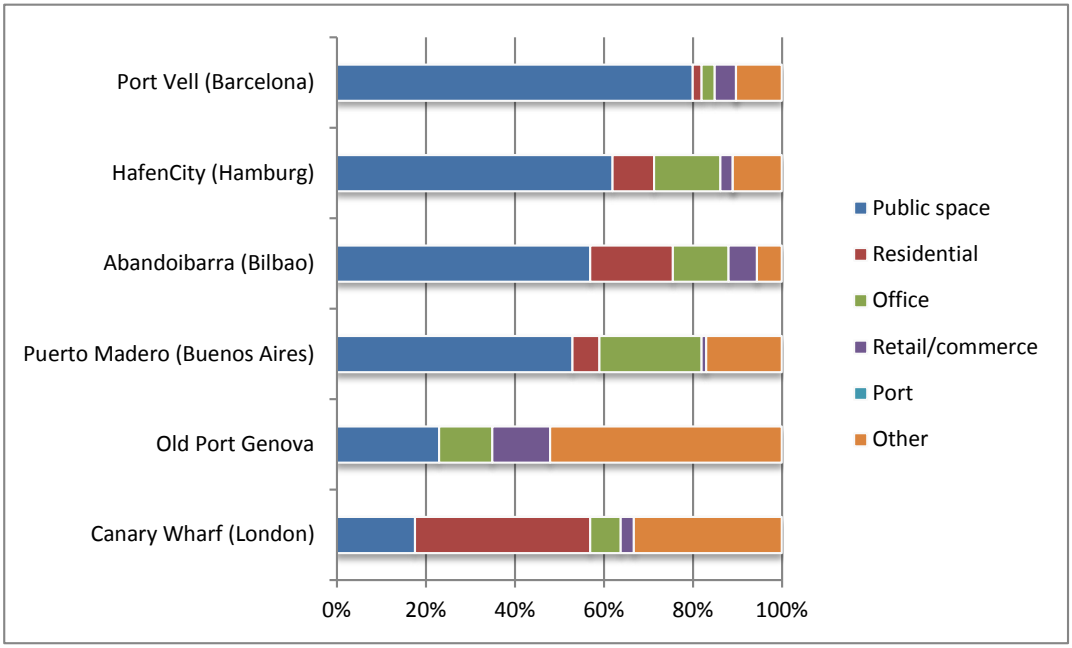
Port-related waterfront development provides the third policy option to increase local economic value from ports. These waterfront development projects transforming old industrial port sites into contemporary places of consumption follows similar dynamics all over the world. The emergence of the containing shipping industry accelerated the abandonment of old port areas all over the world, mainly due to the fact their piers had too little space to deal with containers. As a result, port functions, especially deep-sea shipping, started moving out of the historic old port area. Ports were faced with the enormous challenge – and opportunity – that surrounds the redevelopment of huge, abandoned land areas, including the old port and the original waterfront in the heart of the urban core (Brown, 2009; Hoyle, 1988). Port-related waterfront development might present an opportunity to create a new image, or marquee, for a city or a region – a new waterfront focal point that will be a signal for people to once again enjoy the visceral pleasure of coming to the water's edge, and to share that pleasure with visitors or tourist (Millspaugh, 2001). Several measures and instruments have been applied in the great amount of waterfront developments that took place over the last decades, which include commercialising its location of being close to water (marina, fisheries, aquariums), applying the port function to tourism industry (cruise passenger terminals), making the most of its maritime heritage (historic building preservation), and organising mega events that can attract people and tourism.

Typology of urban waterfronts

Although urban waterfront projects generally have common features such as mixed land use or the links to maritime heritage and flagship buildings, they can be classified according to the economic motivation or development orientation. The frequent way of classifying urban waterfronts would be sorting them according to its main function, observed mainly through land allocation: for which area the surface of land is allocated the most – residential, office, commercial (retail), or recreational area? On the other hand, a waterfront could also be categorised according to its development orientation (Daamen and Vries, 2012): Has it been developed mainly within market orientation such as encouraging tourism or business activities? Or, has it been initiated within spatial orientation, such as creating a public space or preserve historical areas? Lastly, is the development led by financial orientation, which focuses on the value creation by land use intensification?

Alternatively, the classification could also be done looking at the land allocation on the public space and port terminals in addition to the non-maritime functions such as residential, office, or commercial land uses (Figure 23). For example, it can be observed that Barcelona's Port Vell waterfront development has focused a lot on the creation of public space, since total surface of residential, office, and commercial area represents 20% of the land use, leaving rest of the area for the development of public space (boulevards, promenades) and road infrastructure. This is also the case for Argentina's Puerto Madero, whose surface area for public space is 53%, and Bilbao's Abandoibarra where the public space occupies the largest segment of the land use. Apart from the public space, these cases have differences: Port Vell has focused on retail/commercial function in its development, aiming to add economic vibrancy to the area; on the other hand, the office area is the largest after the public space in Puerto Madero whereas the residential and office land use, more than retail land use, have had the importance in the development of Abandoibarra of Bilbao. In case of other cities, the office areas take the largest part of the HafenCity of Hamburg, while Canary Wharf of London showed that its land surface has been occupied mostly by the residential uses.

Figure 23. Functional land use in selected urban waterfronts



Source : own data collection based on data from the various waterfront development agencies

The place for port functions in waterfront projects has been rather modest so far; while there are increasing attempts to integrate port terminals to the waterfront areas, it could be observed that the most of successful waterfront examples focused their land use on non-maritime functions such as residences, offices, or development of commercial centre, etc. However, it does not necessarily imply that the identity of the port does not play an important role in waterfront development projects: there can be a group of waterfront projects that particularly recognised that the link with the port can contribute to become a successful waterfront area. Strengthening the link with the port can be done in different ways, such as preserving of historical port heritages, transforming the fishing port area as a touristic destination, or developing marina facilities to attract pleasure boat activities. For example, Liverpool's waterfront area is well known for utilising its port heritage as a catalyser that drives tourism industry; its preservation of port-related heritage played a major role in becoming a popular touristic destination – the Merseyside Maritime

Museum, part of the World Heritage Site, attracted 1,027,475 visitors in 2010, topping the table of most visited free attractions in the city, according to a report on tourism statistics in Liverpool published in March 2012 by England's Northwest Research Service. The Port of Valparaíso (Chile) is to start building the urban waterfront of Valparaíso called "Puerto Baron", corresponding to a space of 12 hectares that generates 65% of public spaces, with tourism, cultural and commercial programs. This project also recovers an old heritage warehouse, the longest of South America, incorporating it to the new buildings. In this area will also be the new passenger terminal and a community boating marina. In case of the waterfront areas in San Francisco and Cape Town, the existence of local fishing port and activities gives them place identity that attracts tourists as well as businesses; the Fisherman's Wharf in San Francisco has become a popular tourist attraction that consists of a long, coast side row of seafood restaurants and markets, whereas in V&A Waterfront of Cape Town the equipment for the existing fishing industry are considered as a tool to attract more pleasure boating activities.

Finding the right mix of functions

Successful waterfront projects, in general, have achieved a right mix of diversified functions that render the waterfront area economically vibrant. In most cases, the mix of functions that attracted people, tourism, and businesses – and thus creates economic value - consists of 1) port functions, 2) developing recreational and cultural activities, and 3) expanding food related businesses such as food markets or restaurants. For instance, Port Vell of Barcelona, which attracts more than 16 million visitors per year, can be considered as an exemplary case where the old port area is transformed into a successful waterfront area owing to its balanced and interesting mix of functions: Port Vell continues its port function through marina facilities, ship repair dockyards, and cruise terminal; in addition, it offers a plenty of cultural and recreational activities, including its Maritime Museum, Aquarium, water sports facilities, and a variety of events such as International Boat Show; furthermore, its historic former warehouse Palau de Mar has been refurbished to accommodate restaurants with terraces on the ground floor, where visitors can enjoy the view of berthed sailing boats.

Cape Town's V&A Waterfront is another example that shows how a mixed maritime activity, surrounded with the quays that are well-equipped with recreation facilities, cafes, and restaurants, can make a unique and busy working waterfront (Charlier, 2009). In addition to the pilot boats, yachts, and leisure craft offering water tours, there are numerous fishing boats and a real industrial activity that is more active than ever. Moreover, there is a ferry terminal which has been built in the Clocktower precinct in the context of a mixed use development completed in 2002, with a 6,000m^2 tourist centre with more retails stores and restaurants. These maritime activities present a working port scenery that is distinctive and attractive, which contributes significantly to the economic vibrancy of the waterfront area. San Francisco's Waterfront area also adequately combines its existing port function with recreational activities and restaurant businesses: the passenger cruise terminal is located nearby the Fisherman's Wharf that houses historic fishing operations, visitor-serving activities, and seafood restaurants. In addition, the restoration of historical port heritage such as Ferry Building brought vibrant commercial uses and public access to the waterfront.

Since attracting people and tourism is now a crucial factor in stimulating the area's economy, developing a popular recreational function plays an important role in forming a successful, economically vibrant waterfront site. Although many of the exemplary waterfronts possess historical landmarks or port-related heritage, a successful waterfront project does not necessarily require heritage sites when the recreational function is suitably developed. The case of Dongjian Bay Area in Tianjin, China is a very recent example that demonstrates that a vibrant waterfront area can be created anew without the area's historical background: Dongjian Bay Scenic Area, which houses the largest manmade sand beach in China and Asia's largest cruise port, forms a new spot for the development of the city's tourism and cultural

industries; well-equipped with aquatic sports clubs and leisure facilities, Donjiang Bay Beach also hosts a variety of festivals and events such as Tianjin Harbour Tourism and Culture Festival or Tianjin Sailing Competition. It is reported that the Donjiang Bay area has attracted 150,000 visitors a year, and tourism is expected to usher 700,000 tourists in the summer season of 2013.

Achieving the right mix of functions can be a challenging task, due to the difficulties in financing the project. The land use of waterfront projects typically include residential, commercial, tourism, recreational functions; yet the cities or redevelopment agencies are oftentimes submitted to include residential developments because "low-density" land uses – such as park or recreation based anchor – do not generate the revenue required to cover the cost of buildings or preparation of the sites (Brown, 2009). Therefore, the issue of finding the right mix is closely related to how the project is going to be financed and especially the financial capability of the involved public sector, since it is the role of public sector to ensure that the waterfront would serve the local economic as well as social interests. It would be crucial to balance between the functions that help the financing of the project (e.g. residences) and the functions that do not immediately generate sufficient revenues yet are essential for developing a vibrant waterfront (e.g. leisure or recreational sites). Concerning this matter, it has been recommended that a waterfront development project needs to have a realistic business plan for the achievement of the concept in the master plan based on a projection of market demand and of public and private funding sources (Millspaugh, 2001).

Table 34. Main economic functions in selected urban waterfront developments

Waterfront	Port functions	Tourism & Recreation	Food
Port Vell, Barcelona	- Marina (Port Vell Marina) - Ship Repair (Barcelona 92 Marina: dockyard specialised in the maintenance of superyachts) - Ferry Terminal (Barcelona Ferry Terminal)	- Museum (Barcelona Maritime Museum) - Aquarium (Barcelona Aquarium) - Events (International Boat Show, Barcelona World Race, Swim Across the Port, Catalan Wine & Cava Show) - Sports Facilities (Swimming Clubs: Sant Sebastia Beach with sports facilities, Barcelona Swimming Club with family activities) - Markets: Palau de Mar Craft Fair, Port Antic Antique Market, Port Vell Association of Painters' Market - Hotel Grand Marina - W Barcelona Hotel	Restaurants at "Palau de Mar", old general trade warehouses transformed into business units on the ground floor, restaurants with terraces
HafenCity, Hamburg	Cruise terminal (Hamburg Cruise Centre HafenCity)	- International Maritime Museum Hamburg - Speicherstadt (historic brick buildings transformed into museum spaces) - Traditional Ship Harbor - Elb-Philharmonic Concert Hall - Hamburg-America Centre (cultural events) - Sports facilities (Oberhafen) - Stortebeker SV Sports Club - 25 Hours Hotel - Stadthaushotel - and many other hotels to be constructed - Centrurion business centre	Plans for public spaces with restaurants, cafes. Increasing number of restaurants in Überseequartier
San Francisco Waterfront, San Francisco	- Cruise Terminal (James R. Herman International Cruise Terminal) - Several ferry tours operated by different ferries - Marinas (Pier 39, South Beach Harbor, The Ramp) - Fishing port, fish handling facilities (Fishermen's Wharf Waterfront) - Ship repair (BAE Systems	- Historic preservation: The Ferry Building - Events: America's Cub (sport competitions - featuring the best sailors on the world's fastest boats) - AT&T Park (Baseball/ Sports facility) - Swimming clubs, Aquatic Park (at Fishermen's Wharf Waterfront) - Boating & yacht clubs	Restaurants and Seafood Market at Fishermen's Wharf Waterfront

	San Francisco Ship Repair)		
V&A Waterfront, Cape Town	- Marina facilities & berths - The local fishing industry occupies some 60% of the harbour - Ferry Terminal in the Clocktower - the former commercial berths of the Victoria Basin converted in the sixties to cater for the expanding local fishing industry: 1) 160 meter long dry dock (Robinson Graving Dock, located near the New basin) and 2) a synchrolift (located near the entrance runabout).	- Leisure boat/ ferry cruises - Cape Town Diamond Museum - Chavonnes Battery Museum - Craft Market & Wellness Centre - Donaled Greig Bronze Art Foundary & Gallery - Iziko Maritime Museum - Kids Ahoy Kids Playground - Nelson Mandela Gateway & Robben Island - Ocean Sailing Academy - Diamond Tour - Two Ocean Aquarium	Over 80 restaurants V&A Market on the Wharf (a fresh food market)
Abandoibarra, Bilbao		- Guggenheim Bilbao Museum - Bilbao Maritime Museum (the Karola crane. It was used for many years by the shipyards, now remaining intact) - Zubiarte Shopping Centre (commerce and leisure) - Memory Lane Sculpture Collection in Ribera Park, a reminder of the vitality of the area's industrial past - Park " La Campa de los ingleses " - Euskalduna Conference Centre / Auditorium	
Puerto Madero, Buenos Aires	The Marina of Yacht Club Puerto Madero	- Port heritage: 16 refurbished warehouses that house modern offices, restaurants, bars, pubs and other businesses - Casino: floating casino, the 'Star of Fortune,' a replica of a Mississippi riverboat - Corbeta Uruguay Museum, a gunner boat that pioneered Arctic exploration - Fragata Presidente Sarmiento, a 1897 Argentine Navy training boat converted into a museum that will delight children - Buenos Aires Yatch Club and the 200 sailboats docked there. There is a nautical school here that gives classes in sailing, rowing and kayaking - Public art collection of Amalia Lacroze de Fortabat - Museum Centre of Buenos Aires in the old Munich Brewery	Over 100 restaurants
Liverpool Waterfront, Liverpool	- "Prince's Dock" area – Liverpool Cruise Terminal - arrival of Royal Navy vessels - "Pier Head" area – Mersey Ferries terminal	- "Pier Head" area – significant aspect of the World Heritage Site: Three Graces of The Royal Liver Building, The Cunard Building and Port of Liverpool building, Museum of Liverpool - "Albert Dock" area – Tate Liverpool, Maritime Museum, International Slavery museum and the Beatles Story - "King's Dock" area – ACC Liverpool: BT Convention Centre which houses a 1,350 seat auditorium, 18 break-out rooms and 7,126m2 of exhibition space, and the interlinked 11,000 capacity Echo Arena	Around 27 restaurants

Source: own data compilation

Effective planning mechanisms

Master plan and implementation process

Most of the successful waterfront development projects begin with a master plan; a master plan not only guides the implementation process towards the project's initial goal, but it also provides a common ground where different actors (e.g. private and public sector, different local authorities) can agree upon. It is recommended to have a master plan of land uses, which blends the values of both old and new structures and uses, and express the desired concept in three dimensions; the plan should provide for public access to and enjoyment of water, with circulation extending from the old city, and planned uses of the water as well as the surrounding land (Millspaugh, 2001).

Depending on the size of waterfront area or planning custom of the country, a master plan can contain several plans for different districts in the waterfront area: for example, in case of the current waterfront area developments of San Francisco or Liverpool's docklands development, plans are established within different districts in the waterfront area; for example, Port of San Francisco, according to its Waterfront Land Use Plan, divides its waterfront area into five different districts: Fisherman's Wharf, Northeast Waterfront, Ferry Building Area, South Beach/China Basin (adjacent to Mission Bay), and Southern Waterfront – and each of them attempts to possess its own theme and goals that are distinguishable from one another. Liverpool Waterfront also has divided docklands, each of which has its own theme and function: it consists of Prince's Dock, Pier Head, Albert Dock, and King's Dock; while Albert Dock brands itself with its culture and heritage based attractions, Prince's Dock claims maritime character with its Cruise Terminal where navy vessels can be observed. Alternatively, a master plan can initially decide the percentage of the land use function (e.g. residential, office, commercial, leisure, etc.) of the entire waterfront site, which is the case of Buenos Aires' Puerto Madero and Bilbao's Abandoibarra.

It has been underlined that the incremental approach to design and to finance the project is highly important in the actual implementation process. A successful waterfront development agency relies on an incremental approach to design, a high degree of political autonomy, and the related ability to move quickly and flexibly to time individual development projects with market cycles (Brown, 2009). In case of Cape Town's V&A Waterfront, the development process has been incremental although the initial master plan covered the entire 123-hectare site. The project first focused on refurbishing historical buildings and architecture in the Pierhead Precinct, which have been introduced to new uses such as restaurants, shops, a theatre, and a craft market, etc (Van Zyl, 2005). After that, Victoria Wharf Shopping Centre was completed, whose size started from 26,500m^2 then has been extended several times with its popularity and demand. The initiatives such as V&A Marina luxury housing project and a mixed-use development in the Clocktower Precinct were followed after the huge success of the waterfront's previous projects.

Project leading entities and implementation agency

Since the waterfront projects in port-cities in general involve the old port area that is adjacent to the city centre, the project leading entities involve local port authority and city government, and in some cases state or national government can also take part in the process. One of the crucial conditions for completing a successful waterfront project is the absence of the intra-local conflicts (e.g. the conflicts among local port authority, city government, and other interested parties), and this can be achieved either through a strong support and lead from the national government or effective coordination among the different local authorities or actors. For example, in the cases of the V&A Waterfront and Puerto Madero, the national government strongly backed the project which facilitated the implementation process; as for the V&A Waterfront, transformation process of the old port was made very easy because the initiative came from the South African state itself; the port had therefore to make room for a redevelopment considered to be of national interest, and there has been no local conflict between the port and the city (Charlier, 2009). In case

of Puerto Madero, the national government established the implementation agency (CAPMSA) with Buenos Aires city government, and facilitated the process through transferring the territory of Puerto Madero to CAPMSA.

On the other hand, in case of Barcelona's Port Vell and San Francisco's Waterfront, the port authority plays a major leading role in the development of waterfront area, both in land use planning as well as negotiation process. As for the Port Vell waterfront project, "The Urban Management Port 2000" was formed by the Port of Barcelona in 1988, which is in charge of the operation and management of the port's public spaces; Port 2000 drafted the Special Plan for the Port Vell in 1988, which was agreed and approved as a final version after a long process of negotiations between the various authorities with responsibilities in urban planning. In case of San Francisco, the port initiated the land use planning process in 1991 and led the negotiation process with a citizen's advisory committee, whose twenty-seven members represented diverse interests including maritime businesses, port tenants, labour unions, and neighbourhood organisations, etc. In other cases, ports can play a secondary role by assisting the project, and the cooperation efforts from the ports are valuable in completing a successful waterfront site. For example, in case of V&A Waterfront in Cape Town, the local port authority has been a part of the transformation process, by arranging for an efficient system of control of the traffic at the common entrance for the V&AW and the commercial port, and by contributing to make it a vibrant working waterfront by letting the tugs and pilot boats remain in this zone and use it as their operational base (Charlier, 2009). In addition, in case of Bilbao's Abandoibarra, the port authority took part in the development process by transferring the key land parcels (where Guggenheim Museum is built) to Ria 2000 Organisation, an implantation agency which led the waterfront redevelopment project.

In the implementation process, a separate agency dedicated to the waterfront project is often established in the form of corporation; setting up an independent body facilitates the financing of the project, and also plays a role of third party mediator in times of conflicts among the different stakeholders. For instance, in case of HafenCity of Hamburg, the whole operation is coordinated by a corporation HafenCity Hamburg GmbH, owned by the city of Hamburg; this separate agency manages relations between the public and the private sector, and also acquires and contracts real estate devel-opers and larger users. While 97% of HafenCity sites are the property of Hamburg which owns the HafenCity Hamburg GmbH, the corporation manages the Special Fund for City and Port which includes the proceeds of sales of building sites, financing infrastructure, roads, bridges, promenades, parks, site clearance, planning, acquisition of investors, etc. In case of Abandoibarra Project in Bilbao, the project is managed by a non-profit limited liability company, known as Bilbao Ria 2000, established in 1992. It is a private firm of public shareholders, which are composed of: the central Spanish Government via the Ministry for Economic Promotion, the Bilbao Port Authority, the national railway companies, the local and regional public authorities. The stakeholders of Bilbao Ria 2000 assign the land parcels they own to Bilbao Ria 2000, which finance the project through sales of land in Abandoibarra. Bilbao Ria 2000 invests in the development of the land by reclaiming the land parcels via private banks' loans, and reselling them to private developers. As for the old port regeneration project in Genoa, the establishment of a separate agency, The Porto Antico di Genova, helped the dialogue between the municipality and the port, who have had a strained relationship due to long-standing feuds over territorial occupation (Marshall, 2001).

Table 35. Implementation of waterfront development

Project, City	Implementation Agency	Main shareholders
Abandoibarra, Bilbao	Bilbao Rio 2000	SEPES (land management company, a public body under the Ministry of Development): 25% City of Bilbao: 15% Bilbao Port Authority: 10% National railway companies: 15% Basque and Provincial government: 30%
Puerto Madero, Buenos Aires	Corporación Antiguo Puerto Madero S.A. (CAPMSA)	Owned equally by the municipality of Buenos Aires and the national state
Port Vell, Barcelona	The Urban Management Port 2000	Established by Port of Barcelona
HafenCity, Hamburg	HafenCity Hamburg GmbH	Owned by City of Hamburg
Old Port Redevelopment, Genova	The Porto Antico di Genova	City of Genova: 51% Chamber of Commerce: 39% Genova Port Authority: 10%
V&A Waterfront, Cape Town	The V&A Waterfront Company Ltd	Established by Transnet Ltd (the successor of the State-controlled South African Transport Services), yet now it is sold to an international private consortium (Lexhall 44 General Trayding Ltd.).

Source: own data compilation

Incentives and public investments

Cleaning and preparation of the sites, building basic infrastructure, and creating non-profit oriented sites (public spaces, parks, promenades, sports facilities) are provided by the public investments; the funding source for this can come directly from a public institution, or it can be also prepared by the proceeds of land sales. In case of Barcelona's Port Vell, 51.54 million Euros were invested by the Port of Barcelona; in case of San Francisco's Bay Trail, the interconnected trail system that links parks and points of interest around the waterfront area, the initiative and initial funding were supported by the state (California) which designated a regional planning agency for the planning and management of the trail. On the other hand, the cases of HafenCity (Hamburg), Puerto Madero (Buenos Aires), and Abandoibarra (Bilbao), the funding of these basic infrastructure and non-profit oriented sites are prepared with lease and sales of the land parcels. For example, in case of Puerto Madero, the implementation agency (CAPMSA) did not receive any initial budget from the state or the municipality, instead lease bidding and sales of the docks were its source of funding that enabled them to develop and build public places.

The private sector can also take a large part in actual construction of the infrastructure in return of the rights to proceed profit-oriented private developments, which leads to public-private partnerships or concessions. In the case of San Francisco's Waterfront, the port issued a request for proposals to developers interested in redevelopment of the Ferry Building and Pier 1 as a new commercial office building; the commercial components were required to finance the historic preservation and adaptive reuse of the buildings in exchange for ground rent (Brown, 2009). In case of Barcelona's Port Vell, the port held concession projects with private investments, such as World Trade Centre, Aquarium, Imax cinema, Maremagnum (leisure and shopping Centre), and Marina; for these concession projects, 396.52 million Euros was invested by private actors whereas 158.10 million Euros was invested by the Port of Barcelona.

Hosting mega-events can open a policy window for infrastructure building by drawing attention and investments from the public institutions. In case of Genoa, a part of Old Port was redesigned and opened to the public in the occasion of the International Expo in 1992, which paved the way for the rehabilitation of the extended waterfront area. The Expo was located in the Old Port, and investments by the State permitted

to restore the old buildings, build an Aquarium and rearrange the open spaces; furthermore, hosting events such as G8 (2001) and the European City of Culture (2004) also provided resources for transforming other parts of the Old Port. Barcelona's Port Vell project was also launched within the occasion of Barcelona Olympics in 1992; Marseille is pursuing its waterfront project "Cité de la Méditerranée", backed by its current designation as the European City of Culture 2013. In San Francisco, the port's waterfront development succeeded to gain the legislative support from the State of California with the 2013 America's Cup International Yacht Race; the law was passed in order to establish the America's Cup District equivalent of an Infrastructure Financing District, which gives San Francisco the flexibility to finance important waterfront improvements, such as financing for the America's Cup Village and construction of a cruise ship terminal at Pier 27.

As for port cities, it is advantageous to create synergies with their port functions in developing and promoting the waterfront areas. One of the port functions that show a close link with waterfront development is operating cruise terminals. In many waterfront development projects, cruise activity is considered as a strong element of the will of port cities to develop and reinforce the urban tourism industry since cruise tourism has now become a new market for the ports (CTUR, 2007). According to European Cruise Council, Over 6 million European residents booked cruises in 2011, a 9.0% increase over 2010; and the direct cruise tourism expenditures directly generated an estimated 153,012 jobs. Concerning the North America, Cruise Lines International Association reported that there was $19.6 billion in direct spending by the cruise lines and passengers, creating 356,311 total U.S. jobs generated by cruise industry expenditure. In order to capitalise this opportunity, there is a need for cooperation between city and port; the formula used to establish co-operation and define actions is most often the one of "Cruise Club" able to group the port authority, the chamber of trade and industry, the municipality, maritime companies, public tourism agencies, and tourism companies (CTUR, 2007). For instance, in Marseille, the Club de la Croisière Marseille-Provence is organised by the chamber of trade and industry, the municipality and the port authority, which aims to bring together all the public institution concerned and the tourism professional community in order to promote cruise industry. Developing a new cruise terminal in conjunction with other functions of the waterfront is another way of promoting cruise industry in port cities: HafenCity of Hamburg is developing a new cruise terminal which will combine cruise and hotel facilities in the waterfront area of Überseequartier where shopping centres and entertainment facilities are under development. In case of Liverpool, the Prince's Dock area was developed with Liverpool Cruise Liner Terminal, which is surrounded with hotels, restaurants, bars, coffee shop, apartment and office buildings; the existence of the cruise terminal helps the economic vibrancy of the area, since the arrival of cruise ships at the new terminal attract many thousands of additional visitors to site.

The development of marina for pleasure boating could also help to establish a vibrant waterfront area. Sailing, yachting and power boating generate income for the city; support services such as sailing schools, tour operators, insurance brokers, maritime financiers, yacht charters, yacht brokers, marinas bring regular income to the city and hinterland (Anderson and Edwards, 2001). In addition, moored yachts add a unique character and atmosphere to the waterfront area, which is attractive to the visitors. Accordingly, developing marina facilities and promoting watersports activities has been one of the components that contributes to the success of several waterfront project in port cities: as for Barcelona, Marina Port Vell was opened in 1992 to celebrate Olympic Games, and it is now a popular yachting destination that provides mooring rents and supplementary services such as refueling and waste collection for its customers; several yacht clubs are located on the site, offering watersports programmes and activities. In the case of San Francisco, Pier 39 is a waterfront complex which houses several restaurants and more than 90 shops, and its marina is one of the major attractions.

4.4 Side-option: Urban diversification

Staking the growth of all local industry on the performance of the port can be a risky strategy, particularly in smaller port-cities. Over-dependence on the port can render the urban economy vulnerable to the notoriously volatile shipping industry. This lesson has been born out historically, as the comparison of London and Liverpool demonstrates (Box 8). The advent of containerisation dealt a major blow to both cities' maritime sectors, as technology upgrades were both economically unfeasible and fiercely contested by organised labour (Levinson 2006). Other examples illustrate a similar point: in his analysis of the economic history of Boston since the 17th century, Glaeser identifies three periods of structural decline in which Boston had to reinvent itself, one of which was to recover from a decline as a maritime power.

In order to follow in the footsteps of cities such as London and avoid the fate of Liverpool in the 1980's, some port-cities have sought to reduce their dependence on the port through explicit economic diversification strategies. Other well-established continental European port-cities have managed to encourage activities that, whilst not directly related to logistics, increase their attractiveness. Antwerp has invested strongly into its fashion business, Hamburg has invested into the business environment of its local media industries, and Rotterdam has benefited from strong public investment in real estate development to become a leading architectural centre (OECD 2011).

Finally, diversification strategies have also been evidenced in other parts of the world, particularly in smaller port-cities at risk of losing market share to their neighbours. The port-city of Ningbo, for example, grew from a simple transit point until the 1980's, to a fully-fledged industrial port city specialised in port-based industries in the 1990's. Since the 2000's, it has come to view this port-dependency as a potential source of vulnerability, especially in view of the fierce regional competition it faces. As a consequence, Ningbo has now undertaken a concerted attempt to diversify its own economy as a way of decreasing dependency on the port (Huang & Bao 2011). To this end, the city has been investing in its agricultural resources, as well as in the petrochemical and paper industries.

Box 8. Dependence on a port economy: the tales of Liverpool and London

During the 19th century, port operations at Liverpool handled around 40% of the world's trade. The city's economy, which had expanded rapidly during the industrial revolution, was based mainly around the import and export of commodities, with cotton chief among them. By the mid 19th Century, Liverpool's cotton market was the largest in the world, and supplying textile mills in Manchester and Lancashire to form a major port-dependent economic cluster. However, as demand for Northern England's textiles and other traditional exports fell, so too did activity and employment in the port. Containerisation rendered Liverpool's docks all but obsolete, and most of the south end docks were closed by 1975. All of Liverpool's sectors being dependent on the port activity in some way, it was unable to bound back from the shock of changing shipping systems, and the city hit its lowest point during the 1980's, with high rates of unemployment, out-migration and political extremism. In many ways London negotiated a similar transition, with very different outcomes. London too had built a strong cluster of economic activity in the city centre, based on the docks of the river Thames. When containerisation and ships with deeper draughts meant that London's port activity had to be relocated downstream to the east, this resulted in the loss of much dock-related employment in the city centre. London, however, was able to rely on a local economy supported by a diverse range of services, most notably in banking, insurance, and finance, and negotiated the decline of its port traffic much more successfully. In fact, the maritime sector itself was kept afloat through its connections with financial service sectors clusters in the city, and is now the world's leading centre for shipbroking, freight derivatives, bank finance, shipping insurance and securities, and shipping legal services.

Through synergy strategies, cities with mature port economies can use these established markets to boost new and emerging ones. In these cases, the port is used to create synergies with other clusters. However, history has shown that an over-dependence on the port can prove fatal if maritime activities take

a hit. The port-cities that have most successfully navigated the post-containerisation relocation of maritime activities in fact had very diversified economies that eased the transition towards non-port activities, and enabled them to avoid the vicious circles of decline entered into by regions that had staked their entire economies on activities sustained by maritime commerce. For policy-makers in port-cities and port-city regions, the corollary of any synergy strategy should therefore be some measure of economic diversification that is not port-dependent. It should be noted that these two strategies for articulating the maritime cluster with other local economic sectors – synergy and diversification – are not mutually exclusive: the most successful port-cities have been able to simultaneously diversify their economies away from dependence on the port alone, while using it to its fullest potential for driving other economic sectors.

4.5 No regret option: co-operation with neighbouring port-cities

Because port-cities face common challenges, regions with many different neighbouring port-cities are increasingly exhibiting a shift towards regional networking and interest-representation. Port-cities require large amounts of capital to finance state-of-the-art infrastructure, and must increasingly compete for different sources of funding not only nationally, but even at regional or international levels. As political and administrative entities, port-cities are also responsible to their electorates, and must seek to optimise the positive economic impacts associated with increased maritime activity, while mitigating its negative social and environmental impacts. Various forms of cooperative networking amongst port-cities are increasingly employed to reach these goals (referred to above as the triple policy challenge above).

Box 9. Challenges and opportunities of regional port-city networks in the EU

In response to the challenges of economic development in the post-industrial era, on the one hand, and the funding opportunities proposed by the EU for cross-border cooperative projects, on the other hand, neighbouring European port-cities have begun to represent their interests and steer projects collectively through cooperative fora. Ducruet (2006) has compared two early examples of such port-city networking initiatives: the Normandie Métropole and the South Coast Metropole partnership, both of which were created in 1993. Normandie Métropole came into being as an associative partnership between the mayors of Caen, Rouen, and Le Havre, and sought to unite a broad policy network composed of many actors from the fields of infrastructure, education, technology, and research. It aimed to increase the profile of the three port-cities within Europe, to position them competitively vis-à-vis other cities in France and Europe, and to provide a more coordinated planning framework for projects round the Seine estuary. On the other side of the channel, the South Coast Metropole was constituted by Poole, Bournemouth, Southampton, Portsmouth and the Isle of Wight, five cities on the southern coast of England that have experienced similar patterns of decline in their manufacturing and maritime sectors. The partnership aimed to represent interests collectively and to respond to the funding opportunities for jointly-led projects on offer by the EU through its regional development funds.

In their two decades of existence these networks have met with mixed success. In some ways, the Normandie Métropole network can be seen to have failed. Having encountered problems with divergent interests, mismatches between the economic and administrative structures of the respective cities, and a lack of logistical integration between them, it was eventually dissolved (Merk et al. 2011). The South Coast Metropole has been more successful, securing EU funds, which have gone towards regional projects in the fields of tourism and innovation. Furthermore, though they may have lost their initial élan, these two networks arguably set precedents for networking efforts within the Franco-British channel, which have helped to foster further innovative forms of port-city networking. Having met with little success after a first attempt in 1996, the Channel Arc (Arc Manche) network was revived in 2003, bringing together five French and five English maritime regions along the channel. With co-funding from the North-West European Interreg III B programme between 2004 and 2008, the Channel Arc succeeded in producing its Strategic Vision for the Channel Area (EMDI - Espace Manche Development Initiative), which in turn drove the creation of a € 173.5 million Interreg fund specifically for transnational projects in the coastal region surrounding the channel, one of the busiest stretches of water in the world. With the support of this fund, these port-city regions have gone on to produce the CAMIS (Channel Arc Manche Integrated Strategy), which has detailed an integrated plan for joint-initiatives in the fields of maritime safety, economic development, tourism, environmental protection and innovation. In their own ways, both the Normandie Métropole and the South Coast Metropole set the stage for these subsequent institutional successes in neighbouring port-city cooperation.

Co-operation and networking in port-city regions is similar to the port coordination mechanisms described above, in that it seeks to enhance capacities through the alignment of interests amongst a multiplicity of actors. However, because municipal and regional governments have much wider mandates than port authorities, the aims of such cooperative measures between port-cities often go well beyond simply seeking to improve the competitiveness of a given port: they seek to respond to large collective problems that could not be resolved on an individual level.

In that it provides access to regional funding and the opportunity to coordinate regional solutions to regional issues, cooperation between neighbouring port-cities represents a clear advantage, and should be encouraged. When articulated around shared interests, it can enable a range of responses sensitive to several policy fields, and help individual port-cities to overcome much larger challenges, such as environmental management, long-term integrated planning and economic development. Often the impetus for such cooperation emerges in response to specific threats (such as the degradation of collective environmental resources in the Baltic), or to specific opportunities (the creation of funds for pluri-jurisdictional and transboundary projects in the Channel). Maintaining the momentum of such partnerships is not always successful: problems of interest divergence, administrative mismatch, and legitimacy deficits of transnational action by sub-national actors can lead to the exhaustion of such efforts. However, the increasing institutionalisation and diffusion of such instruments is to be encouraged, and port-cities should seek to move toward more permanent, resilient frameworks for cooperation.

5. HOW TO MITIGATE NEGATIVE PORT IMPACTS?

Mitigating negative port impacts is essential for the long-term survival of ports and port-cities. Even if ports generate large local economic benefits, building on competitive strengths in services, industrial development or consumer-driven port-related waterfront development, they will not have sustainable future perspectives if they do not mitigate negative impacts related to their development. These negative impacts can be considerable, as illustrated in chapter 2, and can relate to the environmental impacts – such as pollution of air, water and soil - land use, traffic congestion, and risks related to climate change and security. This chapter assesses main policies to mitigate these impacts and risks, building on the experience of port-cities worldwide.

5.1 Limiting environmental impacts

As market reforms and technological innovations have enabled drastic increases in the volumes traded between states over the past decades, the maritime transport systems that facilitate these evolutions have grown in kind, generating considerable impacts on the environment in the process. Growth in the global maritime transport system affects the social and biological environment in myriad ways, which can be sorted into two main families. Firstly, there are impacts on marine and terrestrial systems associated with the development of ports, which have been driven by the increasing physical scale of transport. Ever-larger vessels, port facilities, and hinterland infrastructures generate concomitant land-use requirements and heavy transformation of local ecosystems. And secondly, the increasing intensity of traffic flows entails emissions-related pollution from shipping, heavier consumption of energy and other resources on and off ports, discharge of pollutants and sewage, waste generation, and threats to biosecurity through the transmission of invasive species. In order to comply with environmental laws, which are increasing in number and in stringency (Comtois & Slack 2007), actors involved in the port sector must seek to limit such impacts. Beyond issues of compliance, the ports and shipping sectors should develop pro-active strategies to address the increasing threats to human health, biodiversity and economic wellbeing that are inadvertently associated with growth (Eyring et al. 2010).

Various policy instruments exist to combat the main environmental impacts associated with ports, and are listed below by the type of impact they seek to deal with and the manner of intervention. These instruments can stand alone, but in many cases fit into a wider effort by port authorities and governments to improve the environmental performance of the maritime shipping and ports sectors.

5.1.1 Air emissions

Even though maritime shipping remains the most carbon-efficient form of transport in terms of grams of carbon dioxide per cargo ton compared to other modes such as rail, road or air transport (WSC 2013), the sheer scale of maritime transport activities generates massive quantities of emissions. These affect the composition of the atmosphere, impacting the climate and human health (Corbett and Fishbeck 1997; Eyring et al. 2005). The main compounds of concern emitted by shipping and port operations are sulphur dioxide (SO2), carbon dioxide (CO2), black carbon (BC), carbon monoxide (CO), nitrogen oxides (NOx), and various kinds of particulate organic matter (OECD 2011). Sulphur is at the origin of many particulate matters that epidemiological studies have consistently linked with a range of illnesses, including pulmonary diseases and premature death (Eyring et al. 2010). Corbett et al. (2007) have estimated that,

because the vast majority (70%) of these emissions occur within 400km of coastal communities, shipping emissions cause around 60,000 early mortalities each year, mainly in the seaside areas of East Asia, South Asia and Europe. Uncertainties in the data and methods used to calculate mortalities bound this estimate within the range of 20,000-104,000 (Eyring et al. 2010), but the impacts remain within a concerning order of magnitude. Main policy instruments are indicated in Table 36, which will be discussed below.

Table 36. Overview instruments emissions policies

Policy types	Instruments	Intervention level	Examples
Regulation	Global emissions cap	Global	IMO Marpol Annex VI
	Emission control areas	Cross-boundary	Table x
	Technical standards	Global	IMO: EEDI, SEEMP
Information	Emissions inventories and monitoring	Local	Los Angeles
	Port state control cooperation	National	Antwerp
	Compliance monitoring		US
Incentives	Bunker tax/emissions trading	Global	
	Fuel switch	Local	Hong Kong
	Slow steaming	Local	Long Beach
	Cleaner ships	Global, local	ESI, Sweden
	Modal shifts	Local	Alemeda corridor
	Truck retirement	Local	Los Angeles
Technology upgrade	Clean bunkering	Local	Rotterdam
	Shore power	Local	Gothenburg
	Electrification equipment	Local	Busan
	Renewable energy	Local	Zeebrugge

Source: own elaboration

Regulation

Initiatives to reduce emissions by port authorities and governments are embedded in a context of international regulation. The 1987 Montréal Protocol and the 1997 Kyoto Protocol constitute two very important pieces of legislation. However, the sixth Annex of the MARPOL Convention of the IMO on "Regulations for the Prevention of Air Pollution from Ships", which was first adopted in 1997 and entered into force in 2005, plays the most direct role in regulating the emissions of the shipping sector globally. With 72 contracting parties as of 30 June 2013, Annex VI covers 94.3% of the world tonnage.

Emissions caps that entered into force on 2005 were tightened through the adoption of revisions to the Annex VI in 2008, which entered into force in 2010. The 2008 amendment reduced the sulphur limit from 4.5% to 3.5%, effective from 2012, and will reduce the limit further to 0.5% by 2020. It also introduced a new 'three-tiered' approach to reducing NO_x emissions, in which ships built after 2000, 2011 and 2016 have respectively stricter limits on their NO_x emissions. A key mechanism embedded within the MARPOL legislation is the creation of emission control areas (ECAs) – zones in the sea in which stricter requirements are applied to the contents of bunker fuels being used. Thus, while sulphur is limited by the 2008 amendments to 3.5% of fuel globally from 2012, and to 0.5% from 2020, in ECAs the limits are 1.0% and 0.1% respectively. The first two ECAs in the Baltic and North Seas set limits on sulphur emissions only (Sulphur ECAs or SECAs), whereas the North American and US Caribbean Sea ECAs cover sulphur, nitrogen and particulate matter emissions (See table 37 below). ECAs are located in areas that contain high concentrations of both shipping activity and coastal populations. According to the U.S. Environmental Protection Agency (EPA), the North American ECA should save more than 14,000 lives annually by 2020, and improve the respiratory health for some 5,000,000 people in the U.S. and Canada. It further estimates that the ECA will cost US$ 3.2 billion by 2020, but that it will have generated between USD 47 and USD 110 billion worth of saving on health costs.

Table 37. Emission Control Areas

Emission Control area	Limited compounds	Adopted #	Entry into Force	In Effect From
Baltic Sea	SOx	26 Sept 1997	May 19, 2005	May 19, 2006
North Sea	SOx	Jul 22, 2005	Nov 22, 2006	Nov 22, 2007
North American	SOx, NOx & PM	Mar 26, 2010	Aug 1, 2011	Aug 1, 2012
US Caribbean Sea	SOx, NOx & PM	Jul 26, 2011	Jan 1, 2013	Jan 1, 2014

Significant progress has been made with regard to operational and technical measures to reduce GHG emissions such as CO2. However, consensus on global market-based mechanisms – deemed necessary to reduce emissions to levels low enough to impact the pace of climate change – has been elusive within the IMO. The Marine Environment Protection Committee (MPEC) of the IMO amended MARPOL Annex VI in 2011, adding a new chapter on 'Regulations on energy efficiency for ships'. It includes two measures that came into force in early 2013 and apply to all vessels over 400 GT: the Energy Efficiency Design Index (EEDI) for all new ship constructions, and the Ship Energy Efficiency Management Plan (SEEMP) for existing ships. The EEDI phases in progressively stringent criteria into the building standards for different types and sizes of ship. Energy efficiency levels are measured in CO2 emissions per capacity mile, and are designed to bear upon all production components of a given ship. The SEEMP constitutes a mechanism for benchmarking and improving operable ships, mainly through the Energy Efficiency Operator Indicator (EEOI) instrument. Under the SEEMP, owners and operators are periodically brought to review and upgrade their energy performance, focusing on such measures as engine tuning and monitoring, propeller upgrades, trim / draft improvement, and enhanced hull coating. Various states plan to implement these measures through the use of Port State Controls.

An IMO-commissioned study has claimed that, under high uptake scenarios (30%), the EEDI and SEEMP should reduce global emissions below the status quo scenario by an average of 330 million tonnes (40%) annually by 2030, and increase savings in the shipping industry by 310 $ billion annually (LR 2011). Nevertheless, the 2030 model suggests that MARPOL measures will not be sufficient to bring about an overall reduction in emissions relative to 2010 levels. In each of the uptake scenarios tested, projected growth in trade will overwhelm any emissions reductions achieved through the EEDI and SEEMP, even if the upward trend will be reduced compared to status quo scenarios. At least 10 different market-based measures (MBMs) for GHG emissions reductions have been submitted by member-states to the IMO. As of 2013, however, opinion has been highly divided within the IMO about the legitimate use of MBMs to bring down GHG emissions from shipping.

Information

Ports are not only at the forefront of strategies to implement international emissions reductions regulations, but are also themselves the originators of emissions reduction policies. The first and most fundamental step that a port authority should take is to conduct a thorough port emissions inventory. Emissions inventories, such as those in Los Angeles seek to identify emissions levels that occur within a given area according to their source (Box 10). Sources can be mobile (i.e. ships and vessels entering and leaving, cranes, trains) or stationary (i.e. energy production facilities). Some ports are increasing their efforts at reporting and monitoring, and integrating emissions inventories into larger sustainability reports that provide measures of a diverse range of environmental impacts and mitigation initiatives. Methodologies employed and main indicators covered vary from port authority to port authority (Table 38). For this reason, national agencies, such as the Environmental Protection Agency in the United States in 2009, for example, published guidelines in 2009 aiming to harmonise best practices across ports.

Table 38. Air emissions inventories in selected ports

Port	Main indicators	Since when?
Los Angeles	– Port-related GHG emissions (Electric wharf cranes, Building electricity, Building natural gas, Port employee vehicles, Expanded GHG inventory) – DPM, NO_x, SO_x, CO_{2e} Emissions by Source Category: Ocean-Going Vessels (OGV), Harbor Craft (HC), Cargo Handling Equipment (CHE), Heavy-Duty Vehicles (HDV), Rail Locomotives (RL). – Containerised Cargo Volume Trend – Port DPM, NO_x, SO_x, CO_{2e} Emissions Trend	2001
Long Beach	– Port-related emissions (PM_{10}, $PM_{2.5}$, DPM, NO_x, SO_x, CO, HC) by category: Ocean Going Vessels (OGV), Harbor Craft (HC), Cargo Handling Equipment (CHE), Locomotives, Heavy-Duty Vehicles (HDV). – Port-related GHG emissions (CO_{2E}, CO2, N_2O, CH_4) by category: OGV, HC, CHE, Locomotives, HDV.	2002
Seattle	– Total Airshed Emissions (NO_x, VOC, CO, SO_2, PM_{10}, $PM_{2.5}$, DPM, CO_{2e}) by source category: Ocean-Going Vessels, Harbor Vessels, Locomotives, Cargo-Handling Equipment, Heavy-Duty Vehicles, Fleet Vehicles	
New York - New Jersey	– GHG emissions (CO_2, CH_4, N_2O, HFCs, PFCs, SF_6) by the category "Port Commerce" (Commercial Marine Vessels, Cargo Handling Equipment, Rail Locomotives, Heavy-Duty Vehicles, Buildings, Landfill, Fleet-Vehicles) – Port Commerce Emission per TEU handled – Total CAP (Criteria Air Pollutant) emission (NO_x, NO_2, PM)	2006
Oakland	– PM (Particular Matter including diesel), NO_x (Nitrogen Oxides), SO_2 (Sulphur Dioxide), ROG (Reactive Organic Gas), and CO (Carbon monoxide) emissions by source category: Ships, Harbor Craft, Cargo Handling Equipment, Trucks, Locomotives.	2005
Vancouver	– Common Air Contaminants (CACs) – NO_x, SO_x, CO, VOCs, PM_{10}, $PM_{2.5}$, NH_3, Green House Gases (GHGs) – CO_2, CH_4, N_2O by Source Group (Admin, Cargo-Handling Equipment, Onroad, Rail).	2005
Shanghai	– Air pollutant emissions (NO_x, SO_2, PM, VOC, CO) of Ships (Ships of International shipping line, Ships registered at ports and managed by local maritime authorities, Ships travelling along the coast, Hotelling, Internal rivers).	2006
Gothenburg	– GHG emissions by: – *Direct emissions: Operational vessels, Operational vehicles, Heating buildings (by fuel usage), Fire equipment – *Energy indirect emissions: Electricity usage, Direct heating – *Other indirect emissions: Business flights GPA, Business travel by car GPA, Terminals, Vessels at the quay/ traffic area, Loading of gasoline, leakage of pipelines, Carpool	2010
Barcelona	– Air emissions at Darsena Sud and Port Vell: SO_2, H_2S, NO_2, C_6H_6, PM_{10}.	2004
Hamburg	– Direct CO_2 emissions – Indirect CO_2 emissions – CO_2 emissions by equipment type: Straddle carriers, AGVs, Container/ rail gantry cranes, Reefer containers, Storage cranes)	2011
Houston	– Maritime related emissions (NO_x, VOC, CO, SO_2, PM_{10}, $PM_{2.5}$, CO_2) by Source Category: Ocean-going Vessels, Heavy-duty diesel-fueled vehicles, Cargo handling equipment, Locomotives, Harbor vessels	2007
Melbourne	– CO_2 emissions by activity: Commercial vessels, Cargo handling & Tenants, Rail, Road	2011
Helsinki	– Nitrogen Dioxide Concentrations, monthly average – Sulphur Dioxide Concentrations, monthly average – Vessel waste waters received by Port of Helsinki – Vessel waste waters pumped into sewage systems in Helsinki	2010

Source: own data collection based on information provided by port authorities

Box 10. Air emissions inventory at the Port of Los Angeles

The Port of Los Angeles and the Port of Long Beach have since 2005 an Air Emissions Inventory in place to measure port-related air pollution and inform the public about this. This inventory is part of the San Pedro Bay Clean Air Action Plan (CAAP) that is designed to reduce air emissions and health risks that are associated with air pollution (see Box x). The 2005 Inventory of Air Emissions serves as the baseline to measure progress on this action plan. The development of the air emissions inventories was coordinated with the U.S. Environmental Protection Agency (EPA), the California Air Resources Board (CARB), and the South Coast Air Quality Management District (SCAQMD). Port tenants and shipping lines also play an essential role by providing accurate activity and operation information. The activity and operational data collected is then used to estimate emissions for each of the various source categories in a manner consistent with the latest estimating methodologies agreed upon by the Port and participating regulatory agencies. All the detailed annual inventories reports are available to the public on the port websites.

The inventories evaluate emissions from five port-related mobile source categories: Ocean-going vessels (OGVs), Harbor craft, Off-road cargo handling equipment (CHE), Railroad locomotives, On-road heavy-duty vehicles (HDV). For each category, exhaust emission are estimated for the following pollutants: Particulate matter (PM) (10-micron, 2.5-micron), Diesel particulate matter (DPM), Oxides of nitrogen (NO_x), Oxides of sulphur (SO_x), Hydrocarbons (HC) and Carbon monoxide (CO). The ports started to conduct emission estimates of Greenhouse gases (GHG) from port-related operation from the 2006 Inventory, which includes carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O). By using the 2005 activity levels as the baseline year, the subsequent inventories also provide the comparisons of main air pollutants between the baseline year and the evaluation year. In the 2011 report, the Port of Los Angeles reported to see cumulative harmful emissions reduced by 76%, including diesel particulates emissions declined by 71% from 2005, NOx emissions down by 51% and SOx emissions fell by 76%.

Such efforts at quantification are essential, as they provide a baseline against which subsequent progress and performance can be measured. Various ports have introduced systems for monitoring compliance with clean air regulations. The port of Tallinn, in Estonia, for example, has installed two automatic stations for measuring concentrations of controlled compounds in the air. If at any point levels exceed predefined limits, operators, inspectors, the harbour master and port authority are automatically warned so that measures can be taken in order to reduce emissions. Modelling is used to locate the probable source of pollution, and is accompanied by a set of guidelines including actions that can be taken by each operator to reduce emissions. The port of Helsinki runs a similar programme in co-operation with the authorities, which is managed in real time through an online platform.

Port state controls play an important role in enforcing monitored standards. In the port of Antwerp, for example, the Port State Control agents have direct access to the information and monitoring system, and use this to target vessels for inspection. Similarly, the US Coast Guard introduced its Qualship 21 (Quality Shipping for the 21st Century) initiative in 2001, which issues certificates to ships with good environmental track records. Amongst other incentives, certificate-holders are subject to fewer Port State Control inspections for a period of two years, which is particularly advantageous given the intensification of such controls in the US in the post-9/11 context. Various public and private actors must find ways to comply with these new standards, and some have sought to do so voluntarily as a cost-effective and socially responsible measure. However, there are legal limits for the application of Port State Controls.

Incentive schemes

In addition to monitoring and enforcing compliance with new mandatory regulations, many port authorities are now employing voluntary incentive schemes to stimulate reductions in emissions from shipping, via slow steaming, fuel shifts, cleaner ships, truck retirement and modal shifts.

Some incentive schemes have sought to encourage slower steaming speeds. Through the Vessel Speed Reduction Programme (VSR), the Port of Long Beach rewards ships that voluntarily lower their speeds within the harbour, through reduced docking fees for vessels that remain within a 12-knot speed limit. The goal of the VSR is to reduce NO_x emissions from ocean-going vessel by slowing their speeds as they approach or depart the port, generally at 20 nautical miles (nm) from Point Fermin. The VSR was first adopted in 2001 with voluntarily participation from the shipping liners, after the two ports signed a cooperative Memorandum of Understanding (MOU) with the U.S. EPA, CARB, SCAQMD, Steamship Association of Southern California and Pacific Merchant Shipping Association (PMSA). The Marine Exchange of Southern California provides the vessel speed data for both ports. Since the 2006 CAAP identified the VSR program as one of the main control measures for cutting air pollution, the two ports start offering the incentives of dockage rate deduction to participated vessel operators –15 percent off for compliance at 20 nautical miles, 30 percent off (POLA) and 25 percent off (POLB) at 40 nautical miles. In addition, ocean carriers achieving 90% compliance in a calendar year will receive the incentive for 100 percent of their vessel calls in that year. As of March 2012, POLA compliance is 94 percent at 20 nautical miles and 74 percent at 40 nautical miles, and POLB compliance is 97 percent at 20 nautical miles and 84 percent at 40 nautical miles. In 2007, the two ports estimated that the VSR program has resulted in reducing: 1,345 tons of NO_x, 832 tons of SO_x, 112 tons of PM, and 52,502 tons of CO_2.

Various ports have introduced environmentally differentiated port dues, based on the environmental ship index (Box 11). For example, the port of Amsterdam, gives a rebate on the port due, ranging from EUR 200 to EUR 1400 in 2012, depending on the size of the vessel. The port of Rotterdam announced in 2011 that it would give a rebate on the port dues to the 25 cleanest ships that would call the ship. The amount of reductions in port dues in Rotterdam related to this were EUR 40,000 in 2011 and EUR 600,000 in 2012, according to the Rotterdam port authority. The effect of these incentives is for the moment fairly small, as the number of vessels that qualify for reduced port dues is limited. Although the reductions in port dues indicated in the previous paragraph are not marginal, the number of vessels that have favourable environmental ship index scores remains fairly limited in comparison to the total number of ports calling the port, so one could wonder about the impact of the programme. As the number of ships integrated in the ESI is steadily rising, the perspectives for effectiveness will rise, but so will the consequences for the budgets of the participating ports, as the rebates have so far not been financed by a simultaneous rise in the dues for the other ships (the non-ESI vessels).

Box 11. Environmental Ship Index

The Environmental Ship Index is an instrument to determine the environmental performance of ships with respect to air pollutants and CO_2. The idea of the index is that ports can reward ships that score high on this environmental ship index, by providing them with lower port dues. The ESI measures a ship's emissions based on the amount of nitrogen oxide (NO_x), sulphur oxide (SO_x), particulate matter (PM) and greenhouse gas it releases. It is a voluntary system, open to shipping companies, ship owners and ports. The ESI uses a formula to provide points to ships according to their environmental performance, considering current international legislation, mainly the International Maritime Organisation (IMO). There are currently 1439 ships with a valid ESI score and 18 ports participating, including Rotterdam, Hamburg, Antwerp, Le Havre, Los Angeles and New York/New Jersey. The ESI was developed in the framework of the World Port Climate Initiative (WPCI), committing to reduce the greenhouse gas (GHG) emissions due to port activity. The ESI ship database is filled and administrated by the ESI Bureau of the International Association of Ports and Harbors (IAPH).

It is also possible not only to reward clean ships, but also to "punish" dirty ships. Sweden has applied environmentally differentiated port dues since 1996, following an agreement between the Swedish Maritime Administration, Ports of Sweden and the Swedish Ship-owners Association to reduce NO_x and SO_2 emissions from ships. This agreement has led to environmentally differentiated fairway and port dues.

The fairway dues are mandatory and consist of two parts, one based on the volume of goods loaded/unloaded and one based on the ship's gross tonnage. The latter part is environmentally differentiated and relates to NO_x and SO_2; the differentiation for No_x is given as a reduction to the first part of the fairway due and divided into several emission levels with the ships fulfilling the strictest requirements exempted from the due. For sulphur there is a surcharge added, divided into three levels, if the sulphur content of the fuel exceeds 0.20%. Contrary to the fairway dues, the environmental differentiation of the port dues was voluntary but all large Swedish ports have introduced these. E.g. the port of Gothenburg has sulphur charges (divided in three classes) and nitric oxide discounts (in three classes). There are different assessments of these environmentally differentiated port dues. According to Swahn (2002), they have imposed strong incentives for reducing emissions, whereas Kageson (1999) states that the dues were not differentiated enough to present an actual incentive for ship operators to reduce emissions.

Various ports have introduced truck retirement programmes in order to mitigate air pollution from old trucks operating in their ports. This makes sense, as emissions inventories conducted in US ports have consistently identified drayage trucks as significant contributors to port-related pollution, accounting for 25-43% of NOx emissions, in part because drayage trucks are typically older and more polluting than the average long haul truck (Norsworthy and Craft, 2013). Examples of mandatory truck retirement programmes can be found in Los Angeles, Long Beach, Oakland and Vancouver. Voluntary truck retirement programmes were introduced in Houston, Virginia and Charleston. These programmes aim to stimulate the replacement of old trucks; the programme in Oakland also stimulates diesel particle filter retrofits in addition to the truck replacement. In many cases the programme provides grants or loans. For example, the ports of Los Angeles and Long Beach together have provided more than USD 110 million in grant funding to incentivise the replacement of trucks. The Houston DLP combines a traditional grant programme from state funds tied to NOx reductions with low-interest loans form federal funds for drivers seeking to replace their vehicles. The mandatory truck retirement programmes in Southern California have been very effective in reducing emissions; the emission reductions in voluntary programmes have been limited (Table 39).

Table 39. Effectiveness port truck retirement programmes

Port	Programme	NOx	PM	CO	BC	HC	Period	Source
Los Angeles	Clean Truck	33%					2008-09	Bishop et al. 2010
Los Angeles	Clean Truck	48%	54%	30%			2008-10	Bishop et al. 2012
Los Angeles	Clean Truck	87%	97%	94%		92%	2005-12	Lee et al. 2012
Oakland	CTMP	41%			54%		2009-10	Dallmann et al. 2011
Oakland	CTMP		75%				2008-10	
Norfolk	GO	4%	4%					Norsworthy, Craft 2013
Charleston	STACS	1%	3%					Norsworthy, Craft 2013
Houston	DLP	2%	1%					Norsworthy, Craft 2013

Note: Abbreviations in the table stand for Comprehensive Truck Management Plan (CTMP), Green Operators programme (GO), Seaport Truck Air Cleanup Southeast programme (STACS), Drayage Loan Program (DLP)

Encouraging modal shifts constitutes another method that port authorities and transport agencies can employ in order to reduce emissions related to the maritime transport sector. The emissions generated by rail transport are roughly equivalent to a third of those generated by road haulage, and many port authorities are thus encouraging switches to rail as a form of hinterland transport. One way of doing so involves incentivising the use of rail in hinterland moves through tax and subsidies. For example, Spanish ports are since 2004 required to give a 20% discount on port dues if a container goes by rail, with much noticeable impact so far (Monios, 2011). Another, more direct solution is to change the port's hinterland infrastructure. The Alameda Corridor, which links the ports of Long Beach and Los Angeles to regional

train networks, is estimated to have reduced certain kinds of GHG emissions by up to 35% each year, compared to what emissions would have equalled under a status quo scenario. Nevertheless, the overall tendency in emissions along the corridor was to increase over the 2002-2004 period, due to growth in traffic.

Modal shifts can also apply to the inter-port transportation of empty containers. In the ports of Tokyo bay, for example, empty containers were traditionally transported between ports by road. The government has subsidised and helped with a green partnership program between the ports that aims to increase the use of barges to transfer empties. The estimated reductions between the ports of Tokyo and Yokohama are roughly equivalent to 85% (APEC 2009). However, the project is still beset by high costs and the unsuitability of barge transport to port facilities. It is also important to note that another emissions reduction technique related to that of modal shifts, in that it also tries to alter traffic dynamics produce less impactful results, is that of congestion reduction. A reduction in the time that vehicles spend on the road translates into a direct reduction in emissions.

Investment in clean technology

Investment into clean on-port technologies is an increasingly effective way of both ensuring environmental compliance and making the port more attractive to shippers. As shipping companies must also comply with increasingly stringent regulations about the types of fuels they can use, ports that can offer green services have become more attractive. For example, some ports located near the edge of ECAs have been able to leverage their position to become key suppliers of low-sulphur fuel. The port of Falmouth managed to develop a strong market supplying fuel for Low Sulphur Oil bunkers, which must be filled before the vessel enters the ECA.

In a similar approach that may indeed prove more sustainable in the long run, several European ports have begun promoting the use of liquefied natural gas (LNG) as a ship fuel. Bremenports, which is responsible for the management and development of Bremen and Bremerhaven, has decided to actively support the future use of LNG. In addition to the construction of an LNG depot in 2011, one of its main strategies is to itself become a consumer of LNG, through the creation of ship services powered by LNG in 2012. It is hoped that the use of LNG by the service fleet will set a precedent for other users in the port, and Bremenports has a policy of providing technical expertise on these matters in order to facilitate the popularisation of such technologies. As mentioned above, the ports of Rotterdam and Gothenburg already run incentive schemes that subsidise the use of LNG by ships. In addition, both ports are investing in LNG facilities. Rotterdam's Gate Terminal built the first LNG terminal in the Netherlands through a EUR 754 million financing agreement signed with the European Investment Bank and 10 syndicated international banks. Construction on the Gate Terminal was approved in 2008, and it officially opened in 2011. In 2013, the terminal had contracts with five customers, and was handling its maximum start-up capacity of 12 bcm per annum. Gothenburg aims to have its own LNG terminal operational by 2015. Swedegas and a Dutch tank storage company, Vopak LNG, will run the terminal. Gothenburg and Rotterdam have already begun co-operating on standardisation efforts to ensure that LNG is handled in a uniform manner and in order to speed up the development and adoption of LNG as a fuel. The push for such technologies will arguably give these ports a competitive advantage over their counterparts as emissions standards in the surrounding ECAs become increasingly stringent. The EC regulatory proposal on GHG emissions from the maritime transport industry (COM[2013] 480), for example, would mandate that all ports in the EU feature LNG facilities by 2020. The Commission notably recommended EUR 35.5 million in funding for the Gothenburg project.

One important instrument that port authorities are increasingly using to induce cleaner shipping practices is that of 'cold ironing', also known as Shore Connection, On Shore Power Supply, and Alternative Maritime Power Supply. Especially in Europe and in North America, an increasing number of ports provide shore

power to ships that come into their quays, following the lead of Gothenburg in this respect (see figure 24 and Box 12). Instead of using their diesel-fuelled auxiliary engines, these ships use power generated by the local grid, which significantly diminishes diesel- and other fuel-derived emissions while in port. Shore power not only requires an on shore power connection, but also ships that are able to connect to this power source. For this reason, shore power is most feasible for point-to-point connections, such as ferries. Increasingly though, issues of compatibility are being resolved, and other ship types are connected to shore power in ports.

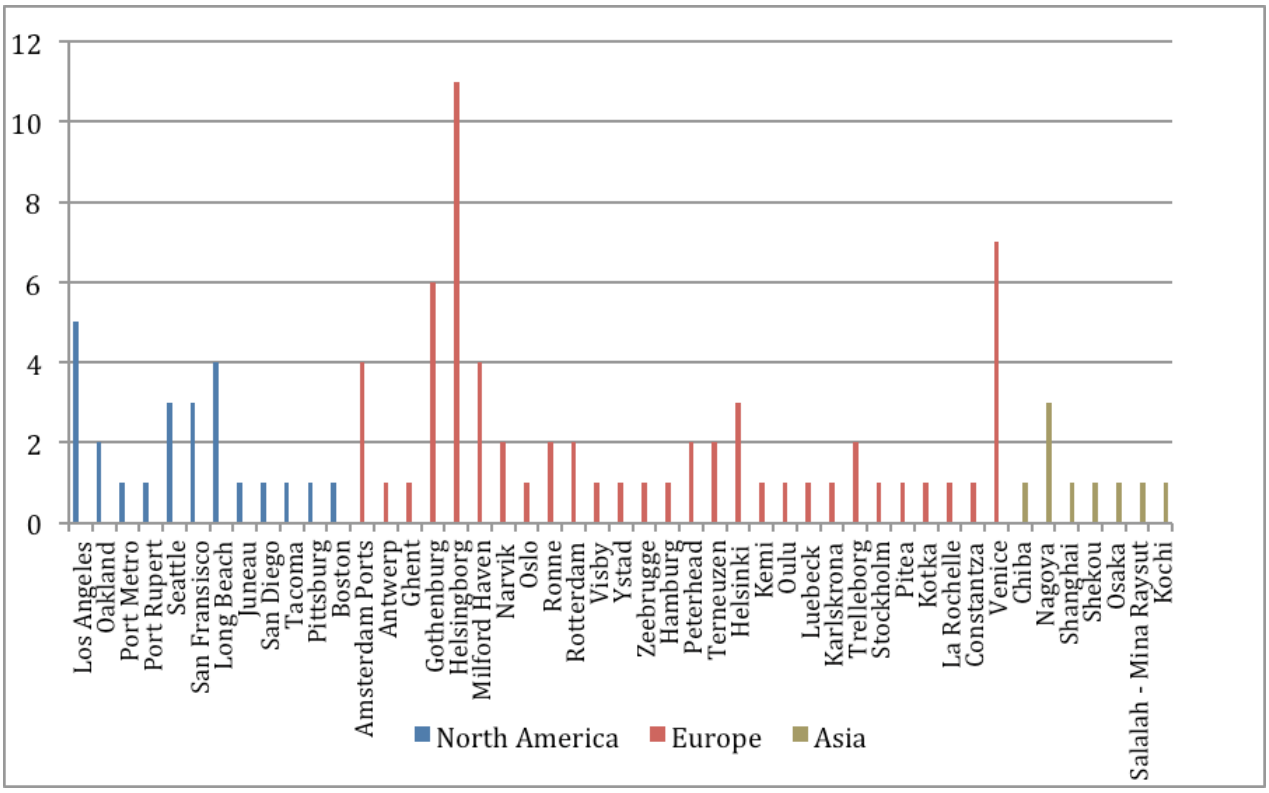
Box 12. Shore power in the port of Gothenburg

Since the beginning of the 2000s, the Port of Gothenburg (Sweden) has put in place an innovative policy of using on-shore power supply. Vessels that are at the quay typically use their diesel engines to meet energy needs for certain functions such as lighting, heating and air conditioning. This use of the diesel engine is a source of considerable local air pollution and greenhouse gas emissions. The Port of Gothenburg was the first in the world to propose that vessels be connected to the local energy network, which made it possible for these vessels to shut off their engines during their stay in the port (called “cold ironing”).

Since 1989, the Port of Gothenburg has provided electricity to ships calling at the port, but only through several low-voltage cables that did not cover all energy needs. Following the initiative of a large paper manufacturing company, Stora Enso, which sought to improve the carbon footprint of transporting its products, the port began designing a more efficient system in partnership with several navigation companies and Asea Brown Boveri (ABB), a company specialising in electrical products. Operational since 2000, this newer system uses a single high-voltage cable providing 6.6 to 10KW 50Hz, which can power an entire ship from these platforms on the docks. The vessels are therefore able to stop their engines, resulting in a significant reduction in both noise and carbon emissions. The Port of Gothenburg estimated that a vessel not connected to on-shore power grid emits about 25 tonness of carbon dioxide, 520 kg of nitrogen oxides and 22 kg of particulate matter during its stop. This innovation thus benefits both the environment in terms of climate change, and quality of life and work of the populations on or near the port (residents, dockworkers and ships' crews). Today, one in three ships calling at the Port of Gothenburg uses the connection for shore-side electricity, but this proportion is likely to increase. Roll-on/roll-off ships and ferries are the most frequent users of the new system because the links they provide are back and forth, but all categories of ships may benefit from this new technology. While connecting to the grid requires vessels to invest in technology to use the new system, costs for retrofitting vessels can be offset by the likely savings in fuel.

Through this programme, the Port of Gothenburg has acquired a first-mover technology advantage in connecting the vessels to shore-side electricity. This system is also present in other ports, such as Antwerp, Zeebrugge and Lübeck. However, a significant barrier to technology diffusion is the non-harmonisation of international electricity standards, with some parts of the world using 50 Hz systems and others using 60 Hz systems. This problem hinders retrofitting vessels, although attempts are underway to harmonise. Because of its pioneering role in this technology, the Port of Gothenburg was chosen as the leader of the Working Group on on-shore power supply created by the World Port Climate Initiative.

Figure 24. Number of shore power supply facilities per port (2013)



In addition to providing clean fuel and energy services for the shipping sector, ports are increasingly investing in cleaner, low-emission technology to drive their own operations. This can be seen in part as a response to legislative changes. The port of Houston, for example, implemented several energy efficiency measures, including improved lighting control systems and the installation of new window systems to reduce the dependence on artificial lighting, following the introduction of amendments to the Health and Safety Code. While many ports have implemented energy efficiency measures due to such regulatory pressures, however, it must also be noted that another incentive consists in the significant cost reductions that there energy savings can bring about in the long run.

Various ports have upgraded cargo-handling technology, which present a shift away from diesel engines. In the port of Virginia, for example, diesel engines were accountable for around a quarter of port facility emissions in 1999, when it voluntarily undertook to change its equipment purchasing policies in anticipation of impending air quality regulation from the EPA. Under the purchasing policy change, suppliers were instructed to provide only the cargo handling equipment with the lowest emissions engines on the market. The policy has met with success: despite a 55% increase in cargo from 1999-2005, emissions from cargo handling activities have decreased 30%, with an additional 35% reduction anticipated by 2015 even under high cargo growth scenarios. This policy, which has also reduced fuel costs while increasing air quality, would appear broadly replicable. For example, the port of Busan, Korea, has switched from fuel-driven Rubber Tired Gantry Cranes (RTGCs) to electricity-driven RTGCs (e-RTGC) in its cargo-handling operations. Even when accounting for emissions produced through electricity

generation, the Busan Port Authority estimates that the switch of 94 RTGCs to electrical systems will have reduced emissions by 28,000 tonnes of CO_2 (OECD 2010). At larger and higher volume ports, there are more opportunities to upgrade or build new terminals. They often replace existing facilities with newer and more energy efficient technology. But at smaller ports with rare opportunity and less financial ability to build new infrastructure, they tend to retrofit the old equipment with emission control devices and focus on implementing process improvement measures such as reducing idling procedures.

Another clean technology strategy involves supplementing traditional energy sources with renewable ones. In some ports, this includes the purchase of power from companies specialised in renewable energy production. The port of Houston, for example, signed a deal with Direct Energy in 2006 that saw 5% of its electricity generated through wind power. In Belgium, the port of Zeebrugge has concluded a similar agreement with Interelectra, which would see 17 500 MWh of wind-based electricity produced for the port every year. Many ports are also beginning to generate their own electricity. Solar power is commonly used to light on-port facilities. PSA Singapore Terminals, for example, have been using Solatube lighting systems in their facilities since 2008. Some ports are even using clean energy technologies to power more consumptive operations. Windpower is used at the Port of Göteborg, for example, to power electricity at the RO/RO terminal.

To a great extent, the impacts of renewables in port energy consumption appear marginal. Many of them are still too expensive, or unreliable. Port Kembla, in Australia, for example, made news around the world for its wave-energy plant, which was constructed by Oceanlinx, with the purpose of generating electricity at levels equivalent to those required to power 500 houses. However, the generator broke free of its moorings in a storm in 2010, has since lain inactive and rusting in the channel, and is largely considered a failure. If ports are to switch to green electricity generation methods, it would appear that very strong commitments are required from policy makers, in both a moral and financial sense, as it is a field that requires large degrees of risk-taking and experimentation.

5.1.2 Water quality

Water is a valuable resource affected by ports and shipping in many ways. In addition to taking steps to reduce the consumption of water in ports, port authorities must also comply with regulations governing the impacts of ships and port-activity on the body of water within the port. Currently, shipping activities are responsible for around one fifth of global discharges of wastes and residues at sea (EMSA 2013).

Regulation

At an international level, the main instrument for the regulation of discharges from seaborne vessels is Annex IV of the MARPOL Convention 1973/8. Generally speaking, the regulations within the Annex IV concern discharge of liquid wastes within a certain proximity to land. It is considered, for example, that deep oceans can assimilate and nullify the effects of raw sewage through natural bacterial processes. Several measures can be taken by governments and port authorities in order to ensure that shipping practices minimise harmful impacts on water quality. Limits on discharge function in two main manners: by regulating *where* discharge may and may not take place, and by limiting *how much* may be discharged.

Around thirty states in the United States have created such no-discharge zones (NDZs). Three different mandates for protection are used: protecting aquatic habitats where pumpout facilities are available; protecting special aquatic habitats or species; or protecting drinking water intake zones to protect human health. In March of 2012, the largest NDZ in the US was created: the California Marine Waters NDZ, covering over 2,600 km of coastline. When functioning correctly, the California NDZ should reduce the

annual discharge of over 76 million litres of sewage by cargo and cruise ships calling in at California's ports from the status quo level. This is expected to generate significant positive impacts for coastal biodiversity, not to mention public health and aquaculture.

Regulatory limits on *how much* and *which kinds* of pollutants may be discharged are often administered through permitting and licencing instruments. In the United States, for example, merchant vessels and cruiseships are eligible for the Vessel General Permit (VGP), drawn up by the EPA in 2008. The VGP sets general limits covering 26 kinds of discharge, from graywater, to bilgewater, various kinds of effluent, lubrication, oil, wet exhaust, and so on. The permit includes operational requirements and a host of best management practices. For example, the Permit recommends that ship-operators use shore-power wherever possible, as a means of reducing the amount of seawater cooling discharge generated as a bi-product of the vessel's heat-intensive electricity generation mechanisms.

Regulation of antifouling treatments constitutes another important regulatory measure for the improvement of water quality in maritime areas affected by shipping and ports. Antifouling describes a range of systems and technologies used to counteract or prevent the build-up of organic or inorganic deposits on marine equipment. Antifouling measures are an important cost-reduction measure in shipping: the build-up of organisms such as molluscs and algae on the underside of the hull can increase friction, slowing down the ship and increasing its fuel requirements. However, the harmful components used to kill biofouling organisms – such as arsenic, and various metallic compounds included in paints – were discovered during the 1980's and 1990's to have serious residual effects in the aquatic environments to which they are introduced, and can even enter the food-chain. At the international level, the International Convention on the Control of Harmful Anti-Fouling Systems on Ships – which was adopted in 2001 and entered into force in 2008 – prohibits the use of several harmful compounds used in anti-fouling systems, and created a mechanism for ensuring that future anti-fouling systems would not include harmful substances. Various national frameworks also exist.

Waste water reception facilities

Port reception facilities play a vital role in reducing the discharges of ships into the sea. Several regulations within MARPOL 1973/78 contain requirements for reception facilities[14]. In the European Union, a specific directive focusing on port waste reception facilities was adopted in 2000 (2000/59/EC). The main aim of the directive was to reduce illegal in-port discharges through the promotion of better availability of port waste reception services. It includes several requirements for member-states, including the formulation and implementation of a waste reception and handling plan (in consultation with stakeholders), and mandatory waste delivery for any ship that does not have sufficient waste storage capacity for its voyage to the next port of call. The Directive also introduces mandatory indirect financing of waste disposal systems, whereby ship owners must pay for waste disposal as part of the port dues, regardless of actual disposal. This measure provides a disincentive for discharge at sea prior to arrival in the port.

With increasingly stringent regulations on ship discharge at international and EU levels, the development of adequate reception facilities can thus constitute a key component in increasing the attractiveness of a port to shippers and in improving the environmental conditions of the surrounding environment.

Some ports have collaborated with local authorities in order to handle wastewater from ships. In the ports of Trelleborg, Sweden and Kalundborg, Denmark, for example, black and grey water is pumped directly from the berths to the municipal sewage treatment plant. In the port of Kapellskär, Sweden, the port itself built a sewage treatment plant that was subsequently sold to the city. In larger ports, such as the

port of Rotterdam, more complex systems are required. With over twenty wastewater disposal service providers operating within the Rotterdam port, the authority has put into place information-sharing mechanisms and acts as an interface between ship agents and waste collectors.

Sewage, sludge and oil spills

In addition to wastewater discharges from vessels, ports must also develop strategies to cope with a range of potential water quality impacts resulting from their own activities and physical layout.

Bunkering often poses a range of pollutant risks, not the least of which are oil spills. A series of important measures can be taken in bunkering ports to ensure that the risk of oil spills is drastically reduced. The Port of Gothenburg, through which passes around half of Sweden's oil imports, has undertaken a range of measures to ensure that gases and oils are not inadvertently discharged into the environment during bunkering. As part of its 'Green Bunkering' project, the port of Gothenburg introduced a stringent set of rules in 1999 that encompasses a wide range of activities, requiring the installation of electronic overflow alarms, the carriage of at least 50 meters of oil booms with absorptive material, and the vetting of all bunker barges by the Port Authority, amongst other things. The port has also mandated oil spill prevention equipment for bunker installations and that all bunker operators attend training programmes to learn safe bunkering techniques. Gothenburg has argued for the expansion of green bunkering practices to the rest of Sweden, supporting a 2011 bill to require regular pressure testing in Swedish bunkers in order to prevent oil spills.

Stormwater constitutes another risk factor for in-port water quality that must be dealt with. The runoff from stormwater can carry many pollutants into the bay, including petroleum products from vehicles, litter, construction materials, sand and other sediments, heavy metals, livestock effluent, fertilisers and pesticides, and various other aspects of the urban system. As part of the National Pollutant Discharge Elimination System (NPDES), most US ports require Standard Urban Stormwater Mitigation Plans (SUSMPs), indicating a range of measures for effectively dealing with stormwater runoffs. The port of San Diego's SUSMP, for example, integrates several design concepts into any new commercial and industrial development projects larger than one acre in dock and maintenance areas of the port. Requirements under the SUSMP include the use of pervious surfaces (permeable pavements and surface structures), and the planning of land slopes and gradients to ensure drainage or retention into designated zones.

Issues with water management can be particularly pressing in dry bulk ports, which require regular cleaning. In the port of Nantes–Saint-Nazaire, an extensive water treatment plant has been built to deal with runoff from the dry bulk docks. Water is first sieved before being treated chemically, in a process that significantly reduces pollutants in the runoff water. The plant was co-financed with the regional water authority.

5.1.3 Biodiversity and biosecurity

Without proper mitigation mechanisms in place, shipping and ports activities can have disastrous consequences for the biodiversity and even biosecurity of regions in which activity takes place. While consensus on the adverse impacts exists, solutions at international and national levels still prove elusive. Ports should help to spearhead efforts to make sure that growth does not come at the expense of biodiversity and biosecurity. Main instruments, discussed below, are indicated in table 40.

Table 40. Overview policy instruments biodiversity

Policy types	Instruments	Intervention level	Examples
Regulation	Ballast water management	Global	IMO
	Nature compensation	Local	Antwerp
	Integrated coastal and river management	Regional	
Technology upgrade	Ballast water treatment	Global	IMO

Source: own elaboration

Ballast water management

Ballast water is an essential component of seafaring: water pumped into the vessel helps to reduce hull stress, replaces weight lost through fuel and water consumption while at sea, optimises vessel manoeuvrability and improves propulsion. However, practices of taking on and emptying ballast water can have far-reaching consequences, because the water that is carried in this manner contains a host of microbes, small invertebrates, larvae, and bacteria that constitute aquatic invasive species (AIS). While relatively harmless in their eco-system of origin, AIS can prove devastating in the eco-system into which they are introduced. They can cause serious harm to biodiversity through habitat loss and mass species kills, damage national economies through bio-fouling and adverse impacts on coastal aquaculture, and even imperil human health.

Well-known examples of species invasions due to ballast discharge include: the cholera epidemic of Peru in 1991, which is believed to have been introduced into three separate ports through ballast water from Bangladesh, and spread throughout South America, killing more than ten thousand people by 1994; the introduction of the zebra mussel to Ireland, the Baltic Sea and the eastern half of the United States, which is estimated to have caused between US$750 million and $1 billion in damages between 1989 and 2000 to the USA alone, primarily through fouling of infrastructure (blockage of intake pipes, sluices and irrigation ditches); and the worldwide spread of toxic algae, which can kill populations of ocean life on vast scales through oxygen-depleting 'algal blooms', and contaminate farmed shell-fish that cause illness and death when eaten (paralytic shellfish poisoning) (Globallast 2004). Measures to better manage ballast water are thus vital in the attempt to reduce negative biodiversity, health and economic impacts associated with the growth of global shipping.

At an international level, the UN Convention on the Law of the Sea requires that States work to "to prevent, reduce and control human caused pollution of the marine environment, including the intentional or accidental introduction of harmful or alien species to a particular part of the marine environment." The first specific guidelines for managing the problem of aquatic invasive species were introduced in 1991 by the MEPC, recognised at the UNCED conference in Rio de Janeiro in 1992, and finally adopted by the IMO assembly in November of 1993. Steps toward mandatory ballast control were finally taken with the signature of the International Convention for the Control and Management of Ships' Ballast Water and Sediments (BWM Convention), in 2004. As of June 2013, the convention was still not in force, its 37 signatories falling short of the ratification threshold of 35% of the world's merchant shipping tonnage. Excepting the Marshall Islands, Liberia, Norway and France, many of the major flag states, such as India, Japan, China and Panama, have held back from ratification. Reluctance appears to stem from concerns about the technical challenges involved with compliance (IHS 2013).

Port states that have already ratified the BWM convention require shipping companies to undertake at least three kinds of measures in order to achieve compliance. Firstly, under Regulation D-1 of BWM 2004, vessels must perform ballast water 'exchange'. This involves the replacement of water taken in at the

beginning of the journey at the port or coastal area with water from the open ocean. Not only does open ocean water generally contain fewer organisms, but those that it does contain are less likely to survive in the coastal environment of the regulating state. It is worth noting that even states that are not party to the convention, such as New Zealand, have long required mandatory exchange measures. New Zealand's *Import Health Standard for Ships' Ballast Water from All Countries*, introduced in 1998, requires all water taken up in a foreign port to be discharged and replaced mid-ocean prior to arrival in New Zealand waters.

Secondly, Regulation D-2 of the BWM Convention of 2004 requires that ballast water be treated so as to remove or nullify invasive species. In order to be compliant, shipowners must implement systems that have been granted approval. For techniques that use chemical treatment, the active substances must be pre-approved, before receiving 'type-approval'. Most states use independent classification societies that issue type-approval, which is reviewed by the IMO. As of mid-2013, some 29 systems had received type-approval. The approved systems use a mix of three main kinds of treatment technology (IHS 2013): mechanical (including filtration and cyclonic separation); chemical treatment and biocides (chlorination, residual control, advanced oxidation, etc.); and physical disinfection (ultraviolet, heat, cavitation, electrolysis, ozonation, etc.). One of the first treatment systems, for example, was designed by the Swedish company Alfa Laval, and uses a mixture of UV treatment, filtration during both ballasting and deballasting to remove organisms. Current barriers to implementation of treatment systems include: cost (brought down by increasing competition as approvals are granted); system footprint aboard (including both space and energy requirements); and the risk of explosion (IHS 2013).

Thirdly, there are measures associated with production of information on ballast water and planning of BWM. Canada, for example, published its non-binding "Canadian Ballast Water Management Guidelines" as early as 2000, and transformed them into binding regulations in 2004. All vessels must now submit BWM plans for review by the national Administration, although only Canadian vessels are subject to approval processes. The master of any ship destined for Canadian ports must provide a 'ballast water reporting form' to the Minister of transport prior to entry into Canadian waters, detailing whether or not ballast water is carried, the nature of the vessel's BWM Plan (including certification by classification society or flag administration), whether BWM procedures have been carried out, and various other pieces of information. Non-compliant vessels are subject to inspection and detention.

Preservation and conservation

In addition to enforcing compliance with ballast water management protocols, authorities may also use offsets to mitigate the increased emissions associated with port development projects. Sometimes this simply involves a change in land use frameworks, stipulating that a certain percentage of developed land must include green spaces. This is a policy employed at the Port of Brisbane, where all new developments must allocate at least 5% of the new port land to green areas, and where 9% of the current land use plan is occupied by green spaces, including 150 ha of wetlands. Similarly, the Port of Durban has declared some 20 ha of its port area, which mainly comprises sensitive mangrove swamps, a natural heritage site. Such measures can increase the visual attraction of such ports, and help to limit the often highly destructive effects of ports on local biodiversity.

Integrated coastal and river management

Given that ports are located on the water's edge, their activity is very often subject to the regulatory framework set up to govern the coastal or riverside areas in their respective jurisdiction. Integrated coastal and river management frameworks increasingly include port actors in their biodiversity policies.

Since at least the mid-1990's, policymakers have worked towards 'integrated' approaches to the management of coastal and river environments. Both such approaches fall under the notion of integrated

water resources management (IWRM). Although human societies have arguably managed their water resources in an 'integrated' fashion for millennia, IWRM was first popularised as a policy concept at the international level during United Nations Conference on Water in Mar del Plata, Argentina, in 1977 (Rahaman & Varis 2005). The term was defined in 2002 by the Global Water Partnership "as a process, which promotes the coordinated development and management of water, land and related resources in order to maximise the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems". Integrated coastal management and integrated river basin management continue in this same vein, though each emphasises slightly different aspects that affect port operations in different ways. Indeed, whereas both focus on the protection of water as a resource, the former focuses more on the marine environment as a whole, while the latter emphasises water as a *consumable* resource used by individuals, industry and agriculture.

Turning firstly to integrated coastal management (ICM), the Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection (GESAMP) in 1996 provided a definition that has, for all intents and purposes, become the paradigmatic one: "Integrated coastal management is a process that unites government and the community, science and management, sectoral and public interests in preparing and implementing an integrated plan for the protection and development of coastal ecosystems and resources". Integration is thus meant here not only in reference to the holistic approach that is adopted when managing water resources (thus including coastal flora and fauna, as well as social systems and economic factors), it also refers to the range of actors that are involved. ICM is thus intersectoral and interdisciplinary.

The extent to which a given port will be affected by ICM norms depends on the stringency of the national regulatory framework. In a country such as New Zealand, for example, ICM is has been implemented as part of the Resource Management Act (RMA) of 1991. The RMA contains a mandatory set of coastal development objectives, referred to as the New Zealand Coastal Policy Statement, with which all future coastal development must demonstrate compliance, including ports.

In the case of integrated river basin management (IRBM), water is treated more as a resource that is subject to conflicting patterns of usage, including environmental conservation, transportation, industry, domestic consumption and agriculture. In such cases, IRBM is often used as a conflict management tool, to arbitrate between upstream and downstream conflicts over water levels during the dry season, for example. To the difference of ICM, IRBM is often pluri-jurisdictional. For the ports sector, this is especially important in water bodies that serve as corridors to inland ports. The Rhine river basin, for example, covers some 185,000km2 of North Western Europe, crossing 9 different countries and serving as an important waterway for the transportation of goods. Ocean-going vessels can navigate as far as Mannheim, Germany, and barges as far as Basel, Switzerland (Philip et al. 2008). At the international level, the principles of IRBM are upheld along the length of the Rhine by the International Commission for the Protection of the Rhine (ICPR), established in 1963 by France, the Netherlands, Switzerland, Luxembourg and Germany. Various ministers from the member-states are represented on this body, including the transport ministers.

5.1.4 Solid Waste

Solid waste management in ports involves the collection, transport, processing or disposal, planning and monitoring of unneeded material bi-products generated through port activity. Solid waste can have many sources in a port, from on-port facilities to vessels and the treatment of cargo itself (i.e. oil refinery). Typically, the management of waste is carried out through three main strategies, applied to different phases of the life cycle. Firstly, there are upstream measures that try to cut down on the overall amount of waste generated in the first place. Secondly, there are downstream measures that seek to recycle and reuse waste that has been produced. And thirdly, there are end-of-stream measures that seek to improve upon the final disposal and treatment of waste that can neither be recycled nor reused.

Reception facilities

Just as with wastewater, the reception and management of solid waste in ports is often best undertaken through coordination with the municipal authorities or local subcontractors. In some ports, this leads to innovative collaborations that make use of the particular specialisation of the port.

In partnership with the Flemish Region, for example, the port of Antwerp has begun experimenting with ways to recycle the filter cake produced through the mechanical dewatering of dredging soil. The AMORAS project thus produces clean water from the solid by-products of dredging, while the VAMORAS project seeks ways to reuse it, in line with a so-called 'cradle-to-cradle' policy. The potential applications of de-watered dredging soils include the creation of bricks, concrete aggregate, clay granules and road foundations.

In a similar move, the Danish port of Aalborg has used its specialisation as an organic dry bulk port to recycle solid bi-products of its activities. Every year, some 300 tonnes of organic waste are produced in the port due to spillage of bulk goods such as soya, corn, pulp and sphagnum. Rather than dispose of this, the organic materials are sent to a local biogas plant and used to generate electricity.

Marine debris

Marine debris is a serious environmental problem in which port authorities might play a more proactive role, particularly in fishing ports. Marine debris is often land-based, reaching the ocean via run-off, but is also produced by shipping and fisheries. Several species are threatened with extinction due to its debilitating effects. In the ports of Groningen, the authority houses and supports the KIMO foundation, which runs a 'Fishing for Litter' programme. Under the programme, fishing boats are provided with large bags for the deposit of litter found at sea. The bags are collected for disposal at the port when full. By involving key stakeholders, such as fishermen, ports may provide platforms for such net positive environmental action, rather than simply seeking to mitigate their own impacts.

5.1.5 Port noise impacts

There are various legal frameworks for port-related noise. The International Maritime Organisation (IMO) specifies a noise limit of 70 dB(A) at listening posts of ships.[15] In addition to the IMO resolution, there are ISO codes for vessels and there may be national and regional legislation on noise limits in the port area, as well as regulations in municipal codes. Many European seaports and their surroundings are covered by the Environmental Noise Directive of the European Commission.[16] The Directive requires noise mapping for industrial port areas near agglomerations (a territory having more than 100,000 inhabitants with typical density for urban areas). Other key provisions in the directive are that information on environmental noise and its effects should be available to the public, that action plans should be made based on the noise maps, a process in which the public should be consulted. Many countries require for new port development projects that an Environmental Impact Assessment (EIA) be made, which usually includes a Noise Impact Assessment (NIA).

Noise measurement is a pre-requisite for noise management by ports. Various ports have invested in noise measurement. The Port of Valencia has three noise meters distributed around the port that can take measurements every second and 24 hours per day (Rizutto et al. 2010). Noise maps can determine priorities in terms of policy interventions. Noise impacts and noise management have been the subject of various co-operative projects between European ports. The NoMEPorts-project dealt with noise pollution related to ports, delivering Strategic Noise Maps for six pilot ports: Amsterdam, Hamburg, Livorno, Copenhagen/Malmo, Valencia and Civitavecchia. The HADA-Project designed an acoustic monitoring network for the port of Bilbao and the definition of an evaluation methodology of the noise levels produced

by ports activities. The Sympic Project aimed at creating tools for environmental policies for port authorities and municipalities (Badino et al. 2010). These different projects have generated useful knowledge for measuring noise impacts and good practices for port noise management. Three sorts of instruments have been identified to reduce noise impacts of ports: technical possibilities for source mitigation, port design and barriers, and adaptations in residential areas.

Technical possibilities exist to reduce the noise from ships. This could be achieved by silencers on the diesel generator exhaust. If noise problems are apparent after the exhaust tack has been installed it can be very cumbersome and expensive to solve because of space limitations in the casing. Another solution would be to use the main engine exhaust silencer during port stay for the diesel generator exhaust by rerouting the exhaust. Standard methods for reducing noise from ventilation systems onboard a ship include adding mineral wool to fan rooms, and more expensive solutions such as cylindrical silences, baffle silencers and noise reducing louvers. Onshore power supply would be another solution, as it eliminates the need for power generation onboard and thus eliminates the noise from the diesel generator and the need for engine room ventilation is reduced. Other sound sources in ports could also be mitigated. This could be in the form of silent equipment, silent exhaustion pipes, insulation of sound intensive components, quiet asphalt and absorbing building materials. Much of the moving equipment in ports is using diesel; electrification could reduce noise impacts, along with air emission reduction; electrification of rubber-tired gantry cranes in Busan Port has reduced noise levels from 85 dB to 65 dB (OECD, 2011). Using cooling water instead of air cooling could also reduce the noise impact of port equipment.

Port layout and design can reduce sound impacts to the urban area. This includes overall port design, the planning of residential areas, roads and railways. E.g. a new access to the passenger terminal in Livorno was modelled to reduce noise levels in the urban area with 5-6 dB (A), due to a reduction of tourist traffic mingling with the regular road traffic (Morretta et al. 2008). Measures within ports could be respect for speed limits and reduction of transport distances within the port. Other measures could include relocating the noisiest activities, such as entrance gates, and more drastically, berths or whole terminals. Port planning schedules could also take noise impacts into account. The noise impacts from ships is sometimes asymmetric, in which case it would make sense to berth the ship with the less noisy side facing the noise sensitive areas in the port. Ships could also be required to provide data on their noise impacts on the surroundings before calling the port, so that the noisiest ships can be berthed furthest away from residential areas. This measure could be combined with a financial incentive scheme, so that ships would be charged with a higher berthing fee if they have high noise impacts or do not provide noise impact information. Noise limits could also be part of licensing schemes of ports; this is for example the case for low-frequency noise for high speed ferries operating from Danish ports. Another set of instruments relates to barriers between the noise and urban residential areas. Container racks in terminal yards could be planned in such a way that they act as a barrier. Other barriers could be new non-residential buildings and trees. All such propagation measures are most effective when the acoustic barriers are located near the source or the receiver. However, this is not always easy, as the barrier can interfere with the source, or because the urban population can object to barriers too close to their housing areas.

Finally, there is a set of instruments related to the receivers of sound in urban residential areas. This could include insulation of houses, sound insulating windows, communication and neighbourhood groups. A good illustration is provided by the case of HafenCity, the urban transformation project in Hamburg whose location close to core port areas has raised the demand for mitigating noise emissions. In the immediately adjacent areas of the HafenCity, a differentiated scheme of noise control measures has been introduced, in order to reach a noise cap at night time (between 22:00 and 6:00) with three different levels, between 55 dB(A) and 63 dB(A), depending on the intensity of the land use. In addition, sound-proofed windows and specific noise-accommodating alignment of buildings have been imposed in order to limit noise impacts. These public regulations are complemented by a tolerance clause in property purchase

agreements to avoid complaints or legal issues arising from residents after their move into HafenCity (Merk and Hesse, 2012).

These measures have most effect when they are part of an integrated action plan. Such a plan could include monitoring of noise impacts and training for port workers to improve their sensitivity to noise. An integrated port noise management plan can have significant impacts: in the specific case of Amsterdam a reduction of noise of more than 30% would be achievable through implementation of the action plans developed for the NoMePorts-project. There is not one universal best solution as every port has its own characteristics, such as the position and height of noise sources, the distance to surrounding urban residential areas, the direction with respect to potentially affected areas, operation hours, distribution of buildings and screening elements and the volume of activity in the port. As such, there is no universal measure that can be applied for challenges with port-related noise.

5.1.6 Other impacts

One of the traditional measures to limit other negative impacts from the port has been to create buffer zones. In this approach urban development is not allowed within a certain distance of the port area, because its noise, emissions, visual impacts or dust. These buffer zones can consist of nature compensation (e.g. in many European ports, there is a form of nature compensation related to new port development), golf courses (e.g. Helsinki) or areas with mixed development, such as creative workplaces (e.g. Amsterdam) or maritime training institutes (e.g. Rotterdam). In practice, many ports have witnessed forms of urban encroachment, where urbanisation around ports has limited the future expansion of the port; although the new urban area would seem to leave the physical space of new port development, in fact it does not because it takes up the noise and air quality contours.

Another approach is to allow the co-existence of port and urban functions, but to somehow find measures to mitigate the direct impacts for citizens. This can be either on the port areas through measures such as dust covers, sound walls exhaust filters, and in urban areas, e.g. through building codes requiring double glazed windows. Several ports in the US have provided citizens living in communities close to the port with some form of monetary contribution, by means of compensation for negative impacts and in order to finance home improvements that could limit the impact of port activity. An alternative form of such a measure is the Amsterdam Convenant Fund, financed by housing projects close to the port area in order to enable port-related companies to take measures to reduce the nuisance of noise, odour, and air-pollution. In several instances, the port also acts as a sort of urban redevelopment agency, helping to transform port-city buffer areas.

5.1.7 Regional transboundary measures

Transboundary issues such as pollution and climate change are often dealt with in international venues such as the UN and the IMO. However, in many maritime regions of the world, ports and port-cities are increasingly cooperating across national borders to develop regionally-scaled responses to collective challenges. Because co-operation between local authorities – such as port authorities and municipalities – can provide solutions that are properly tailored to the scale of the impacts, regional transboundary measures might provide new scales for action in the attempt to better regulate the relationship of ports and shipping to its environment.

Through transboundary co-operation and networking port-cities can respond to collective environmental problems that cannot be resolved without the participation of all concerned parties. This has proven particularly important in the field of environmental protection in the Baltic Sea region, for example. The region features a substantial history of both ministerial and sub-national co-operation that preceded EU involvement, including initiatives created in response to the fall of the Soviet Union, such as the

Council of the Baltic Sea States, which was created in 1992. It was around this time that ministers from Baltic Sea states began cooperation on the VASAB instrument (Visions and Strategies in the Baltic Sea Region), initiated by the Swedish Government at the Karlskrona Conference in 1992. This key instrument, which was incorporated at the EU level through the European Spatial Development Perspective (ESDP) in 1999, provided a set of shared visions for developing the region going forward towards 2010, and set the stage for the creation of a regional fund in 1997 (Interreg IIC), whose three main priorities were the promotion of inter-urban networking, improvement of transport and communication links, and integrated maritime management. Pursuant to these developments, the European Commission developed its first strategy specifically aimed at fostering transnational cooperation in the Baltic Sea region in 2009, following a mandate issued by the Council in 2007. This strategy and subsequent rounds of funding for the Baltic sub-region have given rise to a plethora of cooperative initiatives amongst neighbouring Baltic port-cities. Many of these have sought to align interests around collective resources. The Baltic Metropoles Network, for example, has implemented the Clean Baltic Sea Shipping project, involving a clean shipping strategy and six pilot projects, and various initiatives aimed at financing and promoting innovation and SMEs.

At the European level, the exchange of best practices by environmentally forward-looking ports is facilitated by the Eco-Ports Network, set up through the European Sea Ports Organisation (ESPO). Eco-Ports features two main instruments that facilitate information sharing and monitoring amongst European ports that aspire to lead the way in terms of environmental impact. Firstly, the Self Diagnosis Method (SDM) is a methodology used by all of the member ports in order to identify environmental risk and develop action plans. The SDM provides port authorities with a very easy-to-use and comprehensive checklist, through which they can compare their performance with European and international benchmarks. Secondly, the Port Environmental Review System (PERS) is a well-recognised environmental management standard that is specific to the port sector. It incorporates the main requirements of widely used environmental management standards such as ISO 14001, and allows for independent certification.

5.2 Land use

Mitigating negative land use impacts is of crucial importance in modern port-cities. As cities grow, alternatives of port land use emerge, leading in many instances to conflictuous dynamics on the extent to which prime urban lands should be used for port functions. Main solutions for these port-city land use conflicts can be summarised under three headings: increasing land productivity of ports, port re-location, and alignment of port and city land use plans.

5.2.1 Land productivity of ports

Land productivity rates among ports differ widely, indicating the potential that exists for many ports to become more land productive. The average number of TEUs per hectare per year was 49,005 in South East container terminals run by international operators, while this was 9,303 in North America (Drewry, 2010). Our own calculations indicate that the land productivity in Hong Kong might be approaching 60,000 TEU per hectare per year. These kind of statistics might be slightly deceptive because container terminals in some regions include certain functions that would not be counted in other regions, e.g. many US container terminals have devoted large shares of their lands to rail yards or ancillary facilities that would not be counted in Asian or European terminals; if corrected for this average land productivity rates could double (Tioga Group, 2010). However, even if a net terminal area would be taken, the scores of North American terminals are far removed from those in Hong Kong and Singapore.

Higher land productivity of ports can be reached through planning, regulation and the re-location of non-essential functions. Higher densities can be reached by changing the design and layout of terminals, sometimes realised by land fill, so as to create longer quays and a larger terminal surface that makes the

terminal exponentially more productive. Certain container terminals manage to stack more than five containers high in their container transfer area, facilitated by superior yard planning. In Hong Kong multi-storey warehouses have been erected in order to rationalise space. Such approaches would require changes in local regulation and building codes; even in Hong Kong the boundaries of what is legally allowed have been reached. Another approach would be to de-localise functions that do not need quay access; in various ports non-port related firms have been granted land with access to water. As urban port land becomes scarcer, the port might want to reserve future land for purely port-related functions, while de-localising other functions to other areas.

5.2.2 Port-relocation

An important part of port modernisation is the re-location of ports on new port sites. This is to some extent inevitable if both the city and port are growing, leading to new assessments on the ideal location of the port. Whereas its location might have been good a few decades ago, ongoing urbanisation might pose challenges for further expansion, with more limited acceptance of negative impacts on the one hand and opportunity costs of port land use on the other hand. At some point, both the port and the city have an interest in relocating (part of) the port to another site that has less opportunity costs and that provides the port more possibilities for expansion.

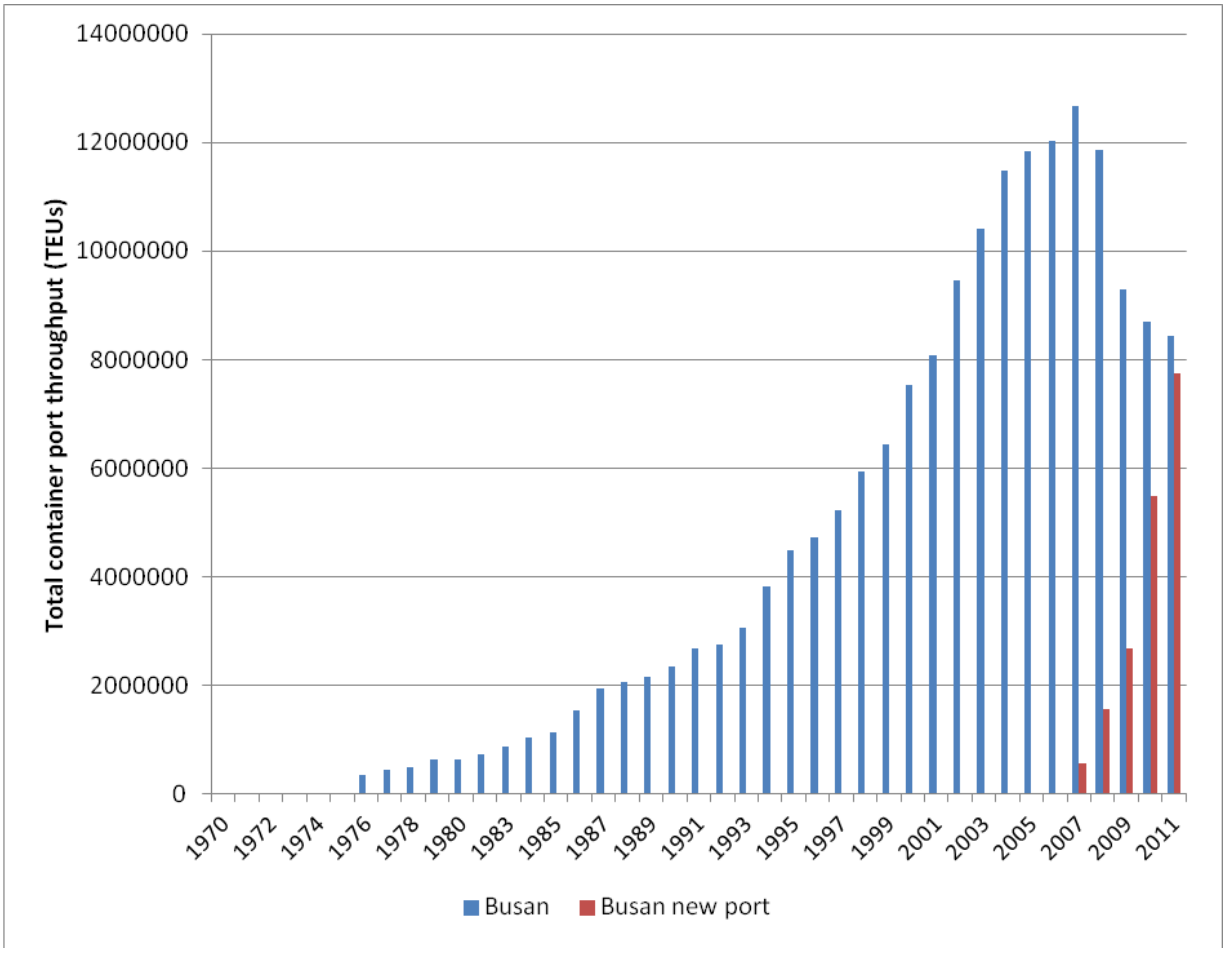
However, this process is a complicated one, due to sunk investments and long-term contracts with private operators. So this process can take place gradually, with port activity gradually shifting towards newer facilities, or radically if announced long enough in advance (e.g. in Singapore). Table 41 provides an overview of ports that have created a new port site, in addition to the existing city-port; in practice many of these new port sites, located further away from city centres, manage to capture a lot of the port traffic from the city-port site, as can for example be illustrated by the case of Busan (Figure 25). A radical re-location is of evidently also easier to decide if the old port no longer very active or if terminal equipment has been written off, as was the case in Helsinki (Merk at al. 2012). Re-location of ports might be facilitated by land swaps, with ports giving up some of their land in urban cores in exchange for new land for port development. This might become a source of conflict if urban and port interests are not aligned, and if the port fears that current industries might move to other sites than the new port sites.

Table 41. Multi-site ports

Old city port	New port site
Busan	Busan New Port
Shanghai	Yangshan
Rio de Janeiro	Sepetiba
Marseille	Fos
Kolkata	Haldia
Bremen	Bremerhaven

Source : own data compilation

Figure 25. Relation between old and new port: the case of Busan



Source : own data compilation

5.2.3 Alignment of port and city planning

Alignment of planning is essential to resolve the port-city mismatch. Such an alignment guarantees that port and city mutually reinforce rather than oppose each other, and could take the form of common master plans and aligned land use planning. Policy alignment is dependent on different variables: the role of port authorities, functions of cities, the involvement of cities in their ports, the role of the national government, the involvement of the port in urban development and finally the way in which strategic planning is used as mechanism to involve stakeholders.

Common master plan for port and city

In order to ensure cohesive and mutually beneficial paths for growth, some port-cities have adopted visions, strategies and plans that are jointly drawn up by the port authorities and local government. Common master plans can cover various scales, ranging from the project level, to the city, to strategies for

much larger regions. The main advantage of such plans is that they provide a set of parameters for long-term decision-making that are visible and clear for all parties concerned.

A port-city is a complex territorial, social and industrial organisation, whose developmental trajectory is determined by a number of actors – ranging from local to national scales of government, and including private and public actors – each of which has a different set of interests and motivations (Jacobs 2007). On the one hand, a coalition of actors and decision-makers seeks to provide for and plan the city, which entails the provision of quality public services, such as housing and transport, as well as support for inclusive economic growth and job creation, amongst others. On the other hand, another coalition of actors and decision-makers plans and provides for the port, which entails the development of infrastructure with sizeable land-use demands, the facilitation of expanding international trade through commercial incentives, and increasing the competitiveness of the port globally through large capital investments in efficiency.

Because these two broad agendas are pursued within the same jurisdiction and space, competing for the same resources (land, transport networks, tax revenues, environment), such efforts can lead to tensions. Tensions are likely to arise when the institutional distance between the port governance and city governance is large, as in cases where the port authority is fully national or private. In such contexts, joint master planning efforts help to avoid problematic tensions further down the road: in providing a joint vision of the respective development of the port and the city, problematic areas can be identified and dealt with much further upstream. Furthermore, joint master planning often sets a new precedent for collaboration, creating the conditions for future joint efforts. E.g. The Port of Valparaíso (Chile) has developed a Master Plan that has been incorporated in the UNESCO nomination document for the historical city centre of Valparaíso that became a "World Heritage Site" in 2003.

It is possible to distinguish between two types of joint port-city planning exercises: ad hoc plans that last for the duration of a given project or initiative (Box 13); and institutionalised plans that provide a broad, multi-sectoral framework for future interactions (Box 14). Port-city master plans often coincide with the opening of a window of opportunity in which the ports and city's interests are all of a sudden aligned. Such master planning efforts should be distinguished from classic port-city interface tradeoffs, in which the port agrees to cede some of its land to the city for waterfronts or docklands, often in exchange for the acquisition of new land from the city (See: Waterfront development). Such waterfront tradeoffs constitute a momentary deal, in which land is exchanged but the interests of the port and city are ultimately kept separate. Whereas, in joint master planning efforts, the city and the port engage in a more serious and lasting collaboration, often in recognition of their interdependence, and often with the city deliberately helping to facilitate the operations of the port (rather than simply reclaim land for its own commercial or electoral uses).

Box 13. A common port-city Master Plan to restore Oakland's working waterfront

In 1999, the decommissioning of the Oakland Army Base (OAB) resulted in the loss of 7,000 local jobs and the dismantling of a significant economic asset. This dealt a serious blow to the urban economy. However, the closure of the OAB also freed up 130ha of land at the cusp of the port-city interface, which was subsequently divided up and transferred to both the Port of Oakland and the City of Oakland during 2003-2006. For both actors, this initial transfer of land thus represented numerous opportunities. The port sought lands adjacent to the main rail connection, hoping to improve hinterland connectivity. For its part, the city sought land on the waterfront and in the northern portion of the former OAB site. Many different options for this land were considered by the city, including the typical private-led waterfront redevelopment ideas (from a casino, to a shopping mall or film centre), which would have in no way benefited the port on an operational level. However, in recognition of the significant economic asset represented by its port, the city formulated an industrial development strategy in cooperation with the port, a logistics park developer (Prologis) and a real estate developer (CCIG). In 2011, this collaboration resulted in the common Master Plan for the Oakland Global Trade and Logistics Centre. The Master Plan, revised in 2012, aims to provide the port of Oakland (the main export gateway for the Northern California region) with a world-class intermodal centre. To this end, the port land

will feature a new intermodal rail yard, and the city's land will play host to 70 acres of logistics and trade facilities.

The results of the 2011 Master Plan have been very positive for both port and city. Because the common planning and implementation of this project involved the pooling of resources and the sharing of costs between the port and the city (as opposed to the zero-sum exchange typical of waterfront tradeoffs), the two parties have been able to leverage significant funding from both the federal and state levels that would not have been available had they applied individually. Moreover, the collaboration has set the stage for weekly project team meetings between city and port actors, increasing their capacity for working collectively. Finally, it must also be noted that the Port of Oakland is governed by a board of commissioners that is nominated by the City Council, so the scope for port-city conflict is already reduced considerably in this case.

Box 14. The creation of a common port-city vision in Durban, South Africa

In the port-city of Durban, the historical absence of coordinated planning for the provision of infrastructure has helped create a sub-optimal spatial allocation of the various links in Durban's logistical chain. The Ro-Ro facility, for example, is in the far north of the port, while the main manufacturing basin that contains the country's largest automobile plant (Toyota) is in the far South of the city, requiring intensive usage of the North-South arterial by automobile shippers that competes directly with commuter traffic.

For many years, interactions between the port authority and the municipality in Durban were strained. Ports in South Africa are owned and operated by a state-owned enterprise, Transnet, and as a result, ports are often managed and run independently from the cities in which they are located. In Durban, conflicting interests would most often become apparent when the port or the city attempted to implement projects that crossed one another's jurisdictions. For instance, the municipality would use statutory mechanisms such as urban zoning regulations to constrict the port's plans for truck movements around the port, using such regulations to force concessions in port-owned areas adjacent to the port.

In the face of growing traffic, such tensions appeared untenable and provided growing momentum for a new approach to port-city relations. Coupled with a change in leadership, this impetus was institutionalised through the signature of a Memorandum of Understanding (MOU) between the city and port in 2003, which gave rise to what is now known as the Transnet and eThekwini Municipality Planning Initiative (TEMPI). The MOU established a 'Port-City Forum', whose purpose is to "develop a sustainable and pro-active planning and co-operative framework between the National Ports Authority (Port of Durban) and the eThekwini Municipality."

In 2010, the Durban International Airport was closed in favour of the new King Shaka International Airport, built to coincide with the FIFA World Cup. In a manner similar to the Port of Oakland, this constituted a major window of opportunity for the Port and the City, as it freed up a substantial amount of land in an area that was prime for brownfield development. Pressure from speculative developers constituted a catalyst for more joint action under the TEMPI framework, and in 2010 eThekwini and Transnet published their ambitious 2050 Vision for a long-term development of the Durban to Gauteng Freight Corridor. The Vision provides a broad and long-term masterplan that sets out an integrated framework for the development of a new digout port at the former Durban International Airport site, and the provision of an extensive road and rail corridor between Durban and the Gauteng Industrial Basin. By providing a conjoint framework for long-term decision-making, the 2050 Vision has facilitated better planning alignment between the port and city. It was largely in response to this Vision that the City has formulated its new Back of Port Area policy, which lays out a new zoning framework in the urban areas directly behind the port, with the aim of better rationalising this space to improve the port's performance. For its part, the port has sought to remediate the problem with the location of the RO-RO terminal in its plans for the new dig-out port: a new automobile terminal will be built in the south of Durban, in direct proximity to the Toyota plant, which should help the city to hang on to this crucial economic asset.

Port land-use planning

With many of the world's major ports under pressure from intense urban growth (Hall & Jacobs 2012), land is a vital resource in port-cities. Port authorities endeavour to keep a tight watch over the land resources at their disposal, including assessments of its real estate value, the potential for land exchanges with the city, and of course, possible acquisitions. Furthermore, land use plans allow the port authorities to steer development: rezoning can be used to rationalise port use by grouping like activities; certain strategic sectors can granted privileged locations or advantageous lease-structures; environmental compliance can be outlined and integrated into land-use; and sectors that do not fit into the port authority's strategy can be gradually zoned-out. Finally, land-use plans can constitute an important consultation mechanism for ensuring that stakeholders are aligned with the direction of future port developments. This can be particularly important for the urban planning department in the city who must plan land-use in the zones directly adjacent to the port perimeter. When used in this manner, land-use plans are often integrated into port development frameworks detailing capital expenditure projects. Although they are not always positioned as such, land use plans are thus highly strategic instruments at the disposal of port authorities, and are reflective of a particular port's strategy.

5.3 Reducing road congestion in the port-city

Road congestion is not only hampering port competitiveness, but it is also a major nuisance to urban citizens. The hinterland strategies indicated in chapter 3.1 can certainly help to reduce urban congestion, as their goal is to provide for smooth traffic flows that will also be to the benefit of urban citizens. The section below will focus on traffic flows within port-cities, in particular those at the interface of port and city. Two sets of policies are discussed below: port gate strategies and modal shift-strategies for hinterland traffic (table 42).

Table 42. Overview main instruments for congestion reduction

Policy strategies	Instruments	Examples
Gate strategies	Terminal appointment systems	New Orleans, Georgia Ports Authority
	Extending gate hours	Los Angeles, Long Beach
	Virtual container yards	Southern California
Hinterland modal shifts	Incentives	Germany, Switzerland
	Dedicated infrastructure	Valparaíso
	Competition hinterland modes	Germany

Source: own elaboration

5.3.1 Gate strategies

One of the main port-related traffic mitigation measures relates to reduction of idle trucks at port gates. This presents highly relevant challenges in many port-cities, leading to urban congestion and environmental impacts. Main policy instruments in this respect are terminal appointment systems, extending gate hours and virtual container yard systems. The section below assesses these instruments as applied in ports and port-cities. In addition, there have been simulation models, but most simulations have represented gate strategies as shifts in demand and have not combined those demand shifts with actual gate operations, so the results of these simulations will not be treated here.

Terminal appointment systems

The goal of appointment systems is to reduce road congestion at port terminals, by giving a preferential treatment to trucks that choose to schedule an appointment. The idea is that an appointment system would allow terminals to spread truck movements more equally over the day. Terminal gate appointments are usually voluntary, but have in a few cases also been imposed on terminals by law. E.g. in 2003 the State of California passed a bill, the California Assembly Bill (AB) 2650, that required 13 terminals at the ports of Oakland, Los Angeles and Long Beach to create an appointment system or face a charge of USD 250 for each truck idling more than 30 minutes.

The results of terminal gate appointment systems can be positive. The Gate Entry Management (GEM)-system in the port of New Orleans and the WebAccess system of Georgia Ports Authority (GPA) are considered to be success stories. Both systems are web-based applications that allow dispatchers to schedule appointments and provide information for pre-clearance prior to truck arrival at the terminal; WebAccess allows customers 24 hours per day access to update data on container shipments. These applications have improved traffic flow, increased terminal throughput and improved productivity for trucking companies and terminal operators, with a reduction of truck turn-around times by 30% on average in the case of GPA (US EPA, 2006).

At the same time, the terminal appointment system in the ports of Los Angeles and Long Beach is generally considered to be ineffective. The majority of the terminal operators did not view appointments as an effective operational strategy, and they did not facilitate the implementation of the instrument. Only a small percentage of trucks used the appointment systems, and these appointments were not given a priority, so queues were not reduced. Other elements that contributed to the lack of success were the inability of terminals to enforce appointments, the lack of willingness of drayage operators to participate in the programme, the lack of dedicated appointment lanes and the fact that the system was opposed from the outside. Similar truck idling bills have been introduced in Illinois, Rhode Island, Connecticut and New Jersey. Conditions for such systems to work would be a large proportion of trips that use appointments and priority to appointment trips to realise significant time savings (Giuliano and O'Brien, 2007; Giuliano et al. 2008).

Extending gate hours

Extended gate hours attempt to redistribute the arrival times of trucks to port terminals throughout the day. The idea is that offering incentives to use off-peak hours will reduce congestion at port terminals, as well as nearby roadways. The most well-known example of extended gate hours is the PierPASS programme implemented in the ports of Los Angeles and Long Beach, which includes a Traffic Mitigation Fee (TMF) for drayage transactions made during peak hours, with exemptions for off-peak hours[17]. The TMF fee is USD 50 during peak hours (originally USD 40), with exemptions during off-peak hours and for empty containers and intermodal transport using the Alameda corridor[18]. The Beneficial Cargo Owners (shippers, consignees, or their agents) are responsible for the payment of the fee. Neither the trucking community nor the ocean carriers is assessed a fee under this program. In addition to providing an incentive for the shippers to divert cargo to off-peak time periods, the TMF also serves to defray the additional costs incurred by the terminal operators to keep terminal gates open at night and on weekends. Extended gate hours were also part of trial programmes in the port of New York/New Jersey.

The instrument was effective in Los Angeles/Long Beach, but not in New York/New Jersey. The PierPASS programme was successful in reducing daytime truck arrivals from 90% to 66% within a few months after introduction (Cambridge Systematics, 2009), and it reduced daytime traffic on a nearby freeway by 13%. The average share of off-peak cargo from July 2005 to September 2006 was 40%, with

an average rate of increase of about 8% per week. Little sensitivity to the fee itself was found, which suggests that adjustment costs, such as additional opening hours, more storage space for cargo etc., are the key factor in cargo scheduling (Giuliano and O'Brien, 2008). The programme was also positively perceived: drayage operators felt that extended operating hours of terminal gates had a positive impact on the overall efficiency of drayage operations, according to a survey (cited in Cao and Karafa, 2013). The only drawback of the programme was that ports experienced heavy queues just before the opening of the off-peak hours, due to a flaw in the design of the programme: a variable pricing scheme would alleviate this side effect. In contrast, the pilots carried out in the Maher Terminals and the Port Newark Container Terminal at the Port of New York/New Jersey were not considered to be a success. Only very few truckers were utilising the off-peak hours (7% of daily truck moves at Maher Terminals), despite the much shorter truck turn times (Spasovic et al. 2009).

The differences in effectiveness could be explained by different market and political conditions. Unlike New York, the situation in LA/Long Beach was characterised by persistent political pressure from the environmental lobby, with port terminals run by large shipping lines, which have more power to coordinate along the whole logistics chain and with cargo predominantly handled for large national shippers, requiring less coordination efforts than the more fragmented customer base in New York. Moreover, not many customers in New York are open at night and there are limited inland port distribution centres, so that truckers would have nowhere to go if they would pick up a container from the port at night (Spasovic et al. 2009). Other conditions that contributed to the success of the programme in Los Angeles/Long Beach were the amount of off-dock rail, environmental and congestion pressures, as well as inter-port competition, with the possibility that cargo would be diverted if terminal operations would not be efficient (Cambridge Systematics, 2009).

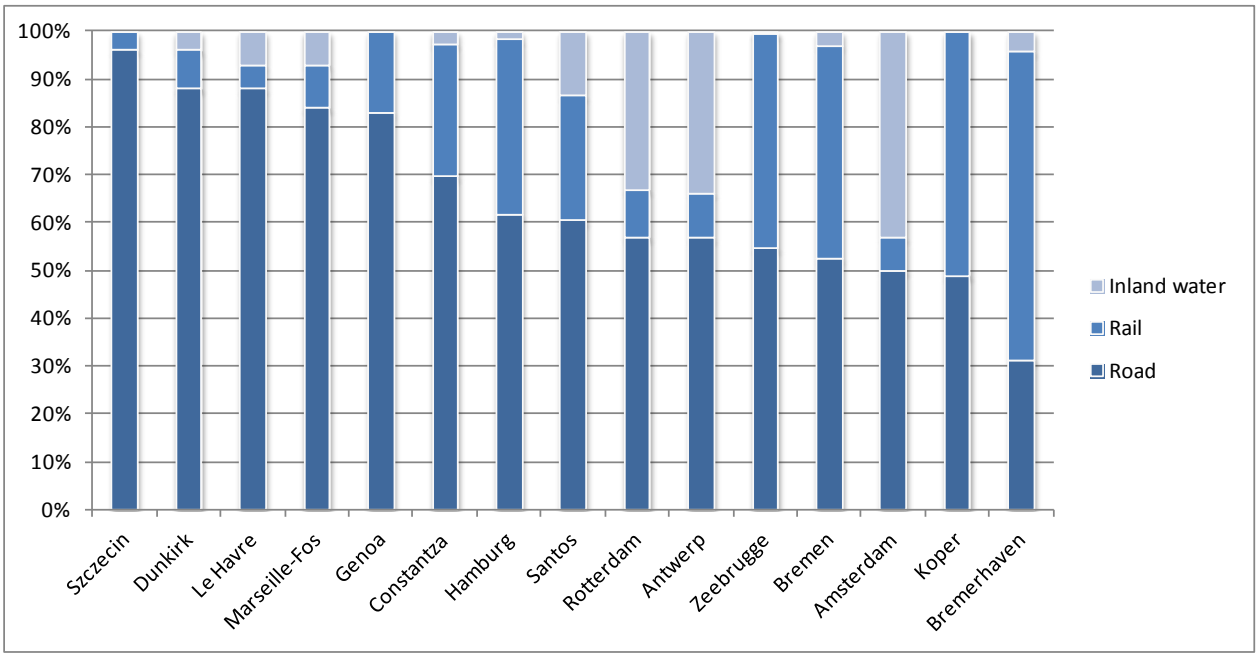
Virtual container yard systems

A virtual container yard system is a web-based approach to matching tractors with trailers as they head back to the port, rather than returning empty. Returning with a load is called a street turn (Thompson and Walton, 2011). The typical rate of street turns in South Californian ports was estimated to be 2%, meaning that 98% of tractors return to the port without a load (Tioga Group, 2002). It is estimated that a virtual container yard system can increase the rate of street runs to 5%-10%, but not much higher due to mismatch of location, timing, owner and commodity type. So, even if the system is found to be very cost effective as a tool to reduce emissions at ports, the maximum penetration of this strategy is quite low.

5.3.2 Modal shifts of hinterland traffic

Reducing port-related road congestion can be realised by shifting towards other hinterland transport modes, such as rail, inland waterways, pipelines and short sea shipping. In practice, the hinterland traffic of most ports is dominated by trucks (Figure 26). Even the ports with the highest shares of non-truck hinterland traffic rarely manage to achieve more than half of its traffic by other means than trucks. However, it is truck traffic that causes most of the congestion in and around port areas; and it is truck traffic that generally generates most external costs. So many ports have in their strategic plans formulated targets for a modal shift of hinterland traffic towards rail and water. This is not easy, as not all ports are connected to a well-developed system of inland waterways or of railway lines. As a result, the modal split shares of most ports tend to remain fairly stable, but there is a variety of instruments that can be applied, including incentives schemes, dedicated infrastructure and competition in hinterland modes.

Figure 26. Modal splits of port hinterland traffic



Incentive schemes

There is a range of incentives that port authorities and other governments can apply to achieve modal shifts of hinterland traffic, so to make port-related truck traffic relatively less attractive and other modes of hinterland traffic more attractive. Negative incentives can include tolls for trucks, whereas positive incentives could include reduced port fees for cargo transshipped on barges.

Although various port-cities have introduced urban congestion charges, none of these were primarily aimed at reducing port-related truck traffic. The most widely cited urban congestion charges are those in Singapore, Oslo, London and Stockholm, all considered to be effective in reducing urban congestion, and in facilitating the use of public transport (in the case of Singapore and Stockholm). Although trucks were included in these charges, no information is available on the extent to which these trucks were port-related, so there are no indications to what extent the urban congestion charge has resulted in a modal shift of port hinterland traffic or more evenly distributed port truck traffic over the day, although it can be assumed that the effects are marginal. Some port authorities that have a very large set of responsibilities, which in some cases also includes bridges and tunnels, have introduced tolls themselves. This is the case of port authority of New York /New Jersey that introduced in 2001 a new pricing structure for six bridges and tunnels, with tolls that varied according to time of day and payment technology. Assessment of this scheme indicates that 7.4% of passengers and 20.2% of trucks changed behaviour because of the time of the day pricing: there has been a significant shift in weekday peak period traffic to the hours just before or after the peak toll rates are in effect (Holguin-Veras et al. 2005). In addition, the new pricing scheme has helped to raise additional revenue for the intermodal investments of the port authority (Muriello and Jiji, 2004).

There are various toll systems for trucks, some of which have the explicit aim to achieve modal shifts and increase the efficiency of truck traffic. Germany's truck tolling system (LKW-Maut) charges heavy trucks driving on the motorways based on distance, number of axles, and vehicle emissions category (not based on weight). The system is considered to be successful in more efficient use of truck trips, in addition to generating revenue and encouraging purchase of lower emission vehicles. Switzerland has a truck toll,

the LSVA, that charges trucks weighing over 3.5 tonnes, with rates varying by vehicle class and emissions. The fee is charged per tonne-km under the assumption that all trucks are fully loaded. This provision has encouraged trucks to take advantage of their capacity and operate more efficiently (McKinnon, 2011). The "Eurovignette" could also be considered a toll for trucks. This is a common system of user charges of heavy goods vehicles above 12 tonnes, operational in the Netherlands, Belgium, Luxembourg, Denmark and Sweden. This system allows hauliers after the payment of a specified amount to use motorways of the participating member states for a given period (a day, a week, a month or a year). Unlike distance-based truck user fees such as the LKW-Maut in Germany, it is not related to the actual use of the road. Since the adoption of the directive 2011/76/EU of the European Parliament and the Council of 27 September 2011, it is possible to internalise externalities in the Eurovignette, e.g. by imposing a surcharge in peak hours, which might mitigate truck congestion in port-cities, although the effects on modal shifts remain to be seen. Inter-operability between these different truck tolls (including the more traditional highway tolls in countries such as France, Spain and Portugal) will remain a challenge for the future (Viegas, 2003), but increase the potential impacts of truck tolling on modal shifts of port hinterland traffic.

Various ports apply incentive schemes to stimulate modal shifts. This can take the form of reduced port fees or handling fees for cargo transhipped to barges or railways, usually embedded in a context of larger national support for inland waterways or freight railway transport. Various ports also negotiate modal split targets with terminal operators as part of terminal concessions, giving the operators and the shipping lines behind these an incentive to organise or accommodate more sustainable hinterland transport.

Dedicated infrastructure

Port authorities can influence the hinterland modal split by providing dedicated infrastructure. Some ports have developed dedicated short sea-terminals, in order to promote short sea shipping as a sustainable hinterland mode; in this way short sea shipping-vessels will not suffer from the lack of priority that they sometimes have in common user-terminals. Various ports have inland barge and river terminals, well connected to deep sea-terminals, in order to guarantee smooth transshipment between ocean-going vessels and barges. Finally, ports can plan for effortless connection between quayside and railway lines within the port, so that additional handling – that might be prohibitive – can be avoided. The provision of this dedicated infrastructure for sustainable hinterland transport is far from obvious in many ports, as can be illustrated by the case of Le Havre where the new container terminal Port 2000 was constructed without sufficient consideration for links with inland waterways and railways (Merk et al. 2011; European Court of Audit, 2013). Dedicated infrastructure for trucks will not lead to a modal shift, but might still be effective in reducing port-related congestion in port-cities. Since 2009, the port of Valparaiso is connected to a distribution centre via a dedicated tunnel for trucks, de-congesting major city artery roads.

Competition in hinterland modes

Sustainable hinterland transport modes are in many countries constrained by lack of competition within these sectors. Short sea shipping from one coastal location to another in the same country is often subject to restrictive cabotage laws, excluding this kind of cargo transport to foreign-flagged ships, vessels with foreign staff, vessels that were not constructed in the country, or a combination of these restrictions. Such laws have had a very discouraging impact on short sea shipping. The railway sector has undergone liberalisation in many countries, but there are large differences in countries, even in EU countries that are all subject to the same EU railway packages; it appears that countries with more liberalised railways also tend to have higher shares of rail in their port hinterland modal split (Merk et al. 2011).

5.4 Climate change adaptation in ports

Increasing awareness of the environmental context of maritime transport does not pertain solely to the impacts of transport on the environment, but increasingly includes awareness of the ways in which the environment impacts maritime transport. Thus, strategies for adapting to the potential consequences of climate change are growing in salience, all the more so given that the maritime frontier is at the forefront of many of the changes anticipated in climate change scenarios (Becker et al. 2010).

Seaports are particularly vulnerable to climate change impacts, because of their location in coastal zones, low-lying areas and deltas. They can be particularly affected by rising sea levels, floods, storm surges and strong winds. In its Fourth Assessment Report, published in 2007, the IPCC estimated that the global average sea level would rise from 18 to 59 cm by the last decade of the 21st century (EPA 2008). Assuming a sea level rise of half a metre by 2050, Lenton et al. (2009) estimated that the value of exposed assets in 136 port megacities may be as high as US$ 28 trillion. Ports will also have to consider anticipated sea levels not only for economic reasons, but also to prevent leeching of contaminants (EPA, 2008). The severity of these impacts, however, will vary widely by geographical location and will be modulated by a number of contingent variables.

This uncertainty renders adaptation measures difficult, as public decision-makers are most likely to act on conditions that they can already observe or easily foresee. One of the major impediments to the implementation of adaptation strategies resides in the discrepancy between port authorities' planning frameworks and the time span of climate change impacts. The highly competitive nature of ports requires that they adapt quickly to changing business circumstances, whereas adaption to climate change requires planning on a time span of up to a 100 years. The typical lifespan of major port infrastructure, including docks and port terminals, is around 40-50 years, and many port authorities' planning horizons are even shorter, at 5 to 30 years (Becker et al. 2010).

In order to cope with these challenges, many ports have begun to design adaptation strategies that attempt to plan on longer timeframes. Some plans feature new land-use zoning frameworks, which have to be coordinated with authorities in charge of zoning, when the port does not have the competencies to plan its hinterland (for flood risks, for example). Another strategy involves the coordination and education of agents involved in the management of the port sector, such as the National Oceanic and Atmospheric Administration's (NOAA) Office of Ocean and Coastal Resource Management, which has developed "Adapting to Climate Change: A Planning Guide for State Coastal Managers" to help U.S. state and territorial (states) coastal managers develop and implement adaptation plans. Other plan-based strategies of this sort include data storage plans, emergency responses and recovery plans, and work-to-ID funding streams. These plans often involve practices such as drills and event reconstructions, simulation of post-storm actions, and storm preparations.

Design upgrades constitute another major adaptation strategy. This entails the elevation of structures and port lands above flood levels, or the reinforcement of structures on port land. Measures can also be taken off port land with breakwaters, flood barriers, or, in very extreme circumstances, the port can even be relocated (this is being considered by the Port of New Orleans as a retreat response [EPA, 2008]). This aspect of adaptation is particularly emphasised in small island developing states, such as those in the Caribbean or Mauritius, where very higher quays are required to avoid flooding (Barbeau, 2012). Adaptation measures can thus feature a mixture of protection, adaption, or retreat.

All such adaptation efforts require research, including damage assessments, risk/vulnerability assessments, improvements in forecasting abilities and cartographic studies of flood-prone areas. Such tools enable ports to formulate better strategies *ex ante,* rather than on the basis of traditional *ex poste* scenario analysis. The Port of Miami, for example, participates in the Miami-Dade Climate Change

Advisory Task Force (CCATF), which recommended the creation of detailed elevation maps of the County (EPA, 2008). Finally, ports may consider designating a single point person to manage and distribute information on climate change impacts. This is not a technical answer, but it can help improving the efficiency of adaptive strategies.

Finally, it is worth noting that a spatial mismatch exists between climate change impacts and port jurisdictions. The impacts of climate change will occur at global and regional scales while ports are traditionally responsible only for their own infrastructure. Adaptation measures will therefore most likely require broader co-operation with multiple jurisdictions.

Today, most ports do not have comprehensive plans of adaptation strategies, and the international institutions such as the United Nations Framework Convention on Climate Change (UNFCCC) underline the urgent need to build common knowledge and take adaptive measures. Some ports, having taken measure of the issue, have begun coordinating regional-level responses. Port authorities should seek to coordinate with local, regional, and national bodies to address climate change adaptation, as these actors may help ports to define specific research gaps, produce the studies and data that they need, and possibly help with planning adaptation responses. Coordinated study efforts can lead to better response efforts. For example, the port of Vancouver, WA is part of a working group of the Climate Advisory Team (CAT) of the state of Oregon. Co-operation is thus not limited to local or regional cooperation, but can be extended to international circulation of ideas and best practices, as the UNFCCC projects aims at doing (UNCTAD, 2011).

5.5 Mitigating security risks

Risk and the associated strategies for dealing with it (precaution, preparedness, resilience, adaptation, etc.), are increasingly important aspects of port policies. Increasingly, port operators must change their modi operandi in order to comply with new regulatory frameworks aimed at 'managing' risk. Sometimes compliance involves a change in customs security procedures and protocols, which may directly affect throughput rates; sometimes compliance means that port actors must undertake the formulation of new internal 'risk management' guidelines and security plans, which might require changes in port governance, such as the creation of oversight committees. Moreover, the management of various kinds of risk in port-cities involves a complex set of interactions between local, national and international authorities, between the public and private sphere, and between geographically distant actors. As a result, the networks of actors with whom port actors must interact are widening as they attempt to recognise, assess and respond to various kinds of risk. Recent phenomena of worldwide significance have led to the introduction of new risk governance logics into port systems. All of these go beyond or extend upon the traditional focus on supply chain security in the maritime sector.

Firstly, a number of regulatory changes and new policies have been introduced in response to the terrorist attacks carried out against the United States on the 11th of September 2001, whose direct consequences for port operations worldwide are still being made clear. Some of these are specific to the operation of container ports and customs procedures. The November 2001 Customs and Trade Partnership Against Terrorism (C-TPAT), the 2002 Container Security Initiative (CSI), and the 2006 Security and Accountability For Every Port (SAFE) act, for example, were all part of a range of supply chain security policies introduced by the United States in the wake of the attacks, which were widely adopted through multilateral agreements by states around the world in the months that followed their introduction. At an international level, the International Maritime Organisation (IMO) drastically sped up development of the 2004 International Ship and Port Facility Security Code (ISPS) in reaction to the attacks of September 11, 2001. Many countries (including the EU member-states, the US and the UK) have already taken major steps towards implementing this legislation, which details a range of specific security requirements for shippers, port authorities, and governments. Moreover, individual port authorities are increasingly seeking

to comply with international risk management standards published by the International Organization for Standardization. Most ports in New Zealand and Australia, for example, have put in place internal risk management systems that are aligned with the Australian/New Zealand Risk Management Standard AS/NZS ISO 31000:2009.

For many ports, the implementation of new national and international risk management policies brings with it a range of challenges. For example, relations between public and private actors can be delicate: sometimes the formulation of security standards is left to the discretion of private operators, making harmonisation difficult. Moreover, compliance can be an issue, because it comes at a cost: new exigencies concerning container scanning, manifest forwarding, tracking and the security environment of the container all involve initial and ongoing burdens for shippers and operators. Nevertheless, the costs of non-compliance are potentially greater: regardless of whether non-compliant actors actually put their supply chains at greater risk, they are perceived as more risky by other potential business partners, and may severely jeopardise their trade relationships by refusing to adopt new security standards. While many studies have sought to assess the costs and benefits of increased supply chain security, the full effects of such policies are only now becoming apparent.

Some of the effects of this new risk climate on the port sector, however, have been more immediately felt. In 2006, for example, the U.S. congress blocked a deal in which P&O sought to hand over terminal operations at six U.S. ports to UAE-owned Dubai Ports World (DPW). Despite this agreement having received approval from the executive branch, congressional actors introduced legislation to delay the sale, citing gaps in intelligence surrounding the operations of DPW as a potential source of risk to the security of U.S. ports. After much debate, DPW eventually ceded the sale to AIG, who bought the operation contracts for an undisclosed sum. This is but one example of how the emergence of a new risk environment is altering the dynamics of the ports and shipping industry.

In addition to new risk management policies that are specific to the maritime and ports sector, the regulatory framework governing port operations has been further altered by a set of trans-sectoral policies introduced in the aftermath of 9/11. So-called Critical Infrastructure Protection (CIP) policies are one such example. Introduced in many OECD states around the world during the period of 2001-2010, CIP policies seek to integrate a range of sector-specific security initiatives into one unified national (or even supra-national, in the case of the EU) protection strategy. To the difference of 'public utilities' denoted through reference to concrete objects (bridges, roads, dams, pipelines, etc.), 'critical infrastructure' tends to be defined in the negative, which is to say, in terms of the material and immaterial systems without which society and the economy could not function. In nearly every CIP policy—from the EU's European Programme for Critical Infrastructure Protection, to Australia's Critical Infrastructure Resilience Strategy, Germany's *Nationale Plan zum Schutz Kritischer Infrastrukturen* and the United States' National Infrastructure Protection Plan—ports are included as a vital part of a broader infrastructure sector, variously referred to as the 'maritime transport system', 'freight and logistics', the 'shipping and postal sector', and so on. Such policies have generally focused on the trans-sectoral and trans-jurisdictional interdependencies between infrastructural systems. In the EU, for example, critical infrastructures such as energy grids and rail-based freight networks span multiple countries: failure in one sector or in one national jurisdiction can 'cascade' into others. Canada's CIP policy has pointed to ports as a site in which infrastructure failures could cascade or be amplified, due to sectoral interdependencies such as intermodal transfers to road networks, or the concentration in the port of petrochemical facilities that service the energy needs of the economy. Given the preeminent economic role of maritime ports in facilitating the import and export activities upon which the economic health of many nations depends, port actors are increasingly included in the formulation, implementation and review of such policies.

The concrete instruments that are used by government and port actors to implement new risk governance policies of course vary greatly according to the kind of risk that is being dealt with, and the

institutional context of the given state. Nevertheless, it is possible to trace several prevailing trends in the kinds of instruments employed as part of risk governance strategies at the international, national and port levels.

The first and most obvious set of instruments used to bring about changes in the risk governance in the ports of the world is the modification of the regulatory framework that sets the rules for actors' behaviour in port environments. This has involved the promulgation of new standards focusing on ports, such as the ISPS code. More recent standards have focused on the resilience of the supply chain as a whole. The 2011 ISO 28002:2011 (Security management systems for the supply chain – Development of resilience in the supply chain – Requirements with guidance for use), for example, reflects a new trend proceeding beyond 'risk prevention' towards enhancing the organisation's "capacity to manage and survive any disruptive event and take appropriate actions to help ensure its viability and continued operation".

The reform of customs procedures worldwide has also functioned as a key instrument for instituting new risk governance norms. Some such reforms have visibly altered the rules governing the behaviour of port actors around the world. New 'Advanced Manifest' rules—such as the 2002 U.S. customs 24-hour Advance Vessel Manifest Rule, Canada's 2004 24-Hour Advance Commercial Information Rule, China's 2009 Customs Advance Manifest regulation and the 2011 EU Customs Advanced Manifest Rule—make it incumbent upon shippers to provide detailed reports of container contents sometimes up to 24 hours before the goods arrive at their port of destination. In U.S. ports, failure to comply with this rule can result in penalties, fines, and even supply chain disruption in order to unload non-compliant cargo.

In addition to such regulatory instruments, a mix of voluntary schemes has been used to implement new risk governance policies in ports. So-called 'secure trading schemes' are one such instrument. The New Zealand Secure Exports Scheme (SES), for example, is a partnership offered by the public customs authorities, into which various private stakeholders can enter in order to benefit from less customs intervention and higher export priority; in return, shippers must commit to cooperation on data sharing and certain security standards. Private-led initiatives include the TAPA (Transported Asset Protection Association), an association bringing together professionals from the security sector as well as shippers in order to produce standards and certification relating to supply chain security, and the BASC (Business Alliance for Secured Commerce), a voluntary cooperative measure between U.S. Customs and the private sector, aiming at combatting the use of legal trade to undertake smuggling and trafficking.

The creation of 'information sharing networks' is increasingly being used as an instrument for the implementation of risk governance frameworks in ports and beyond, especially in countries that have formulated so-called CIP policies (the U.S., the EU, and Australia have all created such networks). Networks for sharing information on threats and disruptions between private and public actors at multiple scales are seen as a crucial platform for coordinating the many different interests that must be brought together in order to increase risk governance capacities in and around port infrastructure. These networks also promote planning for adverse events across sectors, involving increasing cooperation between port authorities, national security agencies, and private operators, in order to put in place response strategies and contingency plans.

Finally, the recognition of ports as 'critical infrastructure' has increasingly lead to the prioritising of resources towards such infrastructure. For this reason, competitive grant programs constitute one key instrument for implementing new risk governance policies in port zones. The United States, for example, created their Port Security Grant Program (PSGP) in 2005. Administered by the FEMA, the PSGP is an example of so-called 'risk-based funding', whereby forty-eight port areas have been grouped into different categories of risk, and receive differential priorities for funding on this basis. The seven ports that fit into group 1, for example, are eligible for funds that many other ports (deemed less risk-prone) are not. The

budget of the PSGP has been around US$ 300 million every year, and aims to "support increased port-wide risk management; enhanced domain awareness; training and exercises; expansion of port recovery and resiliency capabilities; and further capabilities to prevent, detect, respond to, and recover from attacks involving improvised explosive devices and other non-conventional weapons."

6. TOWARDS AN EFFECTIVE POLICY MIX

The port-city does not exist; there is only a collection of port-cities with various characteristics and heterogeneous opportunities. This report attempts to identify common challenges of current port-cities. In doing so, it has confirmed a mismatch between benefits and negative impacts. Substantial benefits from ports were identified, but they come with considerable leakages to other regions, whereas most of the negative effects of ports are localised, including environmental effects and most traffic impacts. Despite this common denominator, concrete impacts and implications differ according to local circumstances, the character of the port-city interface and the functional composition of the port and its city. Large-scale industrial development on or close to port sites requires a huge amount of bulk goods, generally associated with fairly limited job intensity, a variety of environmental impacts but strong local economic linkages. Container traffic has similar low job intensity, less local economic linkages, and environmental impacts related to shipping and hinterland traffic, but overall less polluting impacts because the connected economic activity is less industrial. Maritime business services generally generate high value added and limited environmental impacts, but are connected to large ports or large metropolitan areas. Cruise shipping is less space intensive than most other port functions, but the economic value it generates is fairly limited unless linked to a port-related waterfront; moreover, it can have relatively severe environmental impacts (emissions, noise) especially with terminals close to city centres, which is for obvious reasons frequently the case.

Finding the effective strategic policy is facilitated by a clear insight in existing local assets. Economic history is to a large extent determined by path dependency – and heroic but not always successful attempts to change existing trajectories. For example, not every port-city or every maritime nation can or should stake its economic development on the growth of its maritime cluster, if only because there can only be a few leading global maritime clusters in the world. Various port-cities have in the past invested in heavy industrial development, which provides them with certain assets but also with sunk investments that effectively limits alternative economic development options. Similarly, not all port-cities can develop into successful waterfronts, because success is also defined by how well it can divert visitors, high-earning residents and investors away from other urban waterfronts. There are only a few examples (Bilbao, Bremerhaven) of radical conversions of economic destinies of port-cities. The quest towards an effective policy mix is thus a delicate balancing act between building upon existing strengths and developing new assets and capabilities.

Facilitating competitive ports

Recent studies have stressed the important role of ports in global supply chains. The effectiveness of ports depends thus ultimately on how they are linked in these chains; this relates to their maritime and landside links, but then also how port operations are integrated and aligned with shipping and hinterland transportation. Four kinds of policies for competitive ports were presented, related to maritime connectivity, effective port operations, strong hinterlands and increasing local goodwill. These policies are complements to each other, not substitutes. Ports with good practices within one domain also tend to have good practices or performance in other domain, as is for example the case of Rotterdam. The continuing increase of ship size will put more focus on hinterland connectivity, whilst on-going tendencies of port

concentration will make local goodwill more important to sustain port functions close to cities. However, much depends on the specific local situation. Some factors are exogenous, such as geographical location and – to some extent - nautical access, but even these factors are subject to change, such as the future navigability of the Arctic seas. There is an important role for the port authority to improve its competitive position, in conjunction with other actors, including national governments and cities. The area is relatively well researched: determinants for competitive ports are known and identified, even if it is not always clear what this means in terms of concrete policies. Our study indicates that, in general, port policies have a positive impact on performance. Economic value added created within the port is associated with port-city economic performance.

Finding port-city synergies

The interaction between ports and their cities is underpinned by a set of policy dilemmas, because port authorities and city governments do not necessarily have the same interests, goals and perception of challenges and policies that are needed (Table 43). The typical perspective of a port authority is on cargo handling and ways to grow in this respect. So its priority for transportation investments is in networks for freight transportation networks, efficiency of port labour and land use dedicated to cargo handling and port-related industries. The focus of environmental policies of port authorities, is on limiting negative impacts. The typical perspective of an urban government is different: it is not per se interested in port volumes, but more in the value added it generates for the city; not in efficiency of port labour, but in the number of jobs that it generates, preferably high value added jobs. It will generally have a wider set of challenges to solve including housing and urban transportation, both issues of high relevance to their electorate, so they will tend to prioritise urban passenger transportation and have an interest in redeveloping urban waterfronts into housing areas. Their environmental policies might go further than limiting impacts, as they might want to market good quality of life as one of the competitive advantages of their city, e.g. Copenhagen that markets is swimming facilities in the harbour. The policy challenge for port-cities will be to find synergies between the two perspectives, e.g. by introducing smart and selective port growth perspectives, attracting high value added port employment, use the port as a site for green businesses and develop mixed urban waterfronts with room for port functions. This report has referred to numerous examples of such policies and related instruments.

Table 43. Policy aims for archetypical ports and cities

	Port	City	Port-city
Economic	Port volumes	Value added, diversification	Smart port growth strategies Maritime clusters
Transportation	Freight	Passengers	Disintegration or smart co-existence of freight and passenger traffic
Labour	Efficiency	Employment	High value added port-related employment
Environment	Limit impacts	Quality of life	Green growth
Land use	Cargo handling, industry	Urban waterfront as opportunities for housing	Mixed development, with role for port functions
Structural logic	Closed industrial cluster	Open network with pure agglomeration effects	Mix

Source: own elaboration

Increasing local economic benefits from ports

Three main economic policy strategies were identified for port-cities: maritime clusters, industrial development, urban waterfronts. These models present different orientations, but they are often simultaneously pursued in the world's largest port-cities. Some of these functions are easier to combine

than others; maritime clusters and urban waterfronts can go well together and reinforce each other, whereas a successful marriage between industrial development and maritime clusters is more difficult to attain due to the fundamentally different logic that underlies both orientations (Box 15). However, various port-cities, such as Singapore and Hamburg, have managed to combine the three strategic orientations, to a more or lesser extent facilitated by policies.

Box 15. The diverging priorities of port and urban systems

Spatial clusters could be classified into three different groups, with different characteristics of relations between firms and knowledge spill-overs (based on work by McCann and Sheppard, 2003; Iammarino and McCann, 2006):

- Pure agglomeration: metropolitan areas can be considered engines of growth thanks to economies of agglomeration: the assumption is that people and firms tend to cluster in metropolises because of the positive knowledge spill-overs that result from interaction between individuals. Firms in such a constellation typically have no market power, and will continuously modulate their interactions with other firms and customers in response to market arbitrage opportunities, leading to intense local competition. Loyalty between firms, and long-term relationships, are difficult to establish in these circumstances. The cost of the membership in this cluster is the local real estate market rent. There are no free riders, access to the cluster is open and the price that local real estate can command is a benchmark for the cluster's performance.

- The industrial complex is characterised primarily by long-term stable and predictable relations between the firms in the cluster, involving frequent transactions. In order to become part of a cluster, firms within it each undertake significant long-term investments, particularly in terms of physical capital and local real estate. Access is restricted by high entry and exit costs: the rationale for clustering is that proximity is required to minimise inter-firm transport transaction costs. In this constellation, a few large firms dominate the market; these firms often perceive that knowledge outflows to industry rivals can be extremely costly in terms of lost competitive advantage. These firms will thus decide to locate in industrial complexes characterised by stable planned and long-term inter-firm relationships.

- The third type of spatial cluster is the social network model. A key element of this model is mutual trust. These mutual trust relations will be manifested by a variety of features including joint lobbying, joint ventures, informal alliances and reciprocal arrangements. Relations of trust are assumed to reduce inter-firm transaction costs, because when they exist, firms do not face the problem of opportunism.

Although these models are theoretical ideal types, not intended to represent any particular location, it is tempting to apply this classification to ports and port cities, as they could clarify the challenges facing them. Large ports, especially those connected to heavy industries and specialised in containers and oil products mostly correspond to the industrial complex-model: an oligopolistic firm structure, high entry and exit costs and a relatively closed character, in order to avoid leakage of strategic knowledge. Whereas very large port-cities, such as New York, Singapore and Hong Kong, can combine these two imperatives, the situation is more complicated in smaller port cities such as Le Havre, and also to a certain extent in Rotterdam. Rotterdam has used economic diversification strategies, but still struggles with relatively negative perceptions of its urban attractiveness. The challenge for cities like Le Havre could be to compensate its relative "closedness" due to the port cluster by building regional networks, with Paris among other places, in order to develop a larger mass of "pure agglomeration" effects.

The room for manoeuvre for public policies should not be overestimated, especially not in the global market-driven environment of shipping. Many of the linkages between producers, customers, suppliers, labour markets, training institutions, and intermediary services that compose a maritime cluster or other port-related development form through necessity and through the response to market signals that governments can hardly foresee or influence (Uyarra & Ramlogan 2012). It is not certain that policy intervention is always an effective or necessary component of maritime cluster growth (Doloreux & Shearmur 2009; OECD 2009). Moreover, not every declining sub-sector can be saved. While renewal of declining maritime clusters has been possible in countries such as Norway, where niche specialisation and cost-reduction through targeted outsourcing helped to breathe new life into an ailing shipbuilding sector,

policy focus on declining sectors is not always desirable. This is of particular relevance to industrial development policies, where many port-cities in developed countries have been confronted with outsourcing of heavy industries and refineries. A proper understanding of needs and possible transitions is thus a pre-requisite to any policy formulation.

Policy initiatives can be effective if their underlying rationale is grounded in a response to a real and problematic deficiency in the status quo. Underinvestment into emerging markets, where potential for growth has been identified but is not being exploited due to private sector reluctance, might indeed be remediated by the provision of public funds for R&D. An obvious lack of qualified labour in industries could be at least partially resolved by publicly-promoted partnerships between training institutions and maritime firms. Firms with like needs, who do not interact or represent their interests together as part of shared marketing or lobbying strategies, might better collaborate through the provision of more complementary spatial planning frameworks, or publicly-created networking platforms. When a key component of the maritime cluster is in decline, such as the registration of ship-owners, and this decline is bringing down with it the firms dependent on the demand generated by that component, targeted regulatory or fiscal intervention at the national level might slow-down or reverse such decline. There are examples of successful instruments. Quebec's 'Innovation Maritime' has carried out 200 R&D projects for the maritime sector by virtue of government grants; publicly sponsored educational partnerships carried out through the industry-led Deltalinqs platform in Rotterdam have helped to turn the city into a leading centre for maritime expertise; the UK's tonnage tax has been credited with contributing to the growth in the UK-registered and –owned fleets, not to mention the employment opportunities linked to the in-built training requirement of this policy.

Policy initiatives must be adapted to the maturity of the sector. For example, developmental support, such as incubator infrastructure or the provision of venture capital, might be very important for emergent clusters (as with the LA PortTech industrial park, which has aided in the emergence of a clean port energy cluster), but makes little sense in clusters that have already matured or are in decline. Similarly, it might make sense for countries with large maritime clusters to engage in expensive measures to protect their fleets from competition by other flag states, such as the provision of Vessel Protection Detachments to protect at-risk vessels, whereas this expense would be unjustified by maritime nations who do not stand to gain from increased vessel registries (or to lose from deflagging). Similarly, it might make sense to assist with internationalisation of markets where clusters have matured, or to institutionalise inter-sectoral interactions where such linkages have begun to emerge, but international competition might imperil markets that are not mature enough to handle expansion, and interactions between sectors that have little need of collaboration cannot be forced.

The composition of economic functions is highly relevant to all three strategic policy options. The most successful maritime clusters, such as London, Singapore and Hong Kong are those that have developed into well-rounded and diverse clusters; this diversity attracts new businesses because they can be guaranteed to find high quality services in any maritime-related branch. Some maritime clusters, such as Rotterdam, have developed policies for the benefit of existing strong sub-sectors within that cluster, but should further expand into underdeveloped sectors of the cluster (Merk and Notteboom, 2013). Development of new industrial functions in port areas is hugely dependent on the composition of the existing industrial infrastructure that determines the potential for exchanging residual products. Mapping current and potential links can help to identify gaps (in commodities or infrastructure) that need to be filled in order to come up with new economic opportunities. The mix of economic functions is also of crucial importance for the success of urban waterfronts; the composition of functions determines if it attracts visitors and is able to create economic wealth.

The policy mix should be coherent: policy instruments should neither overlap nor cancel one another out. Overlap can occur, for example, with networking mechanisms: too many different networking

platforms can lead to highly competitive intra-sectoral dynamics and fragmentation of available financing. Instruments cancel one another out where the effects of one policy on another have not been anticipated. States that have chosen to implement a tonnage tax in order to attract shipping activities should also make sure that other fiscal policies are aligned with its aims: in India, for example, the benefits to the shipping sector from the introduction of the tonnage tax in 2004 were largely annulled by increases in indirect taxation through the services tax in 2007, which thereby led to a diminution of prior FDI gains to India's shipping sector. Coordination between instruments is closely related to coordination between actors. The latter requires that stakeholders in the maritime sector are clear about their priorities and intentions, and that policymakers seek to incorporate these priorities through a consultative process. In this regard, the alignment between local and national policies appears as particularly important.

Mitigating negative impacts

There is a variety of types of policy instruments to mitigate negative port impacts, ranging from regulation to market-based incentives, information and technology upgrades. Many of the policy choices to be made will be dependent on the local situation, but the most convincing examples of policy performance consist of a coherent package of inter-related instruments, such as the instruments implemented in Southern California related to the San Pedro Bay Ports Clean Air Action Plan (Box 16). In order to effectively mitigate negative port impacts, the interplay of different intervention levels is necessary, ranging from the local to the global level. Considering the global nature of the shipping industry some of the environmental impacts of shipping can best be tackled at the global level. Self-regulation of ports can work, but in most cases external pressure is needed. There are co-benefits of some of these port-city policies. For example, reducing port-related traffic congestion has positive environmental effects; and modal shifts of hinterland traffic do not only improve environmental performance, but can also reduce traffic congestion within the city. At the same time, there can also be policy trade-offs, for example between security and commercial concerns.

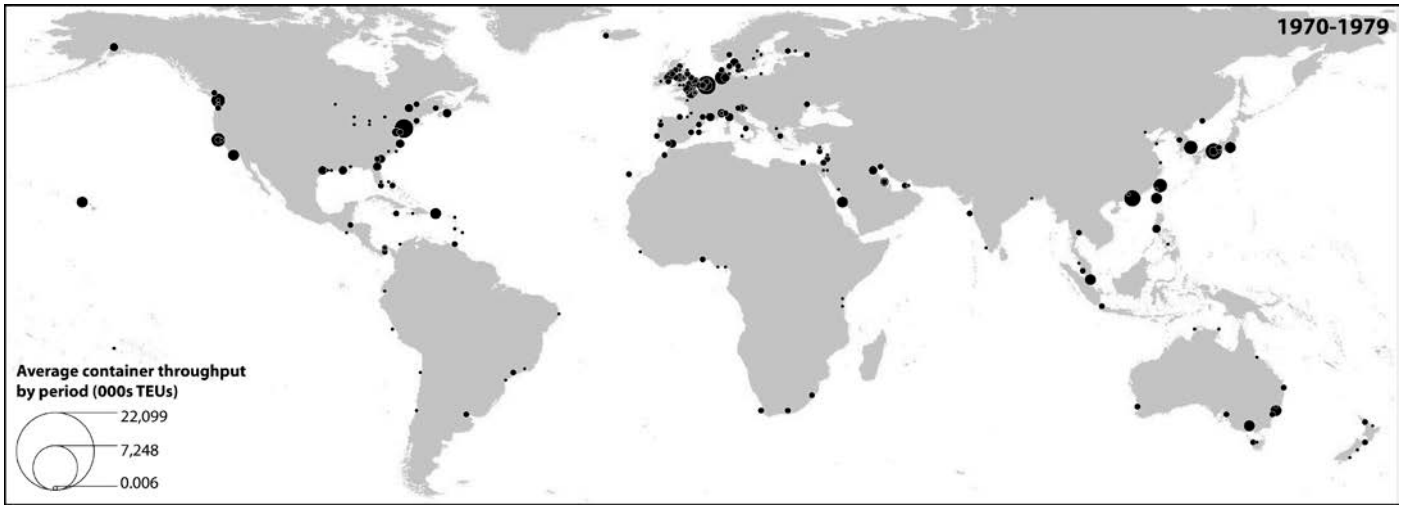
Box 16. San Pedro Bay Ports Clean Air Action Plan

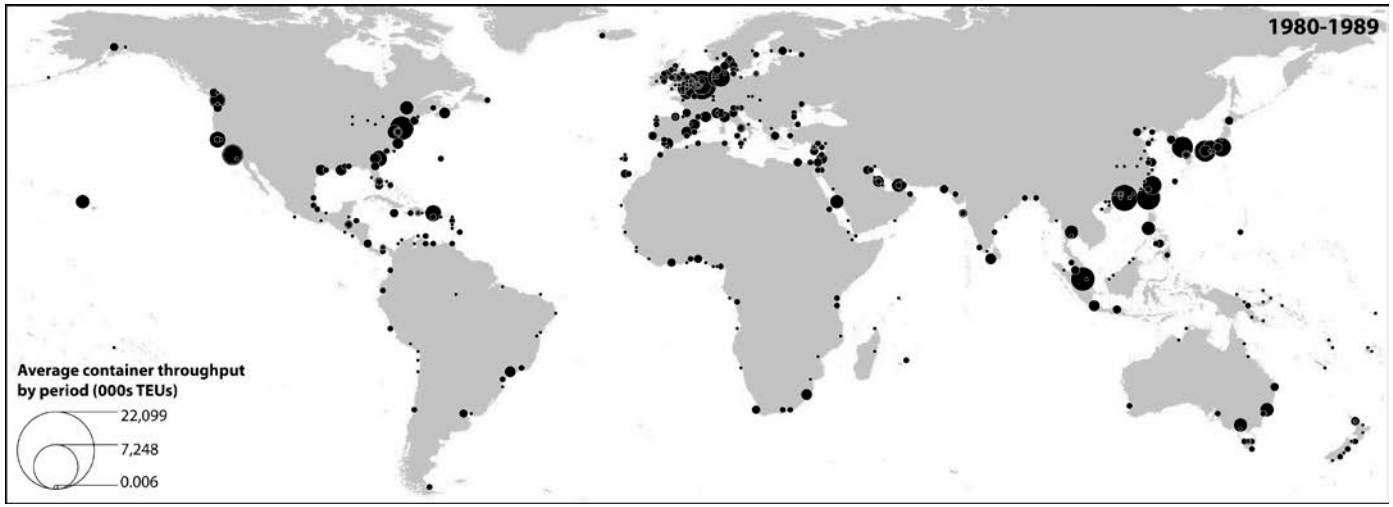
The San Pedro Bay Ports Clean Air Action Plan (CAAP) is a comprehensive strategy on reducing air pollution emissions from port-related cargo movement. As the largest seaport complex in North America, the two San Pedro Bay ports are also the single largest source of pollution in Southern California, according to the South Coast Air Quality Management District (SCAQMD). In 2005, the twin mega-ports of Los Angeles and Long Beach generated approximately 25 percent of the diesel pollution in the region (O'Brien, 2004). The CAAP is a product in response to address the problem between port's growing operation and its associated increasing environmental impacts on surrounding neighbourhoods in the port city. The CAAP's overall goal was to dramatically reduce emissions and their associated health risks for the Southern California region without hindering the continuous port development. The Plan was first approved in 2006 and updated in 2010 with near-term plans through 2014 and long-term goals, which includes reducing port-related emissions by 59% for NO_x, 93% for SO_x and 77% for DPM by 2023 and standards to lower the residential cancer risk due to diesel particulate pollution in the port region. As part of the Plan, the twin ports have developed Annual Emission Inventories, which are made public, to track the progress in achieving CAAP standards. The CAAP employs a combination of regulations, fees, grants and incentives to the goods movement industry to use cleaner technology and operational systems, such as the Clean Truck Program, the Vessel Speed Reduction Program and the Alternative Maritime Power Program. In support of the development and demonstration of clean-air technology, the two ports have also jointly created a Technology Advancement Program that has provided more than USD 9 million port- funding to the industry since 2007.

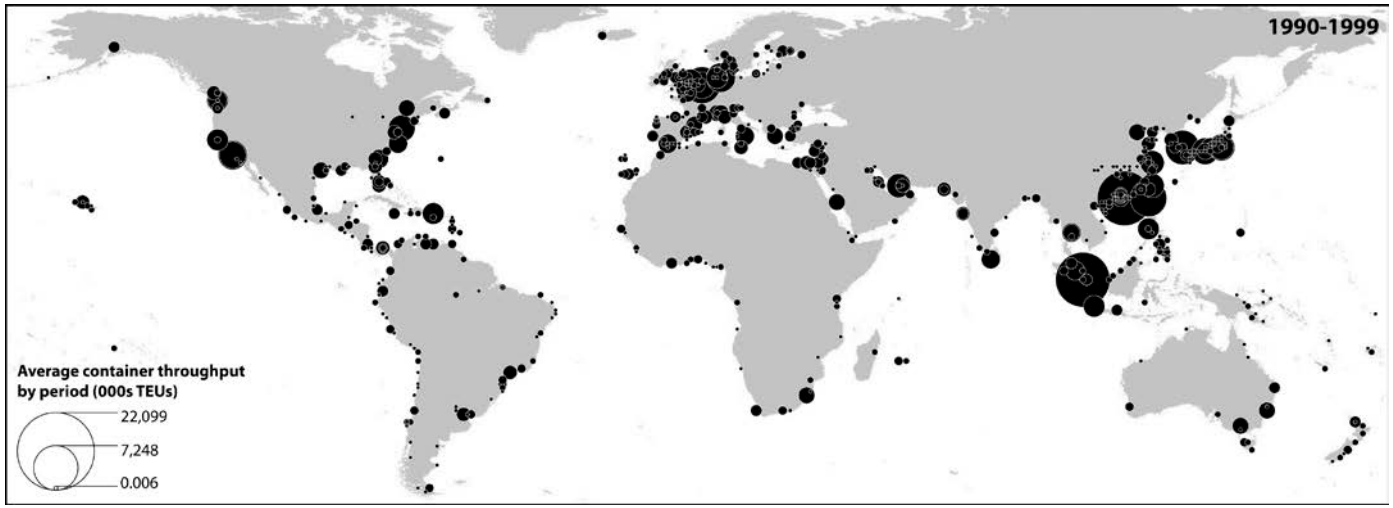
The latest analysis in 2011 indicates that two ports have substantially reduced the key air pollutants from port-related sources since 2005, including a 71 percent and a 75 percent reduction in airborne diesel particulates, respectively. The implementation of several pillar programs has significantly contributed to the achievements at the two Southern Californian ports for reducing air pollution. These programs include the Clean Truck Program (CTP) and the Vessel Speed Reduction Program (VSR).

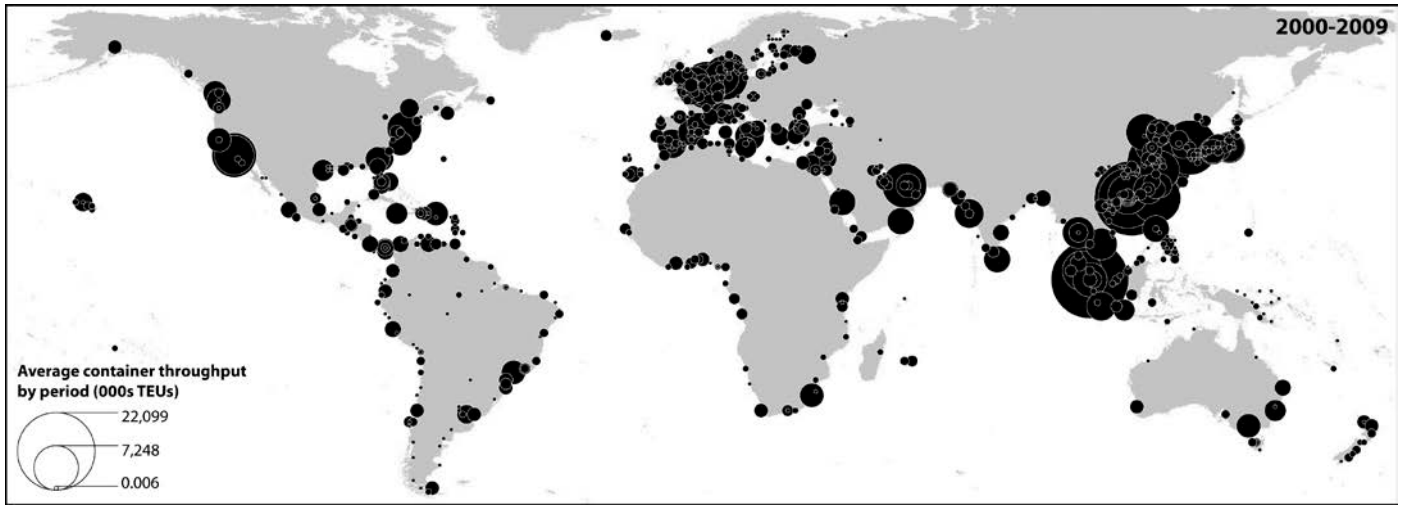
The CAAP marks a milestone for the port industry in the process of mitigating environmental impacts that are resulted from maritime operations. The CAAP was a cooperative venture of the two ports that initiated the concept and were the key players among industry stakeholders and agency leaders (Giuliano and Linder, 2011). The key factor to its success is the cooperation from port users, including terminal operators, truckers and shippers, as well as to gain the support from federal, state and local regulatory bodies and nearby communities (Mongelluzzo, 2012). In addition, the ports were under enormous social pressure as the community concerns over health risks that are resulted from port-related diesel emissions had been elevated after a series of air quality studies published on the correlation between cancer and respiratory disease rates and the proximity to the freight-movement corridors. As the cargo volume rising through the top back in 2004 that called for capacity expansion at two ports, growing public opposition, including a series of lawsuits, has made any expansion plan difficult if not impossible. Moreover, political pressure for legislative efforts for increased regulatory oversight was also one of the driving forces that prompted the ports to respond to public dissatisfaction over air quality, which ultimately led up to the adoption of a comprehensive plan. The CAAP was portrayed as a solution to build credibility of the ports to obtain agreements on future projects as they engaged all the identified key stakeholders. A study considered that "the CAAP was a response to the loss of social legitimacy and to social and regulatory pressures that were restricting the ability of the ports to expand" (Giuliano and Linder, 2011). A final point is that the market power that two ports in Southern California possess also played an important role in their mitigation efforts. The gateway location enables them to have more capacity to impose fees on the industry and hence generate more revenues to implement such environmental policies.

ANNEX 1: PORT GROWTH PATTERNS 1970-2009


1970-1979
Average container throughput
by period (000s TEUs)
22,099
7,248
0.006


1980-1989
Average container throughput
by period (000s TEUs)
22,099
7,248
0.006


1990-1999
Average container throughput
by period (000s TEUs)
22,099
7,248
0.006


2000-2009
Average container throughput
by period (000s TEUs)
22,099
7,248
0.006

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NOTES

1 For example, the Bremen weighing rule states that the value added created by one ton of general cargo (conventional cargo, RORO and containers) equals the value added of three metric tons of dry bulk and 12 tons of liquid bulk. The Dupuydauby Rule attributes the following co-efficients to the different traffic categories: 12 to crude oil, 9 to liquid bulk, 6 to dry bulk, 3 to containers and RORO and 1 to conventional cargo. The Range Rules uses the following co-efficients: 1 for RORO; 1 for conventional cargo; 3 for containers; 5 for dry bulk; 2 for liquid bulk; and 18 for crude oil. See Haezendonck *et al.*, 2000.

2 Excluding the industries that are port required.

3 Los Angeles Expanded GHG inventory, 2010

44 Ship noises come from the diesel generator engine exhaust, the ventilation inlets and outlets, and secondary noise sources, such as pumps and reefers. The diesel generator is used to generate power on board of the vessel, and presents often the most predominant source of noise radiating from the ship to the surroundings. The diesel engine exhaust is often placed at the top of a funnel which has a significant height compared to the surrounding landscape, so if the noise of it is not attenuated it may easily cause high noise levels in the surroundings, even at large distances. The sound power in a selection of ship engines was found to vary between 135 to 142 dB (A); and of the ventilation fans between 81 to 110 dB (A). Large hold ventilation fans are mainly used on RoRo ships for ventilating car decks. Noise measurements of secondary noise sources such as reefers (cooling containers) show that the sound power of a single reefer is in the range of 90 dB (A). Each time the number of reefers is doubled the sound power increases by 3 dB. In general, the sound power of ships increases with the size of ships (as expressed in dead weight tonnes) (Lloyd's Register ODS, 2010)

5 With exposure limit above 55 dB

6 EU Directive 2002/49/EC, Art.2, letter (r)

7 Hedonic prices are the implicit prices of attributes, which are revealed to economic agents from observed prices of differentiated products and the specific characteristics associated with them. This helps to explain house prices in terms of the house's characteristics, such as the type of dwelling, age, floor area, neighbourhood and job accessibility. It can also explain the impact of undesirable facilities on house values due to perceived disamenities. Such concerns (for example, worries about air pollution, health risks and public image) can manifest themselves in property markets, as buyers are likely to pay more to reside in locations farther from perceived disamenities.

8 With the possible exception of the super oil tankers

9 Ningbo Port Corporation Limited (2011), open announcement for related party transactions in 2010 and 2011 (stock market listing code 601018), in Chinese.

10 China Shipping and Trading Network (2010), "Ningbo Port Explains Competition and Co-operation with Shanghai Port", interview with Weiping Huang, spokesperson of the Ningbo Port Group Corporation on 30 July 2010, www.snet.com.cn/106/2010_7_30/3_106_228615_370_5_1280457003231.html, accessed 10 May 2011, in Chinese.

11 The American Association of Port Authorities holds AAPA Communications Awards which aims to underline successful communication strategies and their outcomes. The awarded communication projects vary, including advertisements, social media campaigns, and special events. Regarding the assessment of social media campaigns, the main indicators are the number of followers on Twitter, likes on Facebook page, and views on YouTube. When it comes to the special events, the outcome is assessed based on the number of participants, public reaction on the news posting about the event, and online survey results: for example, in case of Port of Long Beach, it organised free community harbour tours in order to build positive awareness for the port and community pride, which attracted 2,500 participants in total; only concerning the event "Specialty Harbor Tours", additional harbour tours to reach specific audiences, a total of 650 passengers boarded for the five tours, and 60 people reacted positively on the postings of the pictures of the event. Moreover, 75% of the participants rated the event as "excellent" on the online survey via

SurveyMonkey. In case of Port of Los Angeles, the port authority offered free educational boat tours to students in the local schools in order to nurture a connection and an understanding of the port; the project was evaluated as successful, based on the popularity of the program and the Boat Tour Evaluation form filled out by teachers: it hosted 80 schools with nearly 7,000 students, and the port received 72 forms with a 98% excellent rating, with hundreds of thank you letters from students.

[12] "Leader firms are firms that have - due to their size, market position, knowledge and entrepreneurial skills - the ability and incentive to make investments with positive externalities for other firms in the cluster" (De Langen 2004: 59).

[13] Organic CO2 for Assimilation of Plants

[14] Annex I: regulation 38; Annex II: regulation 18; Annex IV: regulation 12 (12bis); Annex V: regulation 8; and Annex VI: regulation 17

[15] I MO Resolution A.468 (XII), "Code on noise levels on board ships", 1981; IMO Resolution A.343 (IX), "Recommendation on methods of measuring noise levels at listening posts", 1975

[16] Directive 2002/49EC

[17] Peak hours are 3 am to 6 pm (Monday through Friday); Off Peak hours are 6 pm to 3 am (Monday through Thursday and 8 am to 6 pm on Saturday)

[18] Other exemptions include domestic containers and transhipments to other ports