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Territorial Impact of Globalization for Europe and its Regions

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Working paper 15
"Maritime flows"

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INTRODUCTION

Recalling the main objectives of the report

The main objective of the WP3 is to underline the position of Europe and its hub/gateway ports in worldwide air and maritime flows. Three levels of analysis are considered: global, regional, and local, as well as relations between those scales. The global level focuses on the weight and position of Europe in global port traffic and maritime connections over time, notably looking at their changing geographic distribution and identifying which dominant port gateways have ensured Europe's maritime relations with the rest of the world. On a world level, the position of Europe will be analysed on various degrees of aggregation: as one single entity, as groups of port gateways (maritime ranges), and as individual cities (multiple or single terminals). The regional level looks at how such traffic and connections are distributed within the European territory, taking into account the previous level (world) while proposing a multi-scalar view on port gateways. We also wish understanding the mutual influence between global level and regional level since port gateways are embedded within local, regional, national, and trans-national economies and spatial systems. The local level will focus on one gateway-corridor through a case study highlighting concrete issues of regional planning and socio-economic development in relation with port and transport activities.

The objectives can be synthesized as follows:

- To assess the position of Europe in maritime and air flows;
- To assess the changing patterns of ports and airports in maritime and air flows;
- To assess the territorial impacts of global maritime flows on regional development.

This report mainly focuses on the position of Europe as a whole in the maritime and airflows. Databases that constitute the base for further analyses at port/airport level are described, and main results are presented. There exists numerous studies of European ports and gateways but few of them have a European-wide or worldwide focus, such as traffic concentration analyses. More likely are individual case studies on a local level of port hinterlands, port terminals or the port-city interface where technological and socio-economic changes are more readable (e.g. waterfront redevelopment, value-added and planning issues). European ports have mostly been analysed from a continental perspective (e.g. their position and accessibility in the road network), notably due to the inland centrality of the London-Milan megalopolis. Therefore, the link with the research on maritime networks remains rather limited, whereas European ports are often compared with each other based on sole traffics regardless of their position globally. Conversely, research on maritime networks is dominantly local in scope, with studies of specific basins such as, for instance, the Caribbean, the Mediterranean, and East Asia, notably about container ports and liner shipping services, while their industry coverage is bound to few or main operators. Recent research has provided some measures of the polarised structure of the global liner shipping network but without looking at its detailed geographic coverage and its evolution except from identifying the most central ports on the East-West trunk route. There remains much to do on the interdependence among the three main elements of the port triptych: maritime foreland, port (city), and hinterland, although this concept has emerged in the 1960s and has been put in question later on with the advent of newer concepts such as transport (or commodity, supply, value, logistics) chains and global production networks. No research has been done yet putting together those elements in a simultaneous analysis, although it may best highlight the strengths and weaknesses of European ports and gateways in the worldwide and European context.

Deviations from initial working plans

It must be noted that due to data problems, the analysis of port traffic concentration has been restricted to container traffic only on the 1970-2009 period, while inter-port maritime flows data could have been exploited in 1996 and 2006 only for containers, and in 2004 for all commodities. Existing databases on yearly port traffic data per commodity, such as Journal de la Marine Marchande and Institute of Shipping and Logistics (ISL Bremen) were either too incomplete or too costly (or both). Lloyd's vessel movement data is extremely costly in digital format, and the time needed to encode and clean paper-based versions that were obtained thanks to previous research projects was largely underestimated. It took more than 6 months to obtain a clean table from two Lloyd's List paper-based registers (October-November 2004). We now possess a huge quantity of raw data in scan or paper format on the 1946-2008 period, which were acquired during the ESPON-TIGER project by means of other funding, but it requires a lot of time and efforts to make it analysable. We hope that the analysis in 2004 only, although it cannot account for time dynamics, can provide sound results to be further complemented by other years. Another difficulty was to the statistically insignificant results obtained from factor analysis applied to European regions based on their socio-economic characteristics and traffic distribution per commodity. We still keep the main results in the last section of the report, but the subsequent steps have been abandoned namely establishing a typology of port regions in ESPON, NAFTA, and Japan. Yet, main trends obtained by factor analysis are still useful to better understand the linkages between port activities and local economies nowadays, although such linkages have greatly weakened. It was the first time such analysis of port-region linkages was tried based on available indicators, and further reflections on relevant measures should be envisaged before going further. The low statistical relationship among variables has resulted in too many principal components (factors) so that it was not relevant to propose a typology of port regions based on these factors, but the factors themselves remain interesting as they clearly describe continental trends.

PORT TRAFFIC CONCENTRATION DYNAMICS WITHIN THE ESPON SPACE AND OTHER MAIN REGIONS

Background on the evolution of port systems

The concepts of maritime range (Vigarié, 1964) and port system (Robinson, 1976) originally depict a set of adjacent seaports in close proximity and interdependent through land and sea freight flows. The search for regularities in the development of port hierarchies has mostly been done from a continental perspective considering ports as heads of land-based transport corridors willing to extend their hinterland coverage. Early works provided spatial models (Taaffe et al., 1963; Rimmer, 1967; Ogundana, 1970) suggesting a trend towards an increasing level of cargo concentration in port systems. However, most scholars have continued focusing primarily on hinterlands, due to the development of intermodalism and logistic chains around ports (Van Klink 1998; Robinson, 2002), and the higher cost of land transport versus sea transport (Notteboom, 2004). Although the development of peripheral ports (Hayuth, 1981) and offshore hubs has a maritime purpose for cargo distribution towards secondary ports (Slack and Wang, 2002; Notteboom, 2005), their emergence has been interpreted from the hinterland perspective of a port regionalization process leading to the formation of a 'regional load centre network' (Notteboom and Rodrigue, 2005). There remain important local deviations from general models of port system development due to path dependency and contingency (Notteboom, 2006a, 2009a), as seen in Table 1 that provides a review on former studies of port system evolution.

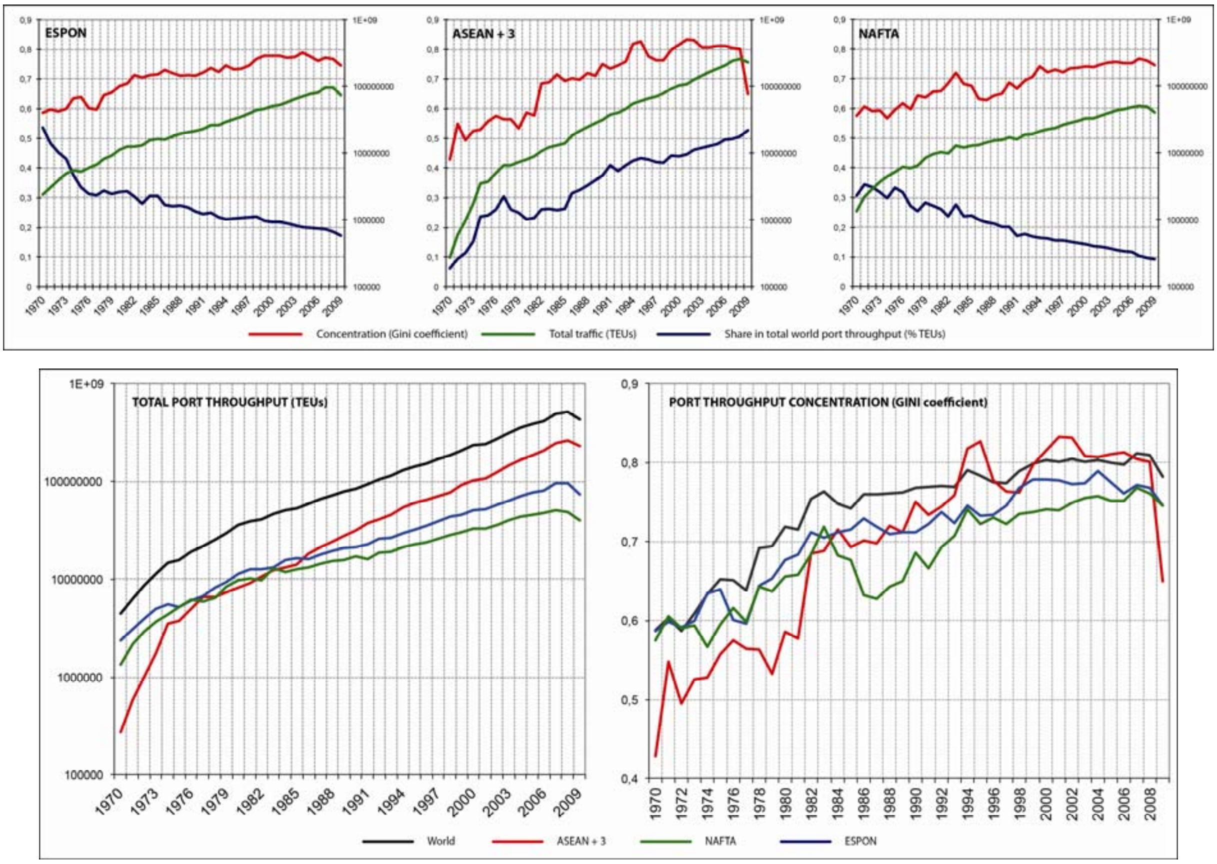
The definition of port systems has, however, often been limited to coastal morphology (i.e. oceans, seas, basins, gulfs, straits, and deltas) and to geographic proximity between ports situated within administrative borders on various levels (see Ducruet et al., 2009 for a synthesis about case studies of port systems). Never have port systems been defined and delineated from the maritime perspective of inter-port linkages. This raises the question whether physical factors and geographic proximity still play a role in the current spatial patterns of container shipping circulations. The concepts of maritime region and port region, which remain rather descriptive and vague in the literature (Ducruet, 2009), may benefit from the application of similar frameworks than in other studies of global networks (see Derudder and Taylor, 2005), allowing for the definition of coherent groups of ports as well as the identification of leader ports.

Author(s), year	Year	Area	Concentration factor(s)	De-concentration factor(s)
Taaffe, Morrill & Gould	1963	Africa	Inland transport corridors	
Rimmer	1967a, 1967b	Australia, New Zealand	Inland transport corridors	
Kenyon	1970	United States	Metropolitan dominance (New York)	Hinterland-foreland changes
Ogundana	1971	Nigeria	Sustained port dominance	Port diffusion, diseconomies of scale
Hilling	1977	Ghana	Spatial consolidation and rationalization	
Hayuth	1981, 1988	United States	Development of large load centres, intermodalism	Peripheral port challenge
Slack	1985, 1990	United States	Level of intermodalism	Port selection by carriers
Barke	1986	General		Congestion, lack of space for further expansion
Hoare	1986	United Kingdom	European integration, national connectivity	
Charlier	1988	Belgium	Stable structure of port hierarchy	Traffic specialization
Airriess	1989	Indonesia	Exogenous development through hinterland penetration	
Kidwai	1989	India		New port construction (bulk)
Kuby & Reid	1992	United States	Technological innovations, disappearance of smaller ports	
Todd	1993	Taiwan	Export-led policy and growth poles	Balanced regional development
Starr	1994	United States	Economies of scales in liner shipping, decreased port calls	
Hoyle & Charlier	1995	East Africa	Concentration of investments	
Charlier	1998	Benelux		Hinterland development (railway), port selection (Zeebrugge)
Notteboom	1997	Europe		Traffic shifts to medium-sized (new) ports
Wang	1998	Hong Kong, China	Technological advance of Hong Kong	Port competition, congestion, modal shift, high handling costs
Hoyle	1999	Kenya	Primate city polarization (Mombasa)	New port development
Brunt	2000	Ireland	Metropolitan dominance (Dublin)	National development plans
Wang & Slack	2000	Pearl River Delta		Carriers' pressures, port policy
Slack & Wang	2003	Asia		Strategies of transnational operators
De & Park	2003	World		Port competition, new technologies
Notteboom & Rodrigue	2005	Developed countries		Development of 'off-shore' hubs and inland terminals
Ducruet & Lee	2006	World		Urban growth, regional port competition
Notteboom	2006a	Europe, North America	Stability of concentration	
Notteboom	2006b	East Asia		New port development
Frémont & Soppé	2007	North European Range	Stable traffic concentration	Shipping line concentration
Ducruet	2008	Northeast Asia	Hub dependence	Military control, logistics barriers
Lee, Song & Ducruet	2008	Hong Kong, Singapore	Technological differentials, efficient planning policy	Congestion, lack of space, port competition
Ducruet, Roussin & Jo	2009	Northeast Asia	Corridor development (Nampo-Pyongyang)	Cross-border cooperation

Selected studies on port system concentration

Application to the ESPON space and other main regions

There is a common trend among regions that is a parallel increase of throughput volume and throughput concentration, despite some exceptional years. Although Europe has the best fit between the two indicators over the period, the last period (2000-2009) shows an inverse relationship due to the lowering concentration of increased traffics. The same trend has occurred in Asia and to a lesser extent in the Americas, because traffic has only slightly dropped in volume (global financial crisis since 2007) compared to the negative fluctuations of concentration. It means that in periods of crisis and decline, traffics tend to be less concentrated than during periods of stable growth. After a period of rapid volume and concentration growth everywhere (1970s to mid-1980s), Europe’s traffic has remained far less concentrated than in other regions (except Africa being the least concentrated) until the late 1990s. The rise in concentration may be explained by the new role of Mediterranean hubs competing for transhipment activities along the Asia-Europe trunk line (e.g. Malta, Valencia, Calabria, etc.) thereby capturing flows from traditional gateway ports.



Container port throughput evolution and concentration by world region (1970-2009)

POSITION OF ESPON PORTS IN GLOBAL MARITIME FLOWS

Background on maritime network analysis

Maritime networks can be simply defined as links between ports created by the circulation of vessels. Yet, there is a scarcity of empirical studies although there is no reason why maritime networks should not be analysed exactly like other transport networks (Joly, 1999). Yet, their specificity is that the spatial design of maritime networks depends solely on carriers' circulations due to the absence of an infrastructure of track as in air transport (White and Senior, 1983). Unlike air networks, maritime networks are spatially constrained by coastal geography: vessels cannot cross continents unless a canal exists. For the rest, oceans allow a great freedom of circulation despite physical factors such as permanent or seasonal icing, depth requirements of bigger vessels technically (e.g. port entrance channels), and political barriers such as the former interdiction to establish direct calls between Taiwan and mainland Chinese ports. As a result, maritime networks form a vaguely defined distribution compared with land networks (Rodrigue et al., 2006), due to greater spatial complexity and volatility.

But the main reason explaining the lack of application of network theory to seaports is more to be found on the practical side of the problem: the rarity of detailed information on maritime circulation including nodes (ports), links (sea lanes), and flows (traffic). Some scholars adopted an intermediate solution using, for instance, data obtained from the French Meteorological Office reporting every six hours the position of about 4,000 vessels worldwide (Brocard et al., 1995), but this could not base a network analysis *per se*. Historians and geographers tended to represent circulation patterns in a very broad way based on qualitative sources (Westerdahl, 1996). The time needed for gathering and encoding data from various paper-based sources on vessel movements (Joly, 1999) as well as the cost of existing numeric information easily explain transport geographers' reluctance confronting such issue. In addition, a comprehensive visualization of shipping networks was difficult simply due to the fact that classical tools of cartography remained limited in representing complex and vast networks.

For such reasons, seaports are often compared regardless of their type of connection on the maritime side, although it can be hypothesized that the characteristics of seaborne connections are a fundamental element of port performance. Early studies of maritime forelands have shown the specialization of ports in terms of geographical reach in developed countries (see Bird, 1969). The lack of detailed, accessible data on maritime networks and related analytical tools often constrained international comparison to local attributes such as throughput volumes, physical equipments, terminal or crane productivity, and number of vessel calls (Langen de et al., 2007). Early works, however, provided some analyses of maritime forelands for given ports, such as Irish ports (Andrews, 1955), Hamburg (Weigend, 1956), Australian ports (Britton, 1965), Tyne (Elliott, 1969), Clyde (De Sbarats, 1971), and British ports (Von Schirach-Szmigiel, 1973), followed by more recent works on French (Marcadon, 1988) and Chinese ports (Wang and Ng, 2011). These works had in common to look at the geographic specialization of ports' maritime forelands, notably at a time when port authorities and central governments were principal actors of the transport chain, based on the concept of port triptych (Vigarié, 1979). The reduction of foreland studies is explained by the growing ability of private and specialized transport firms to spread their networks across boundaries, therefore motivating scholars to look at issues of port selection and competition in a new environment (see Slack, 1985, 1993; Notteboom and Winkelmans, 2001; Robinson, 2002). Some specific studies use the cartography of maritime forelands on the world map for a given port such as Le Havre (Merk et al., 2011) or a port range such as the Maghreb (Mohamed-Chérif and Ducruet, 2011) in order to visualize more clearly the extent of overseas linkages.

Maritime networks have received increasing attention in recent years due to growing availability of data, but global analyses remain few. In their recent review of the scientific literature on maritime network analysis, Ducruet et al. (2010a) particularly stress the scarcity and fragmentation of empirical studies in this field, which may be categorized among four main approaches:

- *Geographic coverage of carrier networks*: regional or global distribution of the port networks for individual shipping companies based on service data (e.g. Coscon, Maersk) revealing their strategic choices in spreading their networks in a context of intense competition and market concentration (Rimmer and Comtois 2005; Frémont, 2007; Bergantino and Veenstra, 2002, 2007; Veenstra and Parola, 2007);
- *Network connectivity*: characteristics of a given network based on its topology, with reference to spatial analysis and graph theory, such as the pioneer study of Joly (1999) showing the tripolar organisation of the global maritime system based on Reeds zones, and

other works on a regional level where hub-and-spoke strategies have modified the port hierarchy and the organization of the network, such as the Caribbean (McCalla, 2004; Veenstra et al., 2005; McCalla et al., 2005; Wilmsmeier and Hoffmann, 2008), the Mediterranean (Cisic et al., 2007), Northeast Asia (Ducruet et al., 2010a), the Atlantic (Ducruet et al. 2010b), and the world (Ducruet and Notteboom, 2012; Ducruet and Zaidi, 2012);

- *Network efficiency*: modelling of port selection processes and search for the optimal location, for instance, of a transhipment hub lowering overall shipping costs, and the optimization of shipping routes (Zeng and Yang, 2002; Fagerholt, 2004; Song et al., 2005; Tai, 2005; Shintani et al., 2007);
- *Complex networks*: description of the network' hierarchical structure on a worldwide level comparing its properties with general models of small-world and scale-free networks, providing series of robust statistical measures such as average path length and transitivity on a world level (Deng et al., 2009; Hu and Zhu, 2009; Kaluza et al., 2010).

Application 1: Position of the ESPON space in global shipping flows

Methodology

Data was obtained from Lloyd's List, the world's main maritime insurance company that covers about 80% of the world fleet. It provides information about the daily movements of merchant vessels, including the sequence of port calls, and information about vessels' carrying capacity, type of commodity, among other. Due to the cost of such information, the analysis concentrates on 1996 and 2006 (January-December) for container flows, and on 2004 (October-November) for all commodities. Due to lack of information on vessel type and capacity in 2004, missing data was retrieved from additional vessel databases such as Fairplay World Shipping Encyclopedia[1], MIRAMAR Ship Index[2], DNV Exchange[3], and the World Shipping Register[4]. This has demanded considerable efforts because of the absence of IMO (International Maritime Organization) numbers of vessels. Since many vessels regularly change their name and flag, the risk of confounding them across databases was avoided by taking into account their type, subtype, year of build, and ex-names.

Another methodological issue was the choice of the tonnage capacity. Although deadweight tonnage (DWT) provides a more accurate picture of vessel's commercial capacity (excluding reservoirs, decks, rooms, etc.), the Gross Registered Tonnage (GRT), which corresponds to the volume of the entire vessel, was chosen due to its wider availability in ship registers. Measuring the weight of maritime flows based on GRT figures, however, may mislead the importance of some commodities as there is no proportionality between DWT and GRT[5]. In any case, the occupancy ratio of vessels (i.e. the number of tons actually carried on each trip) as well as the volume of freight handled at each port are not specified by the sources. Thus, it was assumed that the overall capacity (GRT) of vessels is a good indicator of the importance of flows. Vessel capacities were summed by port and by inter-port link during each period of movements. This results in the elaboration of an origin-destination (OD) matrix to be considered as a weighted, undirected graph as in other studies of accessibility in networks

[1] http://www.ihs.com/products/maritime-information/ships/world-shipping-encyclopedia.aspx
[2] http://www.miramarshipindex.org.nz
[3] http://exchange.dnv.com/exchange/Main.aspx
[4] http://e-ships.net/
[5] The calculation greatly depends on vessel types ; Stopford (1982) suggested to convert GRT to DWT by means of ratios such as 1:1.75 for tankers, 1:1.7 for bulkers, 1:1.44 for general cargoes, 1:1 for containers, and 1:0.9 for passengers.

(Rodrigue et al., 2009). Traffic flows are thus calculated taking into account the volume and the frequency of vessel trips between locations. Lastly, vessel types were aggregated in different categories, such as liquid bulk (i.e. asphalt, crude oil, oil products, chemicals, liquefied natural gas, liquefied petroleum gas, water, wine, edible oil, and unspecified tankers), solid bulk (i.e. aggregates, cement, ores, and unspecified bulks), and containers. Flows of roll-on / roll-off (ro-ro) vessels, which typically carry trucks and vehicles, are not analyzed separately since they are often restrained to short-sea shipping services and remain intra-regional.

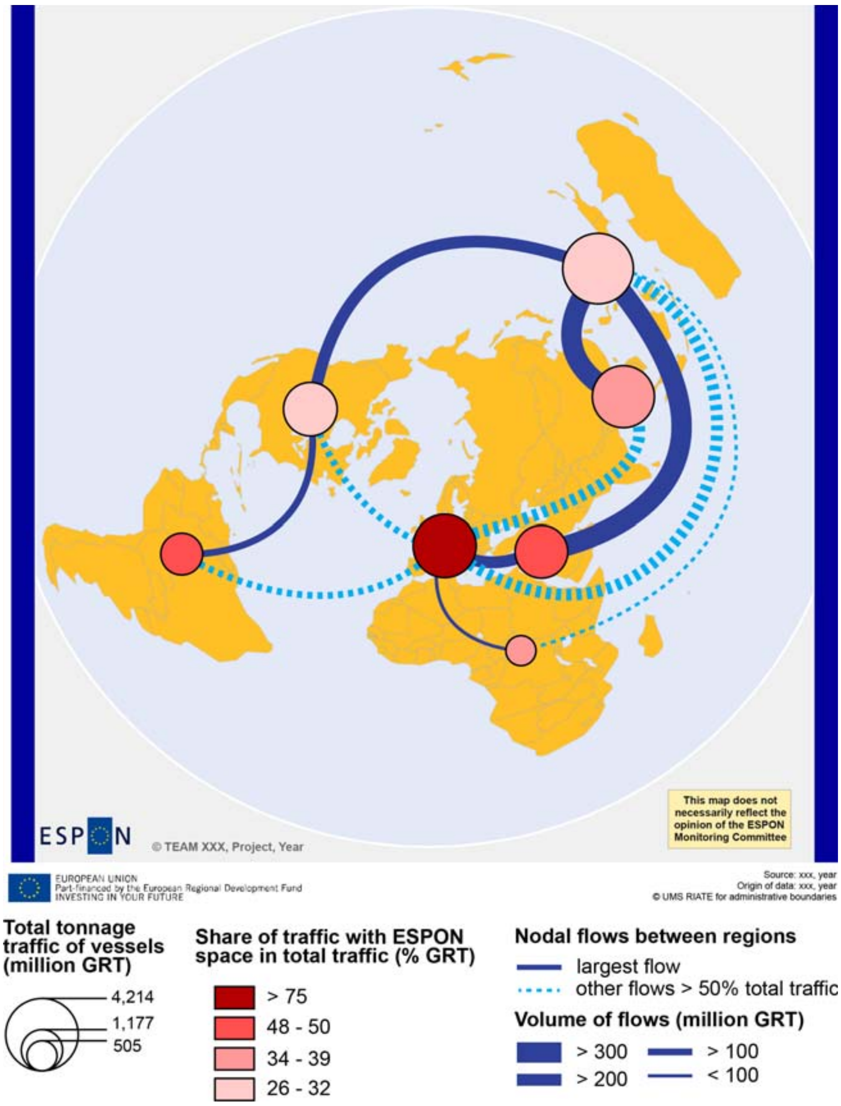
Another crucial aspect of the methodology is the definition of spatial units upon which the analysis will be based. Individual ports and port terminals were aggregated at urban region level because several large cities possess multiple port gateways. The absence of an internationally recognized definition of the urban area forced us to privilege a radius of ten to twenty kilometers within national boundaries. So-called world regions are those defined by the European Spatial Planning Observatory Network (ESPON) as World Unités Territoriales Statistiques (WUTS), which are composed of several countries grouped according to geographic proximity as well as socio-economic affinities.

The cartography proposed in this report stems from different methods of data analysis. Multiple linkages analysis (MLA) retains only the heaviest traffic links among world regions up to 50% of each region's total traffic. This methods helps revealing the inner structure of traffic flows without losing too much information (Puebla, 1987), as it is well adapted to small-sized networks. On the more disaggregated level of world ports, single linkage analysis (SLA) is preferred to the previous method due to the greater network size; only the largest link is kept for each port. These two methods have in common to simplify the network in a way that spatial structures are better readable. Notably at port level, the readability of results is increased by the representation of subnetworks by areas rather than through graph visualization. Each area is a subpart of the network or nodal region centered upon a dominant or independent node. Another method applied in this paper is the calculation of Europe-related traffic at non-European ports in order to verify the regionalism of Europe's influence. In that case the chosen definition of Europe is the ESPON space (EU27+4). Lastly, we apply a multivariate analysis to European ports based on the geographic distribution of their traffic in the world on the level of the aforementioned macro regions.

Main results

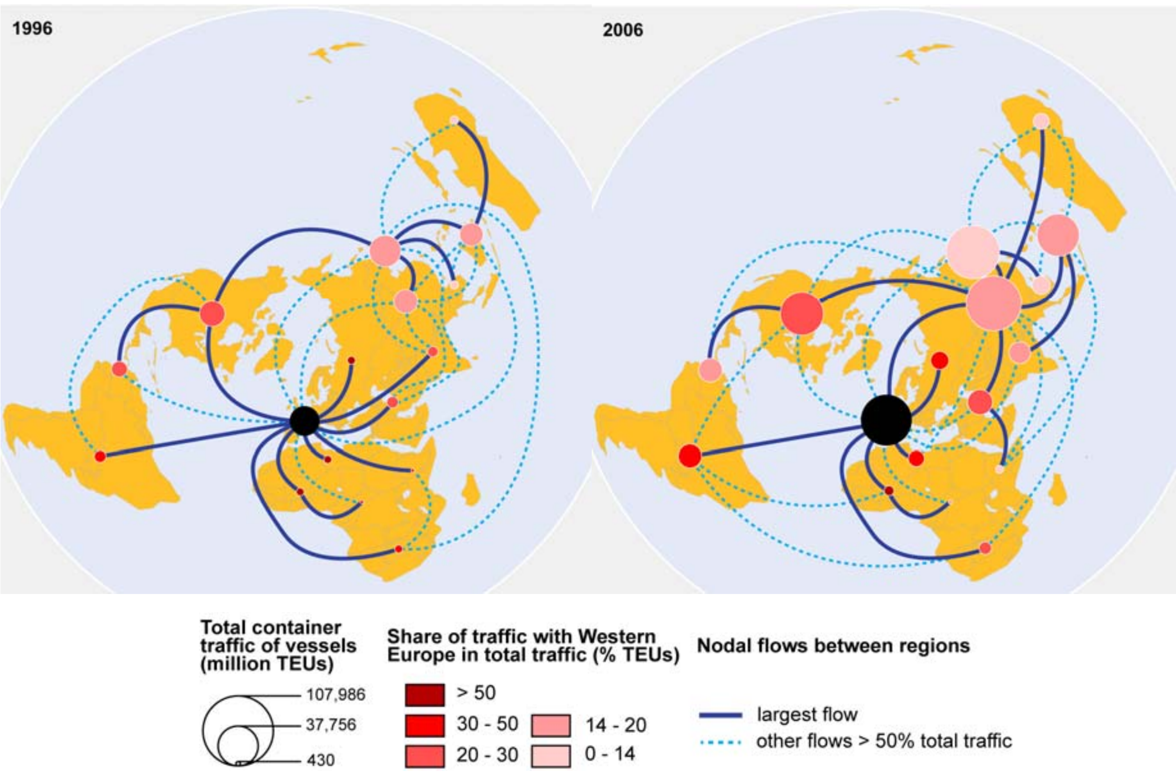
This first analysis of maritime flows simply maps the total amount of traffic flows among world regions (WUTS1 and WUTS2 level) as well as the share of ESPON-related traffic in the total traffic at each region. This gives an idea of the absolute and relative weight of ESPON in the global network compared with other main regions.

The pattern based on all commodities at WUTS1 level shows a clear polarization of network by the Asia-Pacific region, with its largest flows connecting Western Asia and Southeast Asia. Europe has the highest share of Europe-related flows due to the very high density of interregional traffic, followed by Latin America and Western Asia. Europe is still very central but its links to other regions are not their largest, except for Africa and Western Asia.

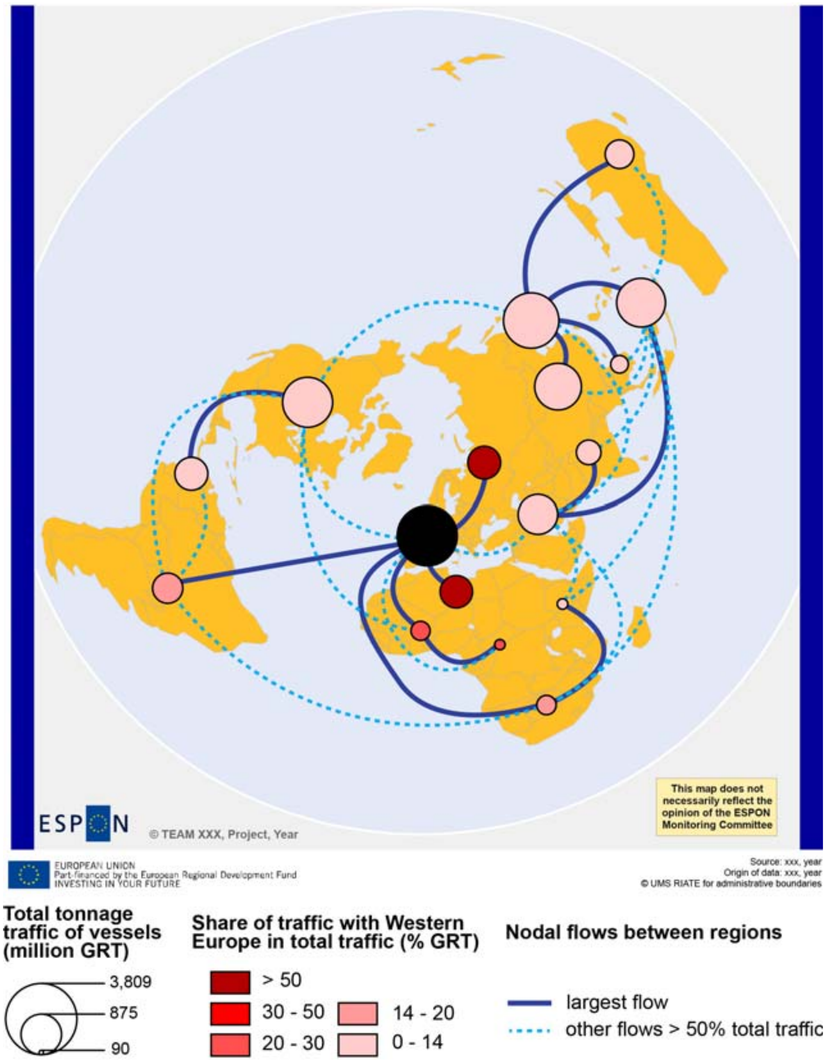


Largest maritime flows among world regions in 2004 (all commodities)

On the level of WUTS2 regions, we observe a very central and dominant position of Europe (here Western Europe) in global container flows. It possesses the highest number of largest flows connected to it, thus reflecting upon its dominance over nearby regions (Africa, Eastern Europe, Middle East, South Asia, and the Americas). North America forms an independent system by dominating Central America, just like Northeast Asia polarizing Asia-Pacific regions. This pattern has significantly changed in 2006. Although its distribution remains comparable, the relative weight of Western Europe has diminished everywhere. In addition, Western Europe has "lost" a number of dominant connections, such as East Africa, Middle East, and South Asia, which are in 2006 directed towards East Asia. Even North America's largest flow is directed towards East Asia as well. Asian regions have become more strongly interconnected, shifting from mono-polarization upon Northeast Asia in 1996 to multi-polarization upon Northeast, East, and Southeast Asia in 2006. There is also the emergence of strong South-South linkages such as between South America and Africa. Overall, the global container system has become more complex and to a large extent less dominated by Western Europe in only 10 years time.



Largest maritime flows among world regions in 1996 and 2006 (containers)



Largest maritime flows among world regions in 2004 (all commodities)

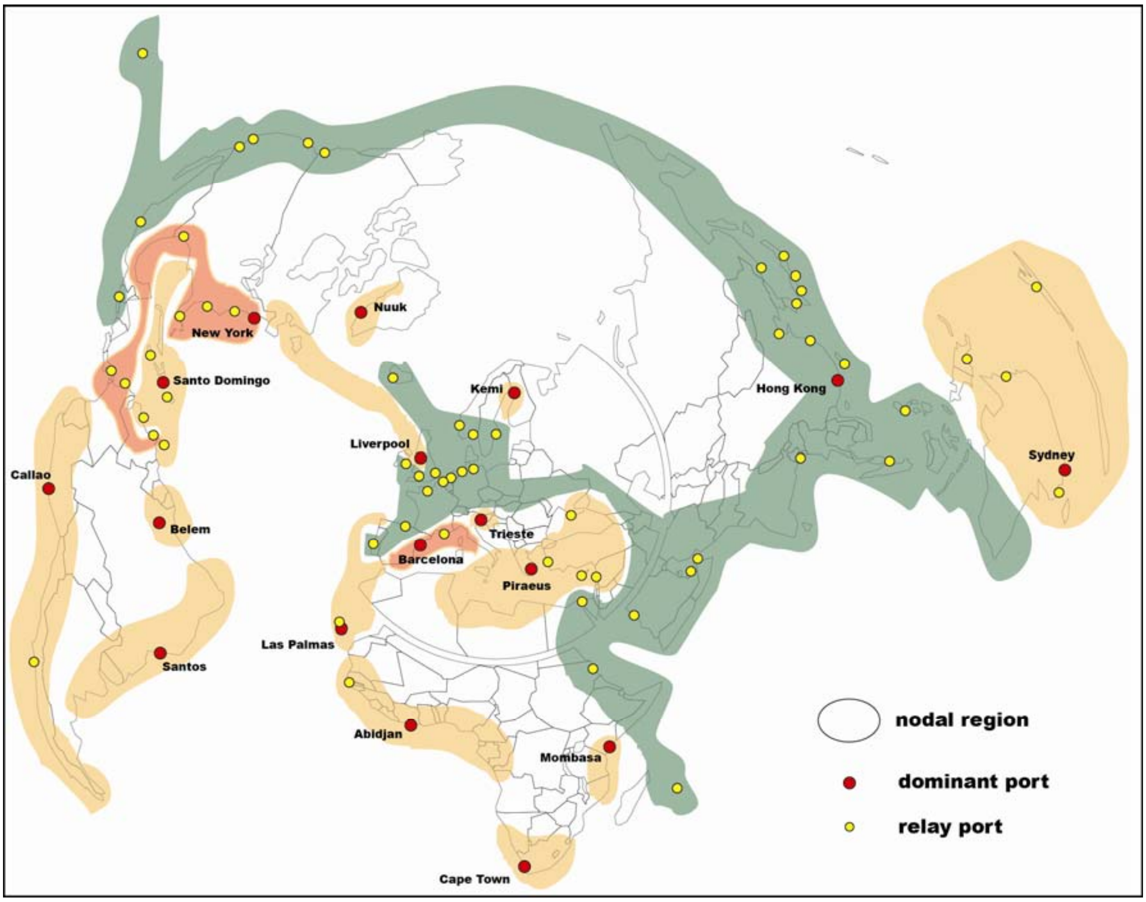
Application 2: Single linkage analysis, nodal regions, and dominant ports

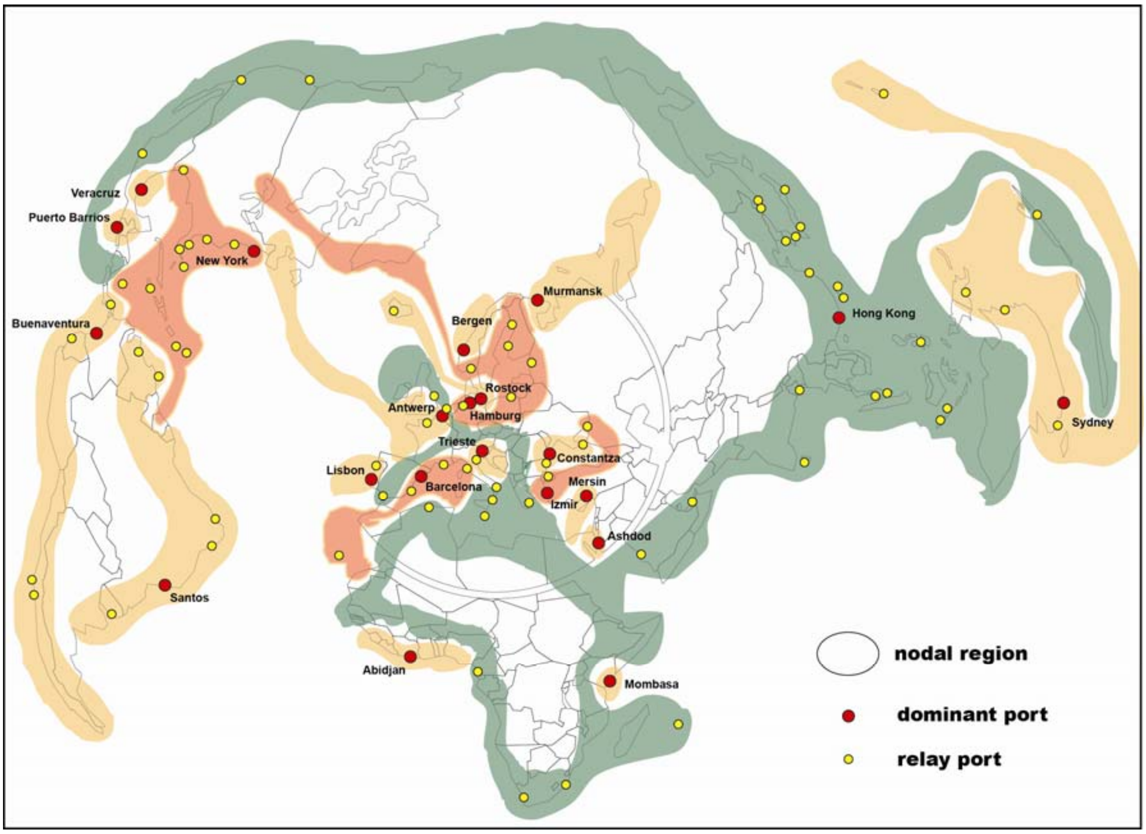
At port level, results provide a number of so-called "nodal regions" as the global network is split. The method is a simplification of the global network through keeping, for each port, only the largest traffic link with another port, and removing all other linkages, thereby obtaining sub-trees. Each nodal region corresponds to a subpart of the whole system and it is internally organized through a hierarchy of ports where one dominant port exerts its influence on other ports. Relay ports are important nodes but they remain under the influence of the "dominant" port. Results can be interpreted in various ways. The geographic delineation of nodal regions provides clues about the extent of the influence of some dominant ports as well as a certain continuity in flows and a degree of integration within certain areas. Each nodal region is polarized by one or more larger ports, and the factors behind the separation among nodal regions can be attributed to "barriers" of all kinds, such as distance, traffic and trade intensity, geopolitical and cultural extensions, etc. Although it remains very much descriptive, such methods allow investigating the integration level of Europe in worldwide maritime flows. Other methods of graph clustering and partitioning should be tested in order to refine the results: although this method has the advantage of clarifying the overall network structure, it gives too much importance to the hierarchical dimension of flows and it operates through over-simplifying the real flows. For instance, if Rotterdam has 135 links with other ports, only the largest traffic link is kept whereas many other links actually matter to explain its position. Of course, it was impossible to represent the whole network. Each nodal region is represented by an area on the world map with colours used only to distinguish distinct regions, and keeping only the names of the dominant ports.

For container flows in 1996 and 2006, one very large region centred upon Hong Kong dominates the world scene and extends across the Pacific and the Indian oceans. Elsewhere, regions are much smaller in scope and reflect upon local patterns of port systems and maritime circulations around one or more dominant hub ports: their existence reveals the geographic coherence of the global system based on maritime ranges. In 1996, most of Europe's main ports are included in the largest region polarized by Hong Kong. This reflects upon the importance of Asia-Europe trades as seen in the previous figures on total traffic. However it is rather surprising that already in 1996, European ports do not form an independent system, or another system turned towards cross-Atlantic or cross-Mediterranean links. Europe is thus split between the Asian region and other local regions centred on Piraeus

(East Mediterranean and Black Sea), Trieste (North Adriatic), Barcelona (West Mediterranean), Las Palmas (Canaries), Kemi (North Baltic), the only exception being Liverpool reaching across the Atlantic (Quebec).

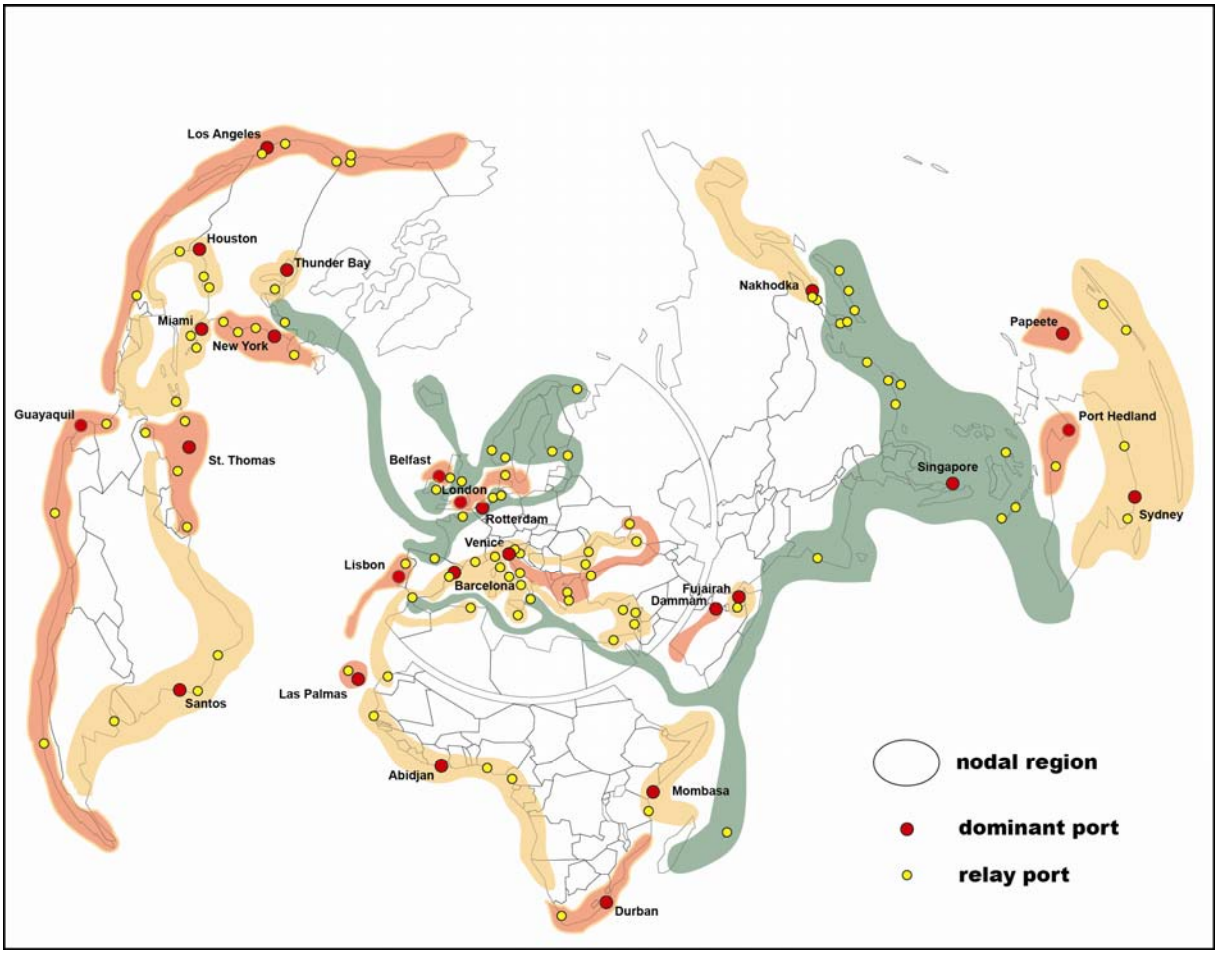
In 2006, the pattern has changed in several ways. The dominant Asian region has extended its dominance towards the Mediterranean region and has kept its influence over Rotterdam and Algeciras. It has also clearly taken over Africa almost entirely except for the (much reduced) regions of Abidjan and Mombasa, but also important parts of Oceania. The trend in Europe corresponds to a wider split into smaller regions. Piraeus has been integrated in the Asian region, but Turkish ports (Mersin, Izmir) as well as Constanta are now dominant ports in their own regions. New regions have appeared with Lisbon, Bergen, Rostock, but also Antwerp and Hamburg forming their own systems both across the Atlantic.





Nodal maritime regions of the world in 1996 and 2006 (port city level, container flows)

For all commodities in 2004, the dominance of the Asian nodal region (this time centred upon Singapore, not Hong Kong) is somewhat more limited geographically than for sole container flows, but it remains the largest, and still extends up to Algeciras and Gioia Tauro in Europe. Other nodal regions of the world are more local in scope: they correspond to relatively clear delineations of "maritime ranges" with a strong regional dimension. For Europe, the overall picture is still the one of a fragmented space; with the largest component centred upon Rotterdam (reaching across the Atlantic up to Montreal and Toronto), and other smaller components centred upon London, Barcelona, Venice, Belfast, and Lisbon. It confirms the lack of integration between North and South in Europe, as only Bilbao is included in the region of Rotterdam. There is, of course, an obvious influence of geomorphology on the results, as merchant vessels need to follow the coastlines, unlike air transport. Nodal regions are thus more likely to appear within rather than across closed seas and basins, as they are among other factors a product of traffic spatial continuity.



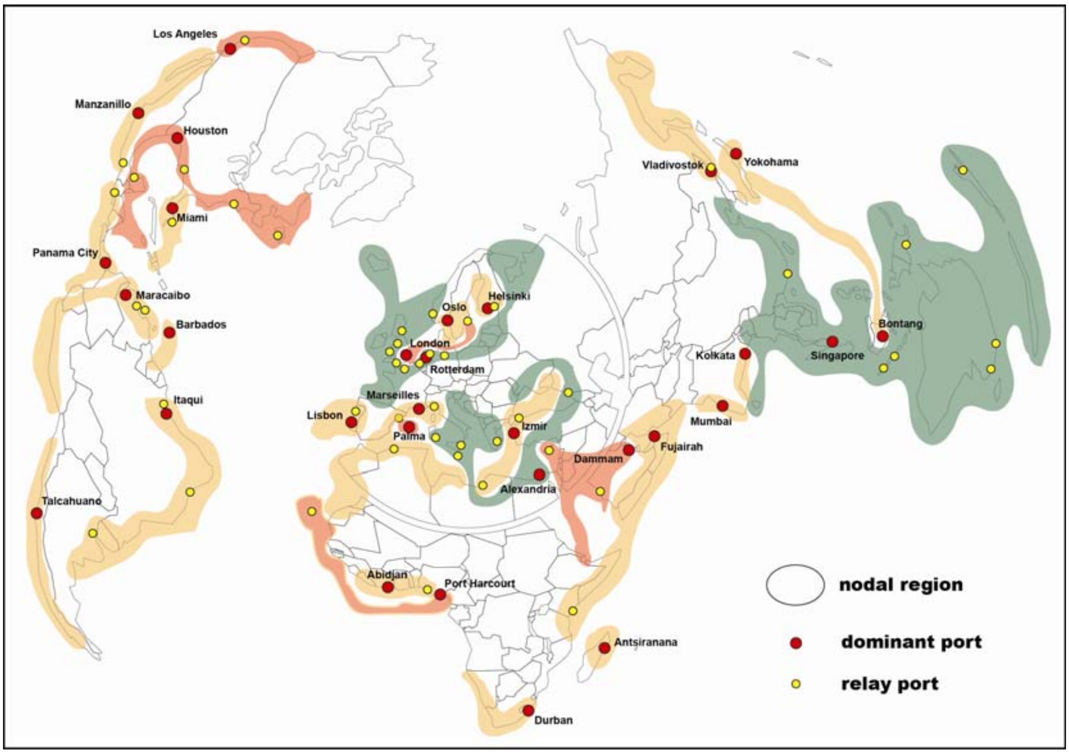
Nodal maritime regions of the world in 2004 (port city level, all commodities)

These results also confirm the continental dimension of Europe-related flows. The fragmentation of the European space into several subcomponents indirectly reflects the importance of land-based networks and flows (railway, road) that are not counted in the analysis of sole maritime flows. In contrast, Asia stands as a maritime region with a much stronger homogeneity and spatial continuity. Further research should integrate, for instance, road and railway networks in order to keep a continental continuity among Europe's cities and regions. This would provide drastically different results as well as for Asia (weaker inland penetration of logistics chains) and North America (transcontinental land bridges). This would also help better understanding the intermodal importance of some European gateways, as well as the relative importance of maritime flows for inland (non-port) cities and regions in Europe and other parts of the world. At present based on these results, Europe is made of different maritime subsystems having their own internal logic, despite the fact that in reality, they are complementary and interconnected.

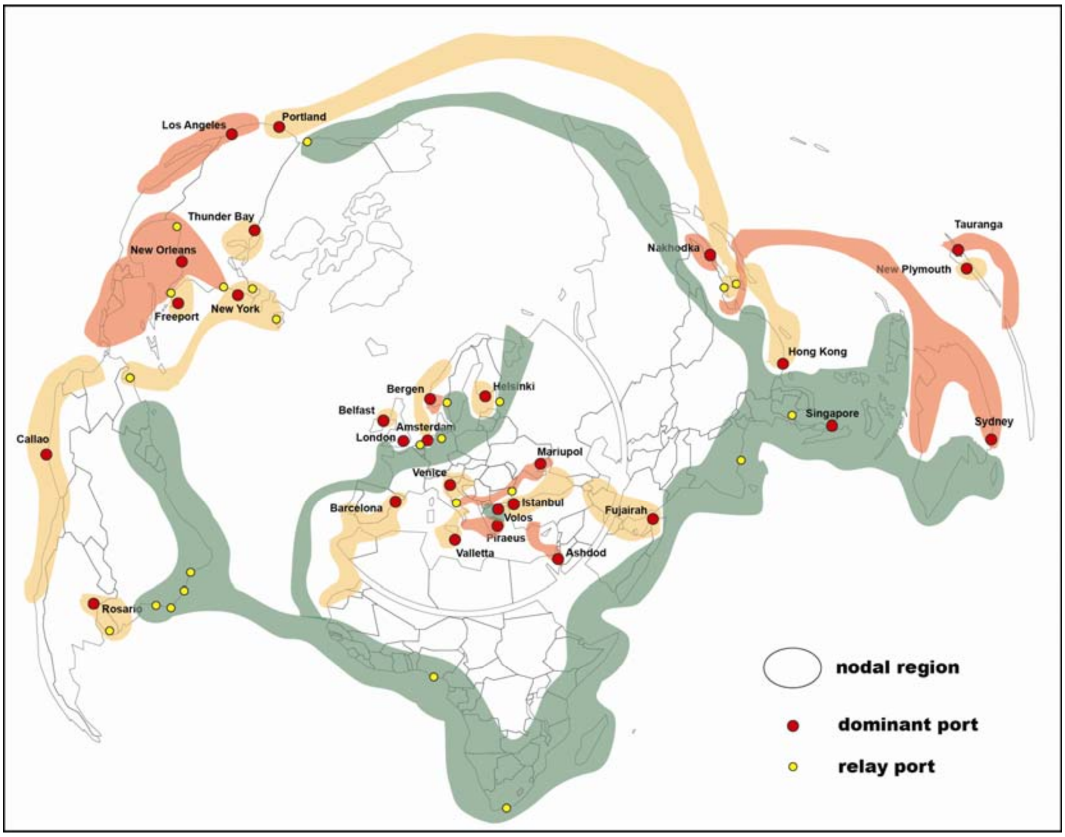
The same analysis applied to container flows in 2004, unsurprisingly, provides similar results to the ones in 2006, which confirms the respective quality and comparability of the sources (digital and paper versions). The overwhelming dominance of the Asian region centred on Hong Kong is visible, with long-distance ramifications towards Africa and North America. However, Europe appears less fragmented than in 2006, with most northern ports polarized by Rotterdam, and a couple of nodal regions in the south (Valencia, Constantza, Mersin, Istanbul, and Piraeus). Other nodal regions are very similar to the ones obtained in 2006. The difference for Europe would mean that there is a continuous process of Asian expansion, but this should be tested using more recent data in 2008 and 2010 for instance. The 2009 global crisis may have dramatically reconfigured such dynamics and patterns.

Complementary evidence about the position of Europe and its ports in world maritime flows can be obtained b applying the same methodology to specific commodity groups: liquid bulks, solid bulks, general cargoes, and also containers. For liquid bulks, Rotterdam, Marseilles, and Alexandria include most of European ports in their respective nodal regions, followed by smaller sub-networks centred upon Lisbon, Oslo, Helsinki, London, and Izmir. Oil, gas and chemicals flows are thus polarized by a few dominant ports, but there is still a clear divide between northern and southern circulation logics within Europe, with lesser cross-Atlantic linkages. The rest of the world is organized amongst relatively clear regional ranges of ports with a number of specialized and dominant liquid bulk ports such as Houston, Itaqui, and Fujairah. It confirms the strong position of Singapore as a pivotal centre for oil traffics in a Southeast Asia-Oceania region, while Yokohama has a distinct subgroup with Japan and South Korea. The Asian influence in Europe is thus much less evident than for containers and all commodities.

A totally different pattern was obtained based on solid bulks flows (i.e. agricultural products, coal, ores,, minerals). The Asian nodal region is still centred upon Singapore, but it extends across the whole world up including most of Asia and Africa, the Latin American East Coast, Canada's West Coast, and most of Northern Europe. The rest of Europe (and the world) is split amongst many small and geographically narrowed regions, except for Barcelona extending its influence towards Morocco. While this would suggest that solid bulk flows create more integrated patterns, the dominance of Asia is better explained by the importance of South-South trades and the enormous needs of Asian countries for such resources.



Nodal maritime regions of the world in 2004 (port city level, liquid bulks)

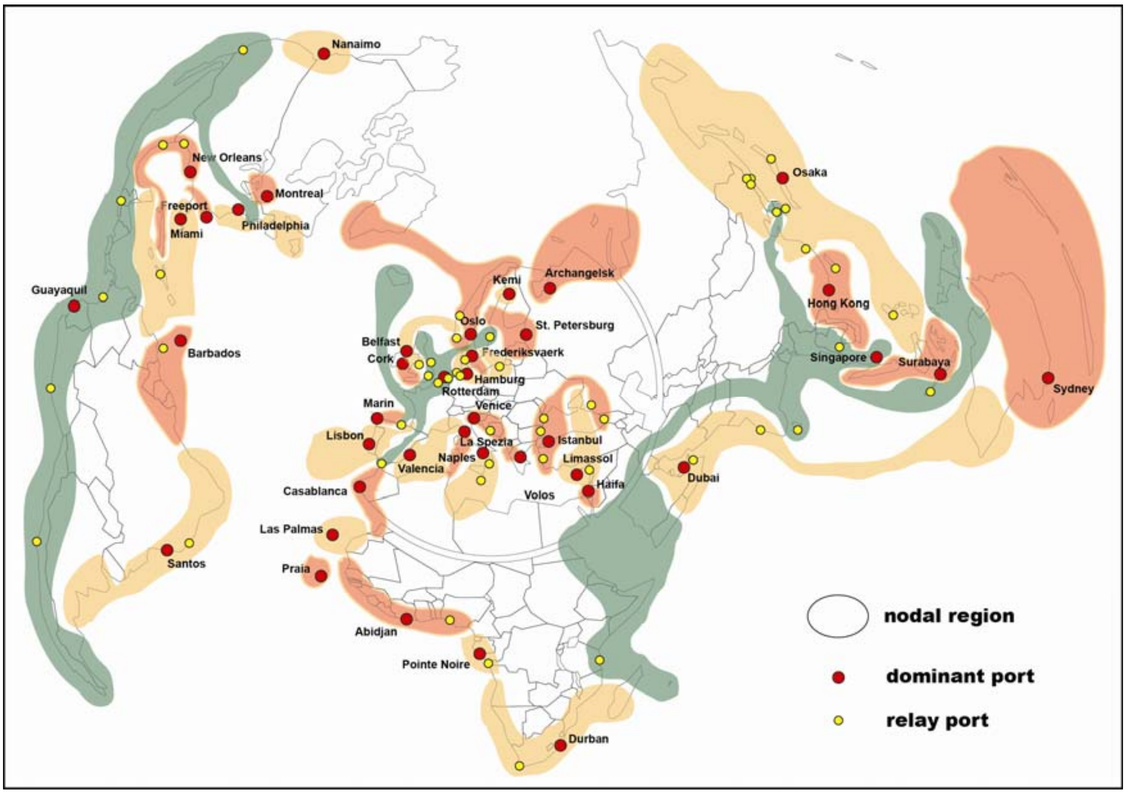


Nodal maritime regions of the world in 2004 (port city level, solid bulks)

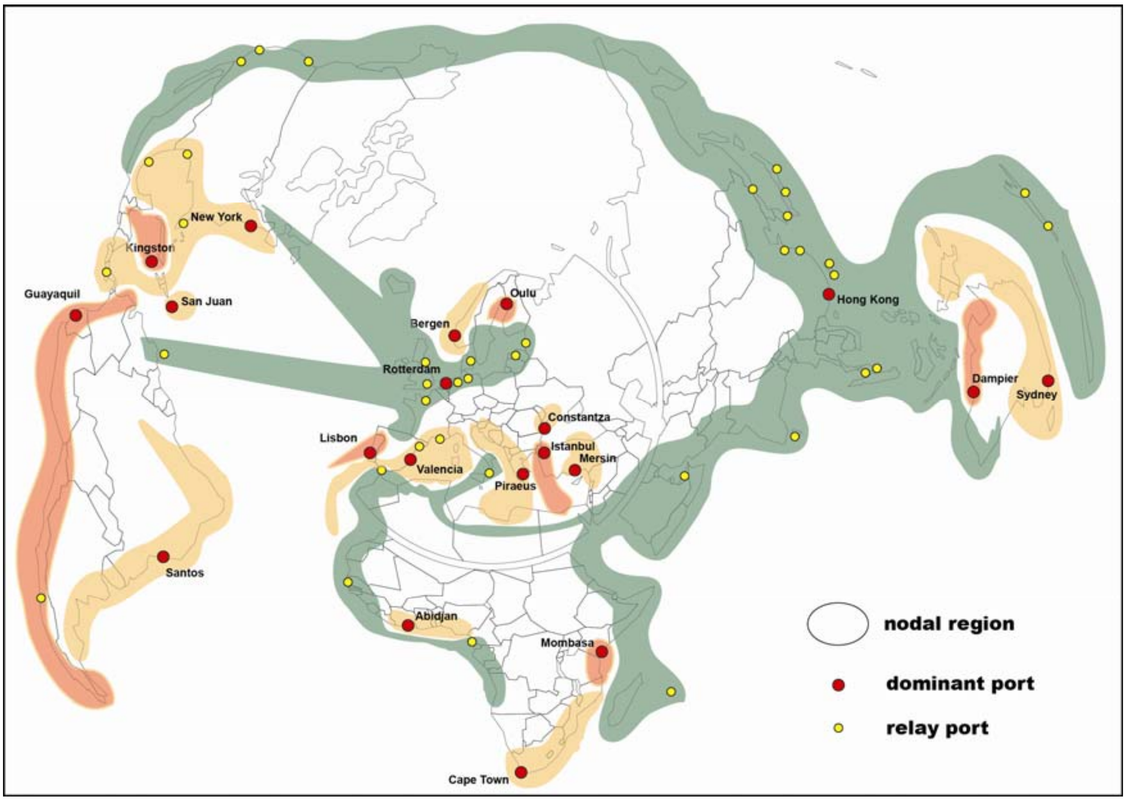
Notably, it reflects upon the growing tendency for Asian countries (Japan, China) to purchase agricultural land at Southern countries of the globe and import products for domestic consumption, as well as the voracious utilization of raw materials from all over the world, China for instance being the world's premier importer of coal, sugar, cement, etc. Singapore is the dominant port because of its central role in regional distribution, and despite the fact that bulk networks are mostly services through on-demand and direct calls, i.e. without hub-feeder systems.

The distribution of nodal regions based on general cargo flows provides the most fragmented picture of Europe, as the maritime network is composed of several local subgroups with the exception of the northern region centred upon Rotterdam. On the contrary, there is striking continuity along the West Coast of the Americas (also including New York on the East Coast), while Asia is split into a few nodal regions with Singapore still being the largest dominant port. Osaka, Hong Kong, Surabaya, Dubai, and Sydney, however, act as pivots within relatively large regions, but the one polarized by Singapore still reaches distant coasts such as East Africa and India's East Coast. In Europe, most nodal regions remain small and bound to national boundaries or neighbouring ports such as in the Baltic (St. Petersburg) and the Mediterranean (Valencia, Naples, Venice; Istanbul, Limassol).

For containers, there is not so much difference with the previous analysis based on the year 2006, although the dominance of Asia is relatively less important, but it already spreads all over Africa and up to the Mediterranean (Gioia Tauro and Algeciras hubs). Because the Asian region in 2006 is even larger and spreads farther, we can hypothesize that there has been a progressive expansion of Asia's influence over time and that it is still expanding nowadays. Asia's dominance in world trade flows is thus the most visible for manufactured goods (containers) and raw materials (solid bulks), but less for liquid bulks and general cargoes. Europe in general always appears fragmented and split amongst relatively small nodal regions, partly because it is a continental power and a peninsula. Perhaps, the results may support the idea of a weaker economic and trade integration in Europe compared with other regions of the world, but this contradicts official trends. It is probably more the influence of geomorphology on vessel circulation patterns than economic fragmentation, but the question is relevant.



Nodal maritime regions of the world in 2004 (port city level, general cargo)



Nodal maritime regions of the world in 2004 (port city level, containers)

Application 3: Weight and share of ESPON, NAFTA, and ASEAN+3 in the maritime traffic of external ports

Methodology

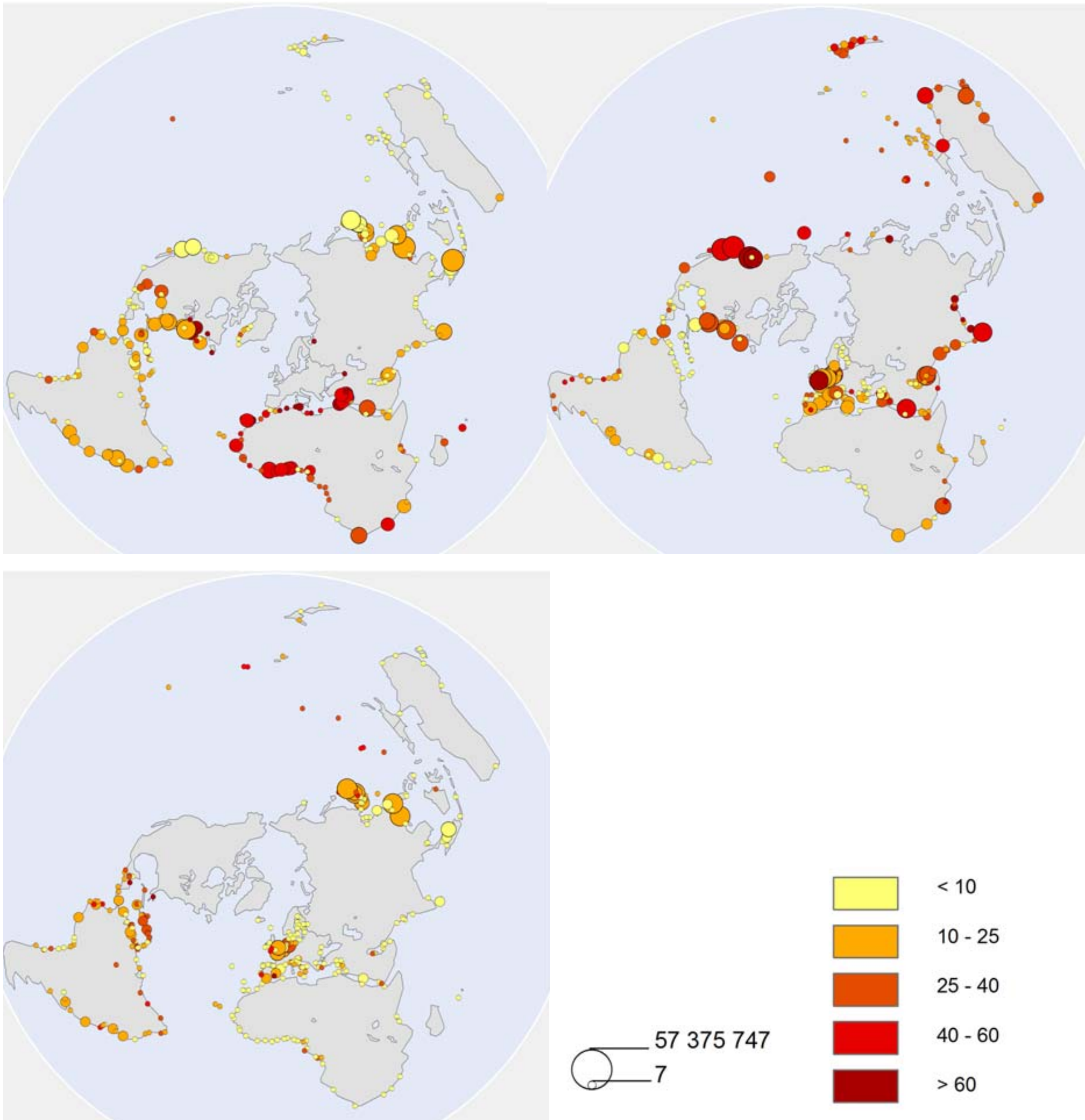
Based on the aforementioned aggregation of individual ports and terminals into metropolitan cities whenever possible, we have calculated the share of ESPON-related container flows in the total traffic of each non-ESPON port. This can reveal how important is the weight of ESPON in the world at local level, and what is the geographic coverage of this importance. Based on the GRT (Gross Tonnage) of vessels and their circulation patterns, we calculated the weight and share of each economic pole (ESPON, NAFTA, and ASEAN+3) in the total traffic of each external port. Such analysis provides a clear picture of the geographic extent of each pole's forelands and as such, those forelands can be interpreted not only as trading links but also as areas of influence in the world.

Main results on container flows (1996-2006)

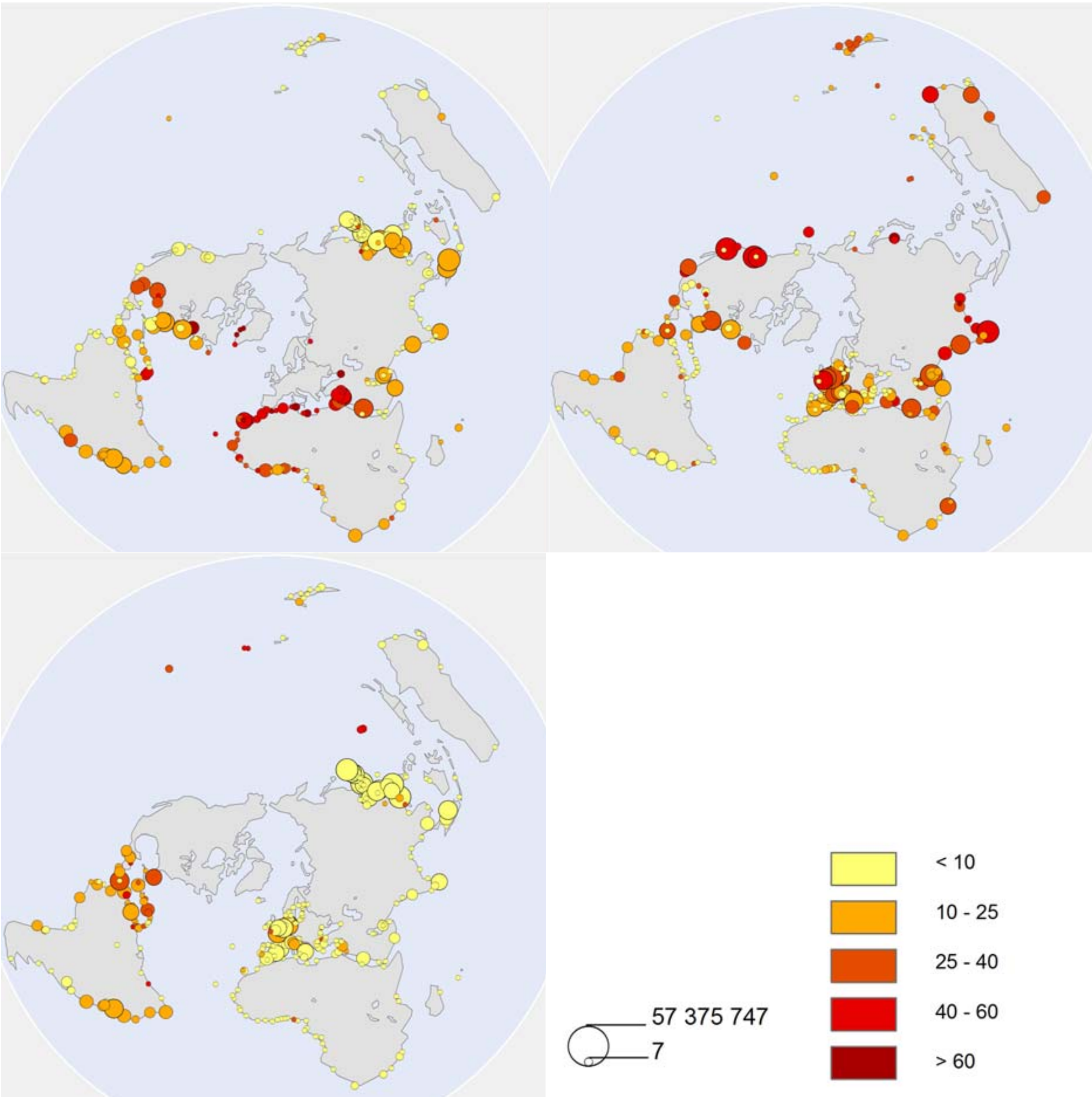
In 1996 and as a confirmation of previous analyses on large region level, the relative importance of ESPON is highest in the vicinity, namely in the Mediterranean basin (especially North Africa), West Africa, Canada (Quebec), and the Gulf coast (Mexico, Texas, Louisiana), with a few other spots in the Indian Ocean (Madagascar, Reunion), in Polynesia, and in Latin America (French Guyana, some Brazilian ports such as Belem and Recife). Trade preference is thus clearly apparent together with the permanency of post-colonial and linguistic proximities.

In 2006 however, we also see some drastic modifications of this pattern. It seems that ESPON's relative weight has geographically shrunk, with a concentration along West and North African coasts, and still in Quebec. Elsewhere, only small and medium-sized ports are heavily influenced by ESPON traffic in their overall activity, such as Greenland, some northern Latin American ports and some ports of the Antilles. Yet, some Asian ports (albeit not very large) exhibit a higher share of ESPON-related flows than in 1996, notably in Southeast Asia. The dominance over African ports has greatly reduced, thus confirming the former single linkage analysis.

For the two other main poles, the effect of geographic proximity on traffic distribution is also made clear, although for ASEAN+3 the influence goes beyond the sole Pacific region, and it has expanded over time. For NAFTA, the influence is much more in proximity: despite high traffic volumes with Asia, the highest shares remain with Latin America, with a noticeable shrink over time. The analysis of container flows shows that the influential area of ESPON and NAFTA remain relatively concentrated around Africa and the Caribbean respectively, while the influence of ASEAN+3 is more widespread on all continents. This also simply confirms the fact that Asia is a major exporter of containerized (finished products) cargoes towards the rest of the world, and it is dominantly a maritime region where ports have a central role in logistics chains.



Weight and share of ESPON, ASEAN+3 and NAFTA in 1996 (containers)

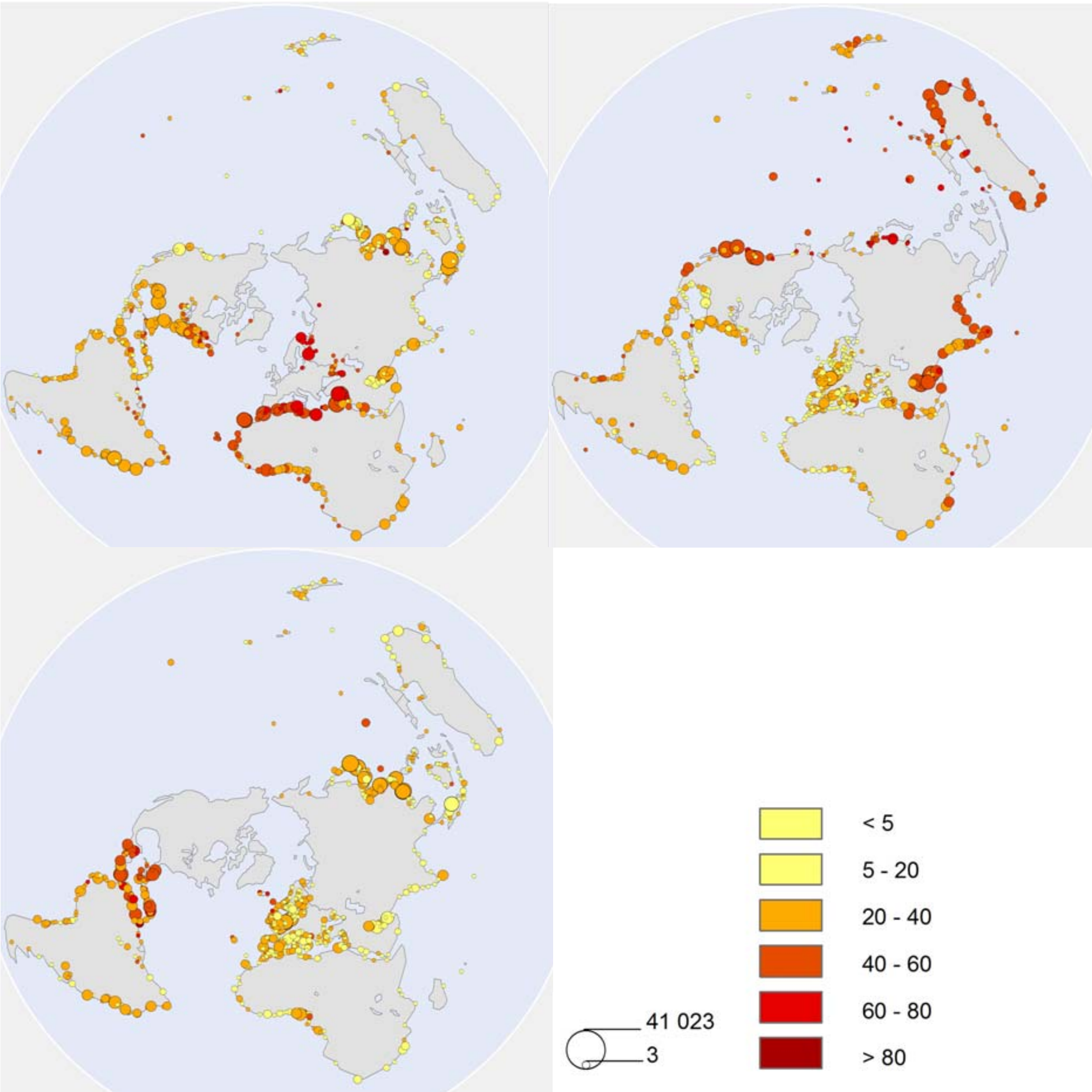


Weight and share of ESPON, ASEAN+3 and NAFTA in 2006 (containers)

Main results on all commodities (2004)

The weight and share of Europe in other ports' traffic is by no means revelatory of the importance of geographic proximity in the geography of flows. All maps confirm the heavy specialization of North African and East European ports in European traffics, with central Maghreb (Morocco, Algeria, Tunisia) and Russian ports (e.g. St. Petersburg) being the most Europe-oriented (i.e. over 75% of their traffic connecting European ports). Only a few distant ports have a dominant share of Europe-related flows in their total traffic, as seen in the map of all commodities, and they often account for relatively negligible Russia. The extent of

Europe's influence varies, however, according to the type of commodities. While container traffics are more widespread, general cargoes, liquid and solid bulks primarily concentrate in the vicinity, with secondary clusters in West Africa, the East Coast of North America, and the Gulf countries. Except for containers, Europe is thus largely dependent upon few and concentrated areas for its imports and exports of raw materials. NAFTA's influence is still (compared with the previous analysis based on sole container traffics) largely bound to the Caribbean (relative values), and it is less global than for ESPON (volumes handled). The influential area of ASEAN+3 is primarily in the Asia-Pacific and Indian Ocean regions as an effect of continuity, from the U.S. West Coast to the Middle East, and a much stronger presence in Oceania, which is a major exporter of raw materials (e.g. Australia) such as coal.



Weight and share of ESPON, ASEAN+3 and NAFTA in 2004 (all commodities)

For containers, the picture is relatively similar to the one in 2006, but with a stronger influence of NAFTA on West Australia, of ESPON on Atlantic Americas as well as Indian Ocean. Such differences can be explained by different dynamics taking place in 2004 and in 2006, and also by the different unit used for the analysis (GRT instead of TEUs). Still, ESPON's foreland is more global than for the two other poles, despite the very high concentration of largest shares in the vicinity (Maghreb, Eastern Europe) and throughout the Atlantic.

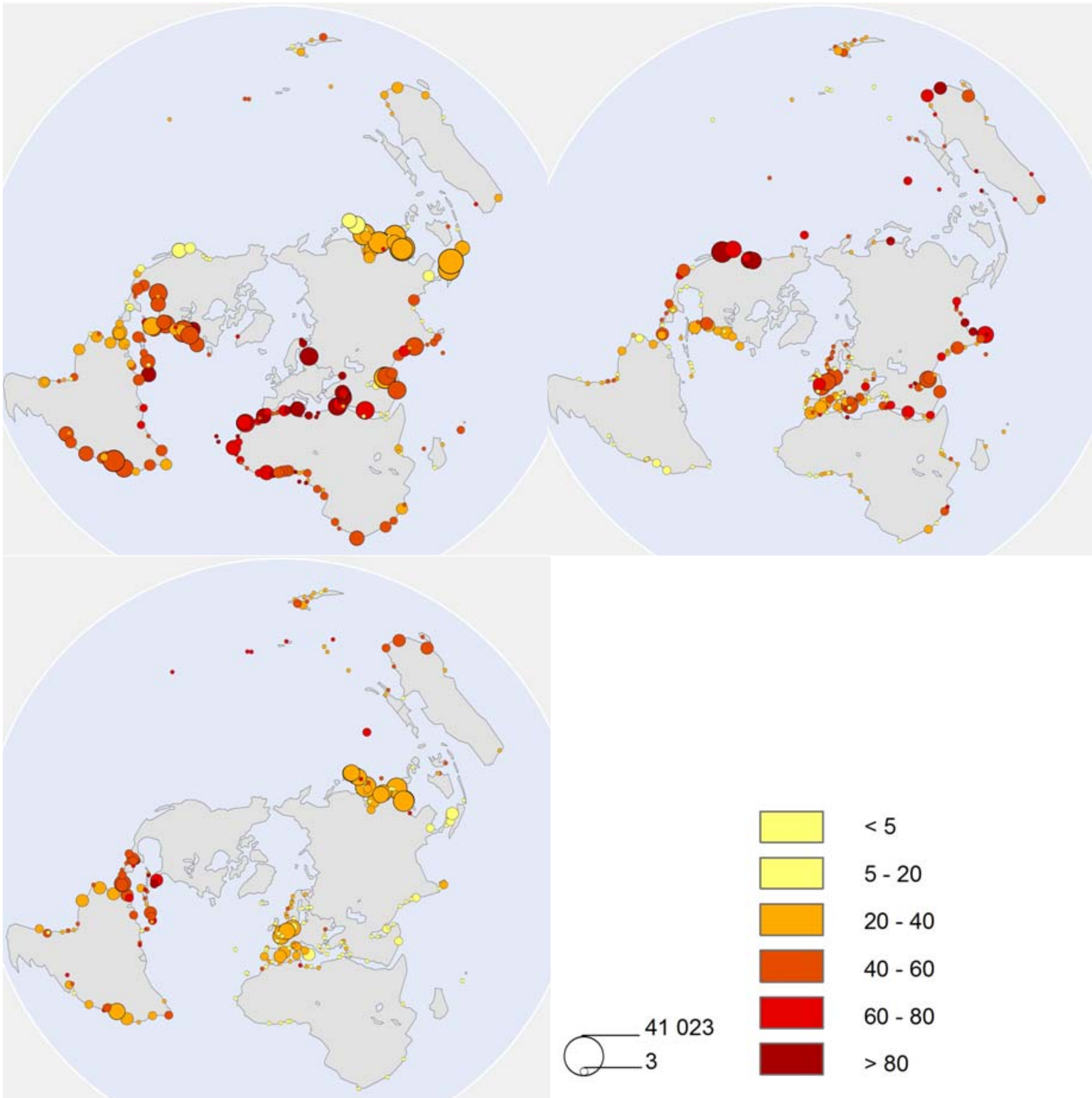
For general cargoes, ESPON's forelands are much narrower than for containers, as they concentrate mostly in the vicinity and at some Latin and North American ports. For NAFTA, there is a much higher concentration in the Caribbean and in some part of the Asia-Pacific (Western Australia, Japan) than for container flows. For ASEAN+3, there is a clear dominance all over the Indian Ocean and Asia-Pacific areas with a specific concentration on Indian and Russian Far-Eastern ports.

Liquid bulks, which comprise oil products, chemicals, and liquefied gas, provide much more specific patterns in relation with the three main poles. This time, ESPON's forelands are dominantly in the vicinity, due to the overwhelming importance of Europe in the energy export flows of Maghreb countries (e.g. Algerian oil and gas) as well as Ukraine and Russia, with a lower influence over West African ports. NAFTA is more influenced on the latter (e.g. Nigeria) but its influential area remains bound, overall, to Latin America (e.g. Venezuela, Barbados). ASEAN+3 has the most narrowed foreland but it concentrates principally on the Middle East and also Australia for natural resources.

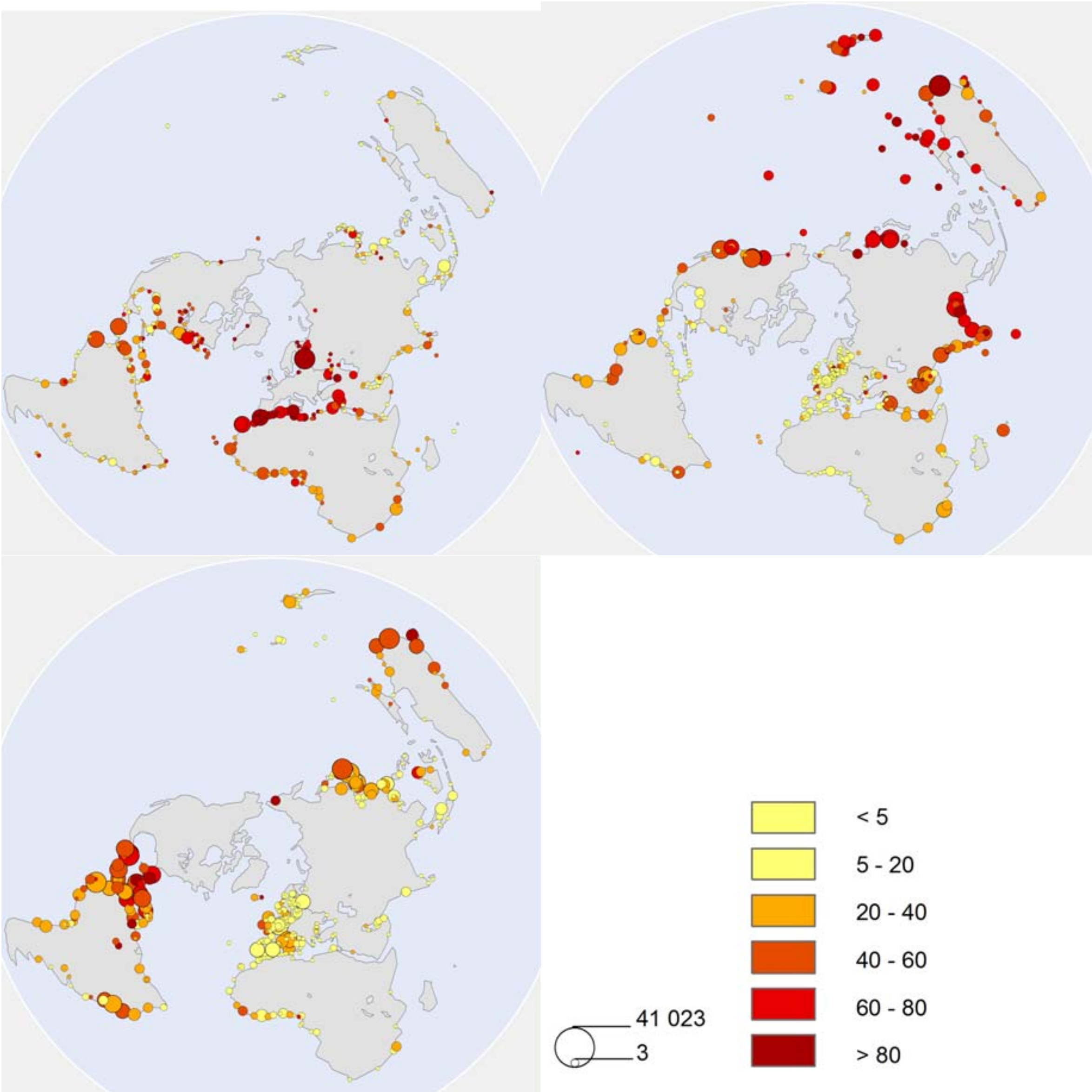
The patterns of solid bulk flows, which comprises a variety of commodities such as agricultural products, minerals, and ores, are very similar to the one of liquid bulks, with the exception of ASEAN+3 for which the foreland is much more global. Australia appears as the main partner for these flows due to its role as major exporter of such materials (e.g. coal, ores) but also South Africa and India, which almost did not appear in the maps of ESPON and NAFTA for solid bulks.

Overall, the analysis if the forelands of main economic poles per commodity groups provides useful evidence to identify where and for which products the influential area of Europe

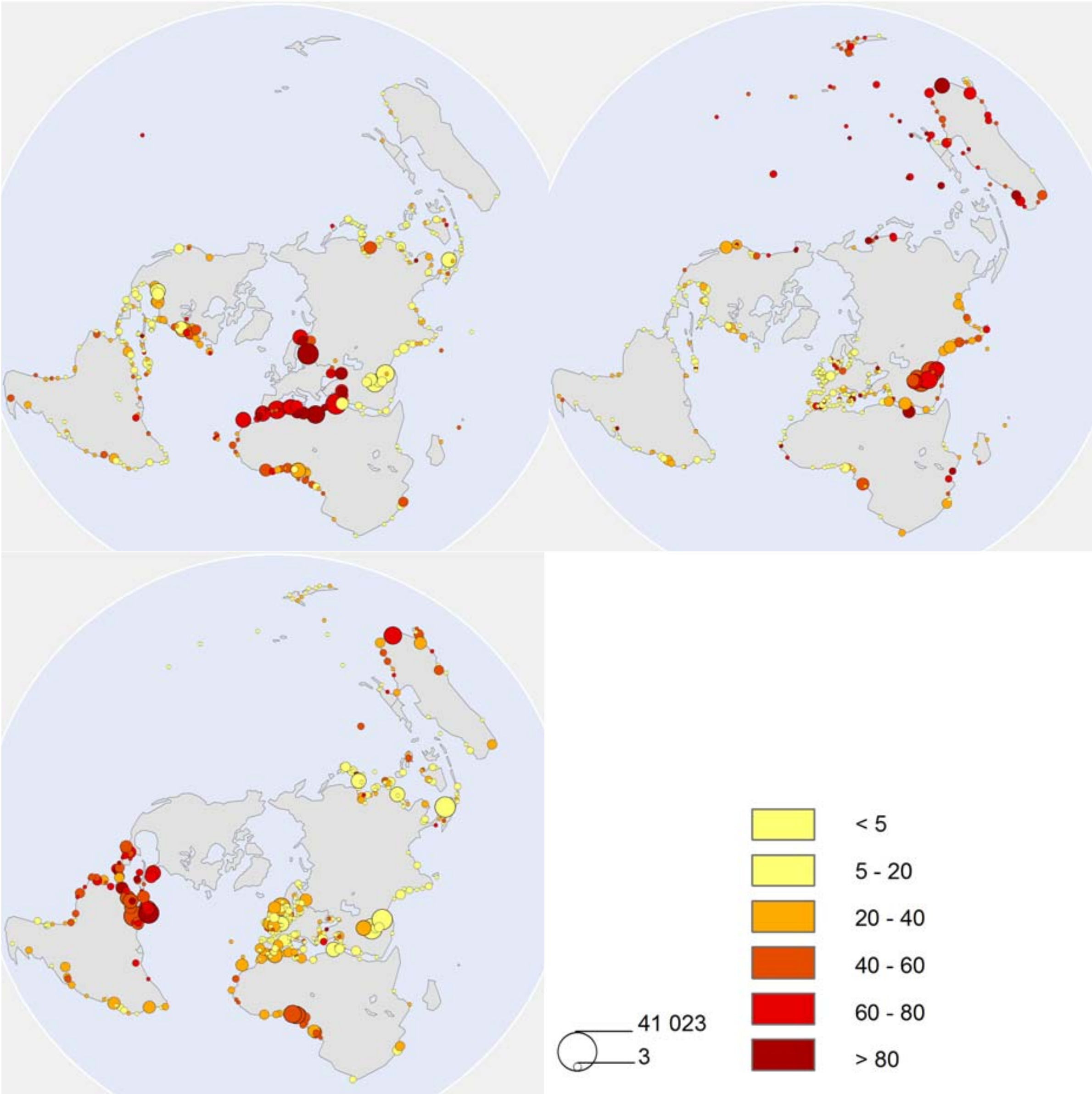
(ESPON space) is dominant and/or limited. Europe's circuits remain mostly local (North Africa, Eastern Europe) despite some exceptions compared with ASEAN+3, but more widespread than NAFTA, which often remains bound to the Caribbean basin. The analysis can be done in the future on more specific products (e.g. gas, crude oil, coal) and for specific countries (e.g. forelands of France, Spain, United Kingdom, China, USA ...) in order to better focus on specific transport chains by sea, and with comparisons established with other years.



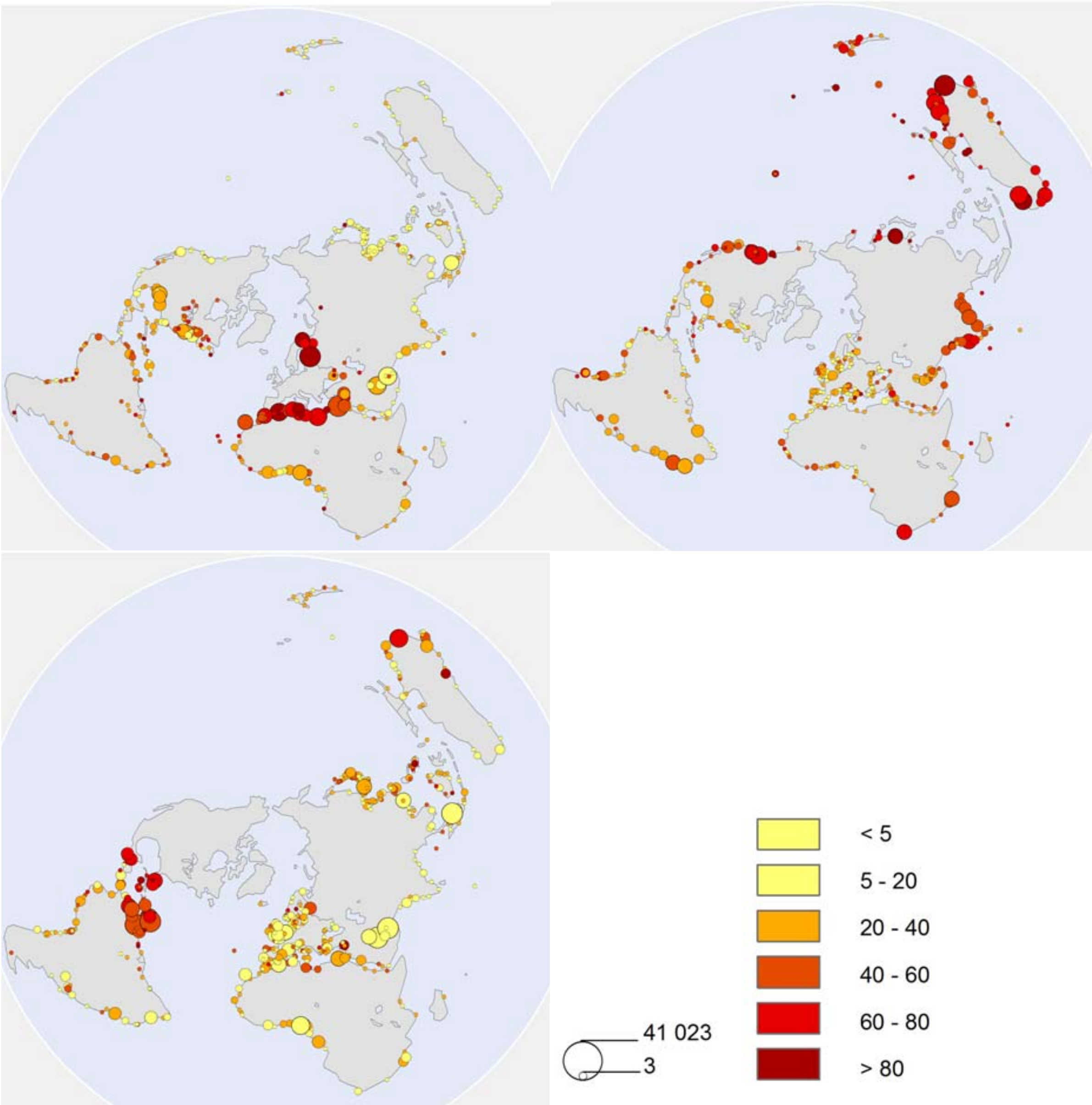
Weight and share of ESPON, ASEAN+3 and NAFTA in 2004 (containers)



Weight and share of ESPON, ASEAN+3 and NAFTA in 2004 (general cargo)



Weight and share of ESPON, ASEAN+3 and NAFTA in 2004 (liquid bulk)



Weight and share of ESPON, ASEAN+3 and NAFTA in 2004 (solid bulk)

Application 4: Geographic specialization of ESPON ports' maritime forelands

Methodology

The objective of this analysis is to differentiate ESPON ports according to the dominant geographic specialization of their traffic connexions with the world. Statistical analysis is used to group ports into common "clusters" based on the distribution of their traffic by WUTS1 region (factor analysis and hierarchical classification).

Main results

The factor analysis of the distribution of traffic by main world region at each European port city was operated on the basis of the share of each world region in ports' total maritime traffics. It provides very clear views about their geographic specializations. At each year and regardless of the type of flows (containers or all commodities), traffic with Western Asia (i.e. South Asia, the Middle East, and Eastern Europe) is systematically opposed to other traffics, especially the Americas and East Asia on the main factor 1, which concentrates most of the total variance.

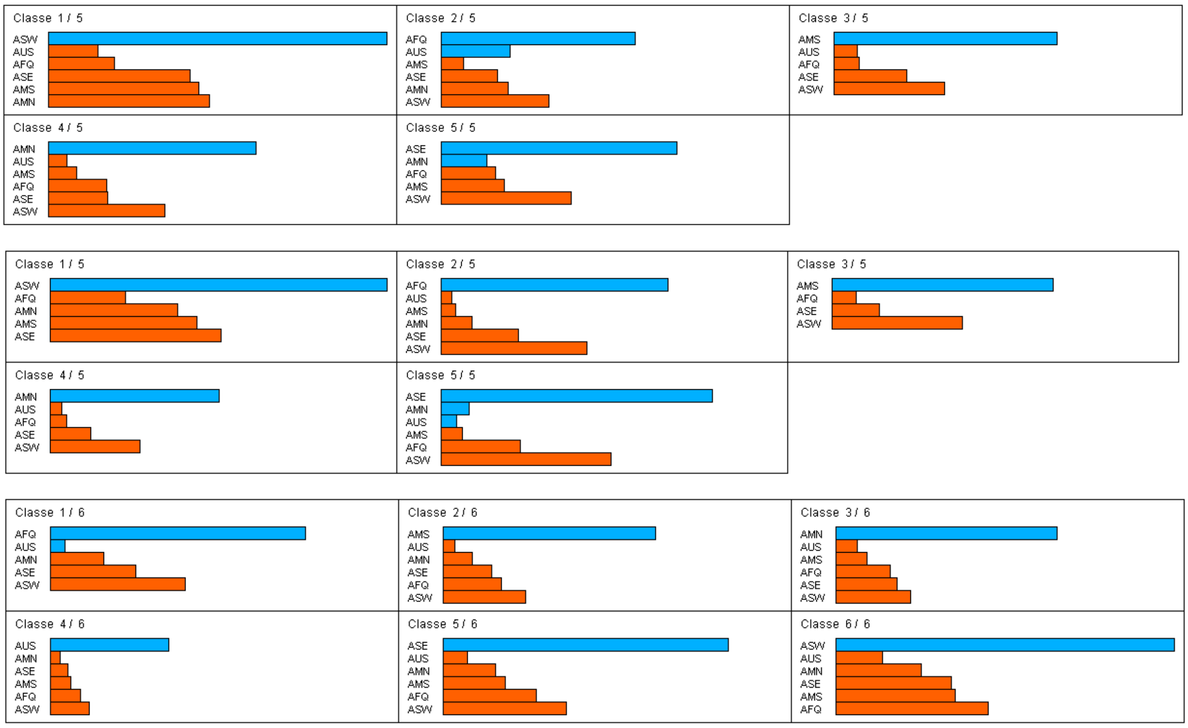
The second main trend (factor 2) somewhat differs between the years, but overall, traffic with East Asia is always opposed to Africa and Latin America traffics (containers, 1996 and 2006) while in 2004, it is only opposed to Africa. These two dimensions of the original data can be interpreted as an opposition between "proximity traffic" (Western Asia) and "distant traffic" (Americas, East Asia) on factor 1, and as an opposition between "Atlantic traffic" (Africa, Latin America) and "Pacific traffic" (East Asia) on factor 2. Other factors being difficultly comparable over the years, we can say that the geographic differentiation of European ports' forelands primarily rests upon their traffics with main economic poles of the world, while African traffics are only secondarily represented in the factors. This stands in contrast with previous analyses showing the enormous importance of ESPON traffic for many African ports, but the opposite is not verified. Perhaps, a clearer picture would have been obtained based on smaller world regions or maritime ranges such as North, West, South, and East Africa, etc. This can be done in further research on the specialization of maritime forelands. In addition, a look at results per main commodity groups such as solid bulks, liquid bulks, and general cargoes might be interesting as well to balance the results.

Year	Factors	1	2	3	4	5
1996 (containers)	Eigenvalue	0.68	0.47	0.43	0.37	0.25
	Variance (%)	30.8	21.6	19.6	16.8	11.3
	Cumulated variance (%)	30.8	52.4	71.9	88.7	100.0
	AMS	-0.93	-1.05	-0.12	1.04	-0.08
	AFQ	0.04	-0.48	-1.05	-0.85	-0.29
	AMN	-1.06	0.02	1.06	-0.74	0.03
	ASW	0.89	0.03	0.27	0.14	0.04
	AUS	-0.60	0.05	-1.19	-0.30	3.82
	ASE	-0.69	1.49	-0.52	0.41	-0.19
2006 (containers)	Eigenvalue	0.63	0.50	0.41	0.32	0.08
	Variance (%)	32.8	25.9	21.0	16.4	3.9
	Cumulated variance (%)	32.8	58.8	79.8	96.1	100.0
	AFQ	0.10	-1.12	-0.97	-0.10	0.02
	AMN	0.97	0.09	0.16	1.83	-0.01
	AMS	1.19	-0.88	1.38	-0.56	0.02
	ASE	1.10	1.18	-0.54	-0.46	0.10
	ASW	-0.70	0.19	0.19	-0.01	0.00
2004 (all commodities)	Eigenvalue	0.57	0.53	0.47	0.43	0.40
	Variance (%)	23.8	21.9	19.5	18.1	16.7
	Cumulated variance (%)	23.8	45.7	65.2	83.3	100.0
	AFQ	-0.28	-1.13	-0.51	-0.04	-0.03
	AMN	-0.29	-0.07	1.07	0.09	1.43
	AMS	-0.47	-0.03	1.24	0.82	-1.19
	ASE	-0.92	1.01	-0.69	0.16	0.06
	ASW	1.00	0.28	-0.08	-0.10	-0.07
	AUS	-1.20	0.33	1.24	-4.30	-0.97

Results of the factor analysis in 1996, 2006 and 2004 (up to down)

N.B. regional codes account for Western Asia (ASW), Oceania (AUS), Africa (AFQ), Eastern Asia (ASE), Latin America (AMS), and North America (AMN)

Based on the factor analysis, we obtained five classes of ports in 1996 and 2006 and six classes in 2004, each class being defined by the dominance of one main region. It is interesting that there was no class characterized by "global forelands", i.e. including a mix of main poles (e.g. North America and East Asia grouped and opposed with the rest of the world), probably due to the use of percentages rather than gross tonnages, which limited the size effect. Thus, each class is dominated by one main region, making it relatively easy to classify European ports according to their main geographic orientation. From one year to another, the obtained classes are well comparable and it is important to underline the existence of a specific class focusing on African traffics, while Oceania remains very secondary due to its low shares at European ports. The most important is to verify whether ports belonging to the same class are located near each other within Europe, thus supporting the idea of shared forelands at given territories due to specialized linkages.

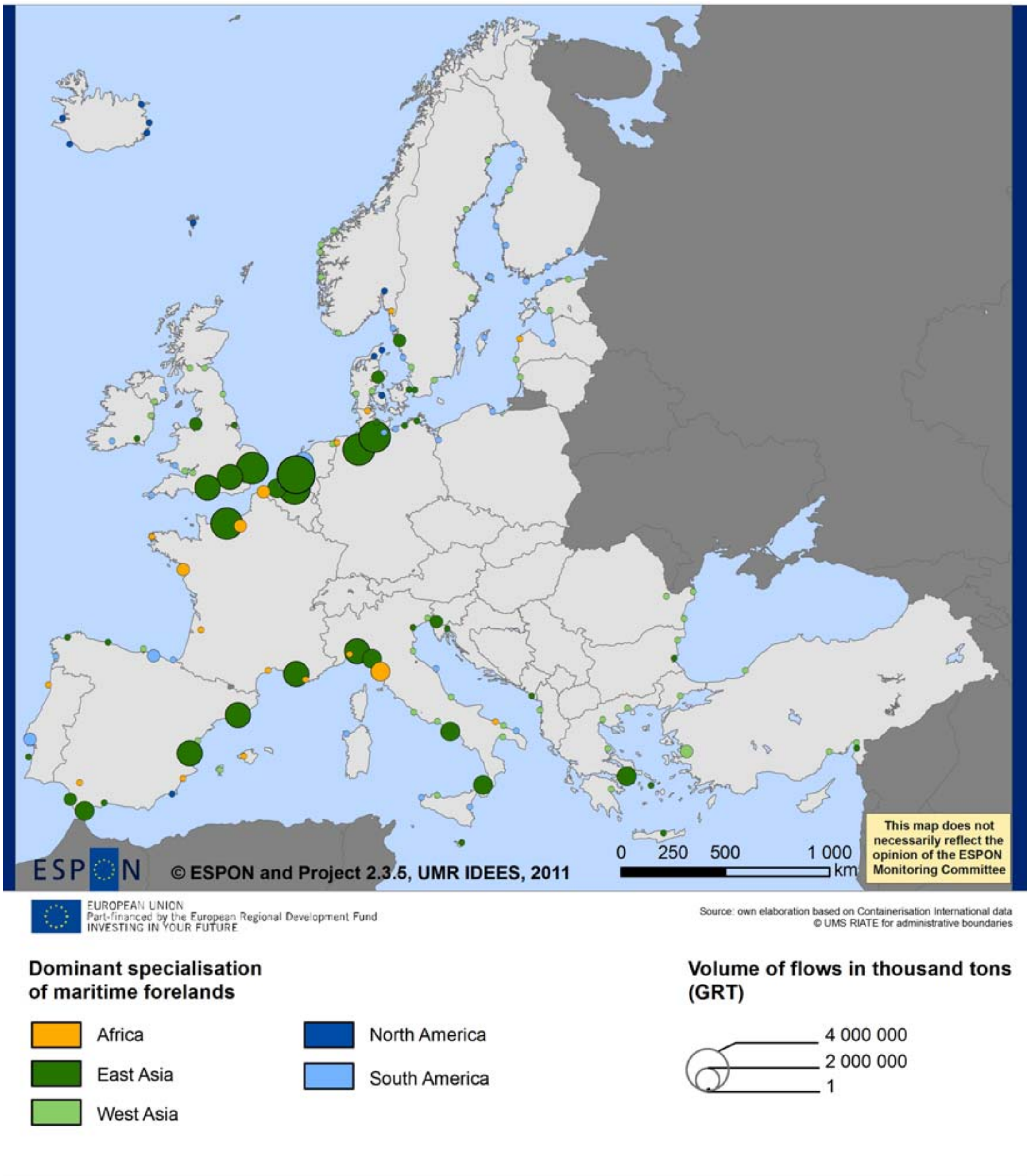


Results of the classification in 1996, 2006 and 2004 (up to down)

N.B. regional codes account for Western Asia (ASW), Oceania (AUS), Africa (AFQ), Eastern Asia (ASE), Latin America (AMS), and North America (AMN)

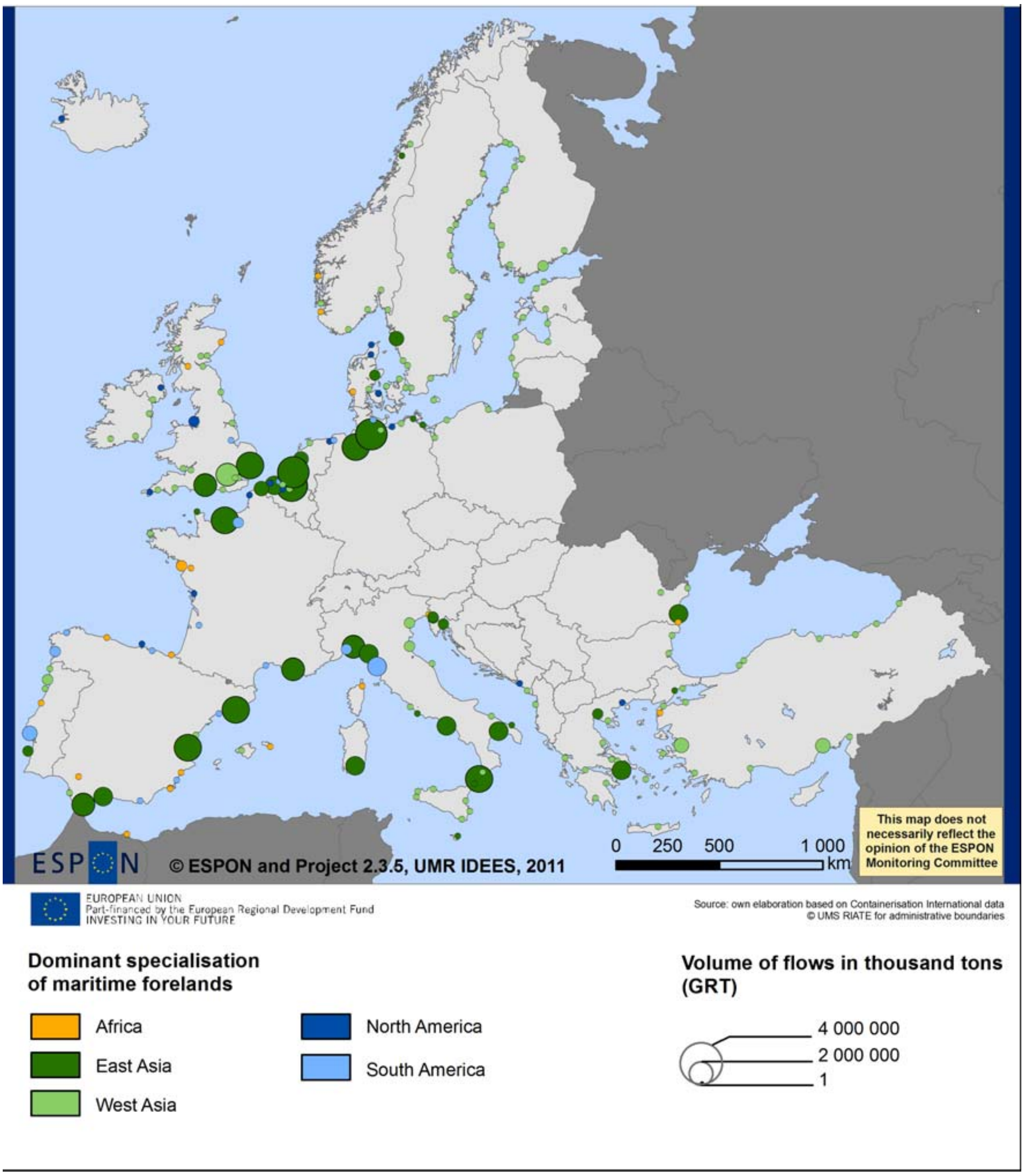
One striking result in 1996 is the overwhelming influence of East Asia as all largest European ports are dominantly specialized towards this region, should they be northern of southern ports. Some medium-sized ports, however, are more specialized towards Africa or South America. All French ports except Le Havre and Marseilles are specialized on Africa, as well as Leghorn (Italy) and other minor ports mostly in the Mediterranean. For French ports, this clearly confirms the permanency of longstanding linkages with many African countries (i.e. North and West Africa). The specialization on South America applies to Bilbao, Lisbon, and Amsterdam, for the same reasons of historical legacies and linguistic/cultural proximities favouring regular trades. The influence of other world regions remains minimal, except for Izmir (Turkey) that is the only port specialized on Western Asia.

In 2006 it is more or less the same picture, with the largest ports turned toward East Asia and a minority of ports turned towards other world regions. Liverpool is the only port with non negligible traffic being specialized on North America, probably because of strong cross-Atlantic ties, while London has shifted under West Asian rather than East Asian influence. Only Montoir and Nantes (Loire estuary) remain specialized on Africa, as Leghorn and Rouen shifted under South American influence. The latter remains strong for Lisbon and Bilbao, confirming the sustained linkages between the Iberian Peninsula and South America for the aforementioned reasons. Such patterns and trends confirm the growing influence of Asian trades in the configuration of global maritime flows.

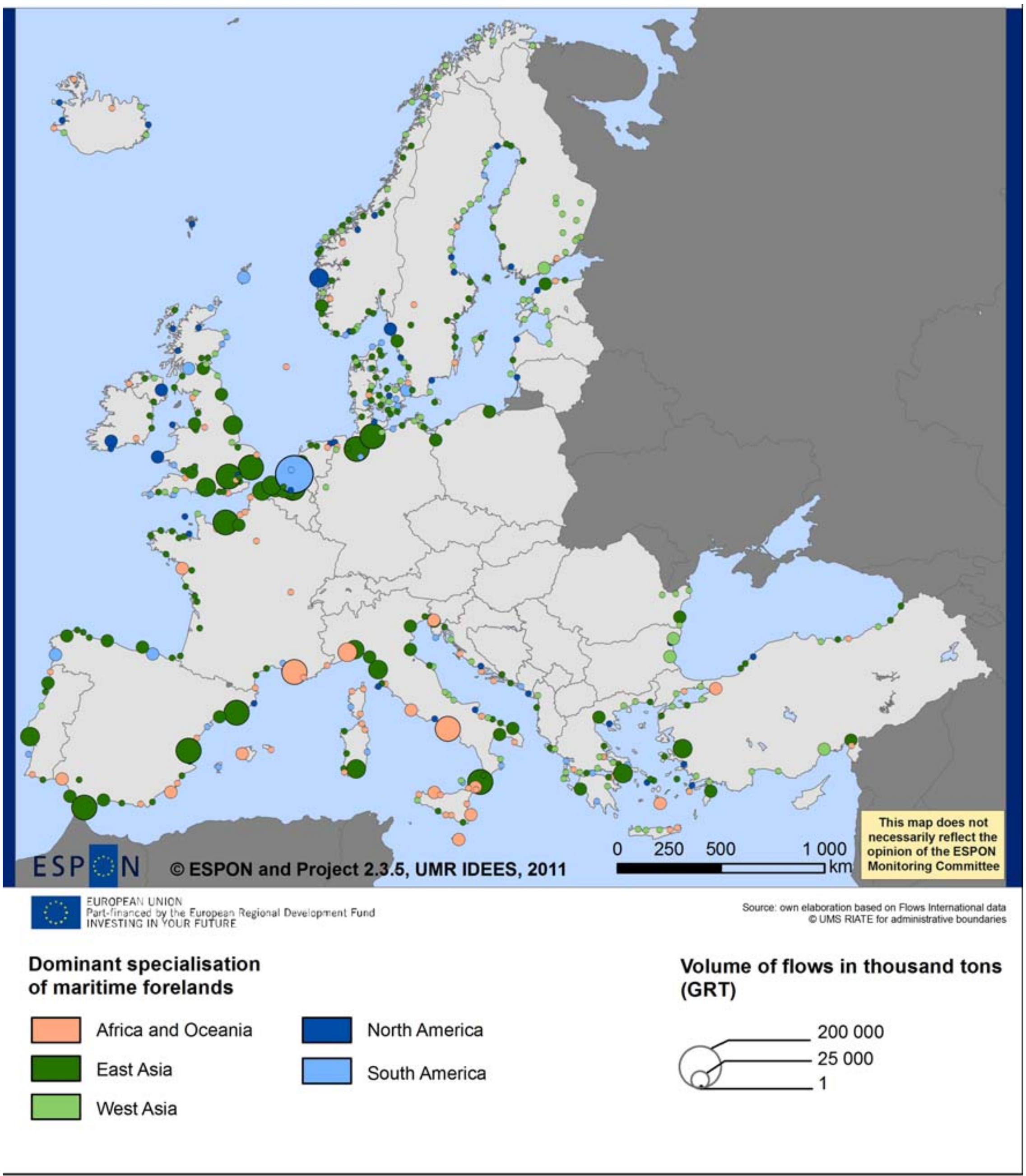


Geographic specialization of ESPON ports' forelands in 1996 (containers)

In 2004 for all commodities, results provide a somewhat more balanced picture of external influences. While still most major ports are under East Asian influence, a majority of southern ports are turned towards Africa and Oceania, probably due to the inclusion of bulk traffics (e.g. Marseilles, Savona, Koper, Naples, and also Nantes). The North American influence is visible only at a few northern ports, such as Bergen, Gothenburg, and in the British Isles. Several small Baltic, Black Sea, and Turkish ports are turned towards West Asia due to spatial proximity with Russian and other East Mediterranean ports. Surprisingly, Rotterdam, the largest port, is specialized on South America, but this might be explained by strong links with other oil ports in Brazil and Venezuela.



Geographic specialization of ESPON ports' forelands in 2006 (containers)



Geographic specialization of ESPON ports in 2004 (all commodities)

Application 5: Centrality and attractiveness of ESPON ports in global maritime flows

Typical indicators are proposed to rank world ports based on their centrality and attractiveness in the global network of maritime flows. Firstly, it is important to mention the different characteristics of the five networks analysed based on maritime flows in 2004: all commodities, containers, general cargo, liquid bulks, and solid bulks. Each network has a different size in terms of the number of ports and links (see table). It is important to mention that all analyses are based on direct and indirect links between ports created by the circulation of vessels and their calls at multiple ports within the period considered.

Network	No. ports	No. links	Complexity (Beta)	Connectivity (Gamma)	Small-world (clustering)	Scale-free (rank-size)	Traffic concentration (Gini)
All commodities	1,831	61,298	33.4	0.037	0.621	-0.930	0.648
Containers	719	10,215	14.2	0.040	0.691	-0.907	0.648
General cargo	1,432	29,441	20.6	0.029	0.604	-1.018	0.620
Liquid bulks	1,187	19,806	16.7	0.028	0.627	-1.046	0.659
Solid bulks	1,089	17,117	15.7	0.029	0.565	-1.043	0.607

Main characteristics of global maritime networks in 2004

The general cargo (GCN) network is the largest in terms of the number of ports and links; but in comparison, the container network (CN) is more densely organized as it has the highest clustering and gamma coefficients. The liquid bulk network is the most concentrated (highest Gini coefficient, calculated on the basis of throughput volumes among ports) and the most hierarchical (highest slope coefficient of the power-law line drawn on a bi-log plot of degree distributions), closely followed by solid bulks for the latter aspect, probably due to the enormous traffic volume at some bulk ports that are somewhat inflated by the giant size of some vessels. The container network is the most selective in terms of the number of ports (smallest network), and has the lowest number of links per node (Beta).

In the following analyses of the port hierarchy by commodity type, five main indicators have been retained. Total tonnage is used to rank ports of the world based on the level of their overall throughput performance. It is complemented by a look at the *clustering coefficient* "C" (likeliness for their direct neighbours to be interconnected, from 0 to 1), their degree centrality "K" (number of direct links to other ports), betweenness centrality "BC" (number of occurrences on possible shortest paths in the network), and eccentricity "EC" (farness to/from other ports in the network). For the top 25 ports in terms of tonnage, such indicators indicate different aspects of their function and position in the network, and can be interpreted in terms of robustness and vulnerability. Such data is the only one capable of estimating port throughput per commodity group (e.g. Chinese port statistics do not release such data and it is absolutely not harmonized on a world level due to problems of units, absence of data, time periods, differences in categories), and it would allow many other analyses such as commodity specialisation by port and by world region, but those have been left behind in order to stick to the central question of the project, i.e. the position of Europe and its components (here port cities) in global flows.

Global port hierarchy in all commodities

In the network combining vessel circulations of all types, ten European ports belong to the 25 largest ports in the world; with both northern and southern locations. Compared with their tonnage ranking, northern ports (e.g. Rotterdam, Antwerp, Bremen-Bremerhaven, Hamburg) often have a higher betweenness centrality (BC) and degree (K) than many larger ports: their position in the network is better than their traffic volume would suggest, due to the number and geographic range of their linkages with the rest of the world. Their lower clustering coefficient (C) also indicates a hub profile that is comparable with Hong Kong and Singapore, while Rotterdam remains the most eccentric port of the world (EC) due to its central position in all commodity flows, which is, with Antwerp, stronger than Hong Kong.

Among the top European ports, results underline certain weaknesses in the global position of some large traffic ports, as seen with the low betweenness centrality of Savona, Bruges-Zeebrugge, Palma, Gioia Tauro, and Katakolon, probably due to their specialization in a few main commodities; these ports often have higher clustering coefficients: they are embedded within densely connected communities of ports locally, and have less connections with the rest of the network (K). It is important to underline that overall, South European ports are far less central than North European ports, as only Algeciras (Spain) surpasses the betweenness centrality of northern ports, and Felixstowe (UK) remains less central than its direct neighbours.

World							Europe						
Rank	Port	Tonnage	BC	C	K	EC	Rank	Port	Tonnage	BC	C	K	EC
1	Singapore	923847763	288427	0.115	752	0.996	3	Rotterdam	429849488	184647	0.128	771	1.000
2	Hong Kong	660723170	75516	0.175	506	0.933	10	Barcelona	272495744	31536	0.236	427	0.907
3	Rotterdam	429849488	184647	0.128	771	1.000	13	Naples	250255944	17985	0.285	312	0.876
4	Fujairah	351553491	28378	0.235	342	0.888	15	Antwerp	224652688	99545	0.157	653	0.970
5	Kaohsiung	345447495	43706	0.202	416	0.905	16	Le Havre	224125660	37142	0.232	438	0.914
6	Yokohama	305625724	39819	0.205	397	0.900	20	Hamburg	206869560	63438	0.185	535	0.939
7	Dammam	288006668	15237	0.262	302	0.873	21	London	205470254	54892	0.197	501	0.928
8	Osaka	280927150	47718	0.191	433	0.912	22	Savona	195946769	6293	0.356	234	0.846
9	Nagoya	277002458	32386	0.222	391	0.900	23	Bremen	193393300	64392	0.189	526	0.937
10	Barcelona	272495744	31536	0.236	427	0.907	24	Marseilles	192013299	31236	0.234	415	0.907
11	Busan	257583519	47025	0.216	370	0.892	30	Venice	141745692	34404	0.248	326	0.878
12	Miami	254364068	43770	0.245	313	0.879	31	Immingham	140464648	47623	0.188	477	0.915
13	Naples	250255944	17985	0.285	312	0.876	32	Valencia	139348827	18848	0.271	364	0.892
14	Los Angeles	241215282	42113	0.219	352	0.888	35	Leghorn	136789622	23778	0.269	358	0.888
15	Antwerp	224652688	99545	0.157	653	0.970	36	Bruges	134185749	5566	0.377	212	0.850
16	Le Havre	224125660	37142	0.232	438	0.914	38	Southampton	132891491	21658	0.259	375	0.896
17	Shanghai	218794784	24859	0.229	372	0.895	39	Felixstowe	132246373	12004	0.317	292	0.870
18	Tokyo	212874390	33175	0.213	407	0.905	41	Fiumicino	123943892	11844	0.319	228	0.833
19	Houston	207154557	34220	0.229	402	0.904	43	Piraeus	122097469	30579	0.253	375	0.894
20	Hamburg	206869560	63438	0.185	535	0.939	47	Palma(Maj)	116842589	3593	0.403	164	0.813
21	London	205470254	54892	0.197	501	0.928	53	Gioia Tauro	100906556	1569	0.466	170	0.831
22	Savona	195946769	6293	0.356	234	0.846	57	Algeciras	94730680	42133	0.217	457	0.914
23	Bremen	193393300	64392	0.189	526	0.937	58	Bergen	93326723	29816	0.244	314	0.873
24	Marseilles	192013299	31236	0.234	415	0.907	59	Genoa	91967731	17239	0.297	318	0.878
25	New York	190610187	30087	0.253	376	0.901	60	Katakolon	90625598	3064	0.461	108	0.760

Global port hierarchy in container flows

For container flows, the number of links (K) is comparable among top world ports, but there are wider discrepancies in terms of betweenness centrality (BC), as Singapore is positioned on 17,000 more shortest paths than Rotterdam but has only 31 more links with other ports. Hong Kong and Singapore are thus extremely well positioned in the global container network, and their position is explained by their transshipment hub functions within East Asia as well as between East Asia and the rest of the world. Port cities acting mostly as gateways often has a lower betweenness centrality and a higher clustering coefficient (C). Within Europe, Northern ports clearly dominate the figure, whereas Le Havre remains under the level of Valencia and Algeciras (BC) despite its favourable position at the entrance/exit of the English Channel and its high number of links (K) to other ports.

World							Europe						
Rank	Port	Tonnage	BC	C	K	EC	Rank	Port	Tonnage	BC	C	K	EC
1	Hong Kong	508639281	44444	0.157	268	1.000	5	Rotterdam	195571194	38326	0.183	228	0.976
2	Singapore	360648005	55563	0.144	259	0.987	9	Hamburg	135754094	27997	0.204	207	0.966
3	Kaohsiung	223138841	8013	0.277	150	0.923	10	Le Havre	129575773	11086	0.262	187	0.954
4	Busan	209863748	23304	0.218	185	0.944	15	Antwerp	110745754	23894	0.209	207	0.966
5	Rotterdam	195571194	38326	0.183	228	0.976	18	Bremen	95472072	15612	0.237	146	0.923
6	Osaka	167811078	9599	0.246	153	0.918	20	Gioia Tauro	88299171	6598	0.340	122	0.900
7	Shanghai	158971542	13862	0.238	180	0.945	26	Felixstowe	72299825	6131	0.318	145	0.924
8	Shenzhen	140816228	5934	0.328	136	0.917	30	London	63763382	7439	0.294	144	0.927
9	Hamburg	135754094	27997	0.204	207	0.966	31	Barcelona	60973898	9280	0.302	148	0.918
10	Le Havre	129575773	11086	0.262	187	0.954	32	Valencia	60338562	11360	0.274	157	0.930
11	Los Angeles	122089750	11959	0.290	129	0.905	37	Algeciras	49020408	11119	0.286	132	0.910
12	Nagoya	114820747	8985	0.287	136	0.907	46	Marseilles	34321602	6294	0.327	132	0.912
13	Tokyo	113647857	6687	0.285	145	0.912	51	Genoa	32756513	3579	0.365	125	0.904
14	Yokohama	113176929	6140	0.325	110	0.874	54	Southampton	30756089	296	0.617	56	0.853
15	Antwerp	110745754	23894	0.209	207	0.966	55	Valletta	30006988	4458	0.359	90	0.870
16	Port Klang	106161049	6828	0.275	141	0.891	56	Bruges	29021379	1532	0.430	71	0.854
17	Ningbo	99969776	3245	0.333	129	0.906	58	Cagliari	28330748	1572	0.461	73	0.848
18	Bremen	95472072	15612	0.237	146	0.923	63	Piraeus	24845535	3428	0.343	96	0.861
19	Taipei	93283178	4151	0.245	118	0.816	64	Las Palmas	24838799	4295	0.305	90	0.789
20	Gioia Tauro	88299171	6598	0.340	122	0.900	65	Naples	24721777	6154	0.306	120	0.899
21	Dubai	87375986	12827	0.320	122	0.889	70	Dunkirk	23169015	5272	0.347	91	0.874
22	Bangkok	84138731	4098	0.343	94	0.859	74	La Spezia	22203041	3302	0.383	94	0.882
23	New York	82977885	8459	0.320	142	0.915	80	Lisbon	20314058	5798	0.333	86	0.845
24	Santos	79879707	5249	0.370	118	0.897	82	Surte	20060119	2242	0.374	42	0.777
25	Miami	72331828	14545	0.304	132	0.883	83	Leghorn	19888270	4052	0.331	99	0.857

Global port hierarchy in general cargo flows

General cargo flows produce a port hierarchy that has the specificity to include many European ports in the top 25, as Rotterdam and Antwerp rank just under Singapore in terms of betweenness centrality but have the strongest connectivity in terms of the number of links (K) to other ports, i.e. more than one hundred links than Singapore and two hundred more than Hong Kong. Some ports stand out due to exceptional betweenness centrality values, such as Busan (South Korea) and St. Petersburg (Russia), probably due to their role as regional distribution platforms within Northeast Asia and the Baltic respectively. Within Europe, this is also the case for Istanbul, Algeciras, and Amsterdam, while many large general cargo ports locate preferably in the Scandinavia-Baltic region. Le Havre does not appear in the top 25 ports due to its specialization in containers and liquid bulks.

World							Europe						
Rank	Port	Tonnage	BC	C	K	EC	Rank	Port	Tonnage	BC	C	K	EC
1	Singapore	33014293	183153	0.094	369	0.974	3	Rotterdam	26562993	123693	0.129	471	1.000
2	Hong Kong	26578427	57525	0.136	240	0.892	5	Antwerp	21948219	116132	0.132	459	0.999
3	Rotterdam	26562993	123693	0.129	471	1.000	7	Bremen	18245765	45414	0.195	321	0.942
4	Osaka	23221843	54944	0.129	260	0.903	8	Hamburg	16853012	39616	0.197	323	0.939
5	Antwerp	21948219	116132	0.132	459	0.999	9	Immingham	15098710	27508	0.200	311	0.877
6	Kaohsiung	20075913	32373	0.171	199	0.884	13	Oslo	13674840	11399	0.288	210	0.835
7	Bremen	18245765	45414	0.195	321	0.942	14	London	13522898	32377	0.210	293	0.914
8	Hamburg	16853012	39616	0.197	323	0.939	17	Lisbon	11819354	24282	0.221	240	0.896
9	Immingham	15098710	27508	0.200	311	0.877	21	St. Petersburg	11324098	52277	0.185	319	0.942
10	Guayaquil	14289001	32789	0.193	178	0.907	22	Szczecin	11046958	29130	0.207	306	0.901
11	Shanghai	13956023	28342	0.173	195	0.884	23	Valencia	10404768	21434	0.239	220	0.905
12	Yokohama	13937156	29596	0.185	182	0.865	32	Barcelona	8636510	11073	0.275	171	0.871
13	Oslo	13674840	11399	0.288	210	0.835	34	Gdansk	8449754	28253	0.232	270	0.915
14	London	13522898	32377	0.210	293	0.914	37	Malmo	7510088	3716	0.383	149	0.806
15	Busan	12849529	45991	0.151	205	0.888	39	Klaipeda	7408867	32480	0.210	267	0.904
16	Nagoya	12221716	19369	0.182	182	0.806	41	Amsterdam	7203630	36922	0.209	303	0.914
17	Lisbon	11819354	24282	0.221	240	0.896	43	Las Palmas	6896605	23772	0.218	192	0.903
18	Tokyo	11741477	25604	0.166	204	0.879	44	Bilbao	6796638	17250	0.250	251	0.873
19	Miami	11572242	24047	0.209	110	0.835	46	Algeciras	6567648	47965	0.200	268	0.927
20	Dubai	11525307	15356	0.189	127	0.855	47	Istanbul	6529743	45976	0.207	220	0.903
21	St. Petersburg	11324098	52277	0.185	319	0.942	50	Belfast	6322140	7028	0.326	190	0.822
22	Szczecin	11046958	29130	0.207	306	0.901	51	Frederiksvaerk	6264919	1102	0.546	91	0.767
23	Valencia	10404768	21434	0.239	220	0.905	52	Surte	6225083	4444	0.367	156	0.797
24	Houston	10231652	31226	0.171	161	0.886	55	Porsgrunn	5923874	6434	0.331	186	0.825
25	Jakarta	10034763	35671	0.163	184	0.868	56	Riga	5867164	8124	0.302	199	0.838

Global port hierarchy in liquid bulk flows

Flows of oil, gas, and chemical products produce a radically different port hierarchy, as large oil ports are clearly recognizable in the top 25, which did not appear in previous tables (e.g. Fujairah, Dammam, Houston, Ruwais, Bergen, Alexandria, Ulsan, Port Arthur, etc.). Singapore clearly dominates this global network as it is two times more central (BC) than Rotterdam despite the fact that Rotterdam has a similar (slightly higher) number of links to other ports (K) and is the most eccentric port. Within Europe, Antwerp that did not appear in the world top 25 ports for tonnage is in fact more central than Le Havre and Marseilles. Except for Marseilles, Genoa, Algeciras, Cagliari and Siracusa, all major liquid bulk ports locate in the North, reflecting upon the failed attempts to create maritime industrial clusters throughout southern Europe in the 1970s based on the growth pole concept (e.g. Huelva, Sines, etc.).

World							Europe						
Rank	Port	Tonnage	BC	C	K	EC	Rank	Port	Tonnage	BC	C	K	EC
1	Singapore	275064745	214558	0.086	414	0.998	5	Rotterdam	117134294	128002	0.116	421	1.000
2	Fujairah	247335231	52276	0.146	260	0.949	8	Bergen	67422081	22548	0.213	184	0.904
3	Dammam	207317342	22905	0.185	207	0.923	13	Le Havre	55963029	34246	0.194	255	0.945
4	Houston	121594935	42527	0.173	255	0.953	18	Marseilles	49977138	24303	0.216	229	0.928
5	Rotterdam	117134294	128002	0.116	421	1.000	21	London	47520164	18105	0.229	205	0.894
6	Ruwais	94353732	12353	0.224	144	0.888	26	Tyne	41203800	19186	0.250	192	0.918
7	Yokohama	79873939	28767	0.179	182	0.902	27	Felixstowe	40207168	1422	0.449	71	0.802
8	Bergen	67422081	22548	0.213	184	0.904	28	Ostend	37741493	6	0.600	5	0.653
9	Alexandria(EGY)	64885722	15697	0.238	173	0.905	31	Leith	35181710	6728	0.296	151	0.832
10	Kharg Is.	62233447	4000	0.305	79	0.841	32	St. Petersburg	34757498	10757	0.289	162	0.891
11	Ulsan	61129274	46926	0.151	240	0.933	34	Antwerp	33891224	34111	0.177	277	0.929
12	Port Arthur	60743811	12744	0.226	156	0.916	35	Siracusa	33681908	18464	0.250	173	0.902
13	Le Havre	55963029	34246	0.194	255	0.945	38	Brofjorden	32990500	7526	0.325	140	0.866
14	Philadelphia	55705953	15869	0.212	152	0.908	39	Milford Haven	32806906	14093	0.264	169	0.893
15	Nagoya	55226616	5339	0.287	115	0.858	40	Bremen	32265830	13350	0.265	173	0.900
16	Doha(QAT)	53258710	1644	0.324	75	0.820	47	Novorossiysk	29741747	8193	0.260	124	0.875
17	Sokhna	50175059	1837	0.388	47	0.836	48	Southampton	29139067	19100	0.227	198	0.912
18	Marseilles	49977138	24303	0.216	229	0.928	50	Surte	28699804	10086	0.276	149	0.851
19	New Orleans	49759477	25356	0.200	191	0.926	51	Immingham	28412813	17356	0.234	202	0.910
20	Los Angeles	47986173	17464	0.221	119	0.881	56	Helsinki	25272582	2803	0.393	104	0.860
21	London	47520164	18105	0.229	205	0.894	57	Algeciras	25111030	23389	0.226	225	0.929
22	Hong Kong	46958077	29797	0.174	197	0.898	61	Bruges	23134508	1243	0.535	48	0.770
23	Yanbu	43560682	11021	0.274	125	0.889	66	Genoa	21175593	8614	0.282	134	0.887
24	Dubai	42194896	14094	0.231	146	0.892	68	Cagliari	20984841	4833	0.332	124	0.875
25	Kaohsiung	42096332	19963	0.203	170	0.887	69	Fredericia	20975034	1213	0.444	90	0.775

Global port hierarchy in solid bulk flows

Finally, solid bulk flows generate a very specific port hierarchy where most top ports are large exporters of raw materials such as mine products extracted locally for the global market. While Singapore remains the most central and largest port in this segment, many ports of the southern hemisphere now appear, such as Australian (Port Hedland, Mackay, Dampier, Gladstone), South African (Richards Bay), Indian (Visakhapatnam) and Latin American ports (Vitoria, Rosario), but their centrality is often much lower than the import/export load centres such as Vancouver, Yokohama, Hong Kong, New Orleans, and Rotterdam, which locate in the North. In Europe, St. Petersburg is the second most central port after Rotterdam and before Antwerp

World							Europe						
Rank	Port	Tonnage	BC	C	K	EC	Rank	Port	Tonnage	BC	C	K	EC
1	Singapore	169282653	161179	0.090	439	1.000	14	Rotterdam	37994400	46390	0.135	236	0.927
2	Port Hedland	69553387	6756	0.282	125	0.851	16	London	33986659	12043	0.213	99	0.840
3	Yokohama	56829441	17982	0.212	170	0.873	17	Ostend	29395782	61	0.689	20	0.675
4	Mackay	55634940	12213	0.235	164	0.877	19	Immingham	26051013	10690	0.212	120	0.865
5	Sydney	55244276	10882	0.225	173	0.871	21	Ponta da Madeira	25192538	7569	0.258	100	0.862
6	Hong Kong	52121143	19744	0.203	183	0.884	22	Antwerp	24638561	25488	0.153	185	0.898
7	Kaohsiung	49816869	21960	0.192	205	0.901	35	Amsterdam	20424526	15144	0.197	128	0.873
8	Dampier	49005530	4443	0.414	70	0.811	38	Bruges	19731000	0	1.000	8	0.640
9	Vancouver(CAN)	44116364	35732	0.161	222	0.901	57	Dunkirk	13184632	11360	0.195	125	0.870
10	Gladstone	42513839	7896	0.248	147	0.853	58	Hamburg	13134411	14579	0.183	147	0.855
11	New Orleans	40375650	73433	0.117	295	0.951	64	Bremen	11650314	23071	0.161	146	0.867
12	Vitoria	40359619	9971	0.233	139	0.888	66	St. Petersburg	11248256	31223	0.148	191	0.903
13	Richards Bay	38262473	22521	0.170	198	0.907	71	Barcelona	10386820	3321	0.250	78	0.806
14	Rotterdam	37994400	46390	0.135	236	0.927	72	Algeciras	10205865	23237	0.156	162	0.885
15	Nagoya	35262692	11099	0.218	163	0.871	83	Las Palmas	9037134	14187	0.194	142	0.873
16	London	33986659	12043	0.213	99	0.840	88	Valencia	8492338	11186	0.205	120	0.863
17	Ostend	29395782	61	0.689	20	0.675	91	Southampton	8354536	738	0.378	49	0.756
18	Shanghai	29203788	5628	0.259	146	0.857	95	Gdansk	7759269	10491	0.212	129	0.868
19	Immingham	26051013	10690	0.212	120	0.865	97	Tarragona	7528403	2609	0.262	65	0.824
20	Mizushima	25212887	4298	0.281	102	0.825	101	Piraeus	7077684	13825	0.189	121	0.854
21	Ponta da Madeira	25192538	7569	0.258	100	0.862	102	Tallinn	6937982	10881	0.232	94	0.844
22	Antwerp	24638561	25488	0.153	185	0.898	103	Escombreras	6851554	3064	0.257	63	0.793
23	Visakhapatnam	24628665	8702	0.230	129	0.868	106	Tyne	6747118	5947	0.227	90	0.822
24	Qinhuangdao	24106287	10860	0.256	138	0.851	108	Espevik	6734184	5771	0.247	92	0.770
25	Rosario	23959760	19349	0.173	176	0.901	109	Rouen	6709878	5889	0.233	81	0.808

TERRITORIAL LINKAGES OF PORT TRAFFIC SPECIALIZATION WITHIN THE ESPON SPACE

Background on port-region linkages

Contemporary transport systems are marked by a dematerialization of the economy and rising average transport distances thereby making it increasingly difficult for decision-makers and scholars to map and explain the distribution of firms and flows in relation to their spatial environments (Leslie and Reimer, 1999; Hesse and Rodrigue, 2004). Continuous progress in the physical and organisational connectivity of transport systems as well as reduced trade barriers and logistics costs fostered the spatial volatility of flows, resulting in both concentration and diffusion of markets and flows across regions and nations (Fujita et al., 1999; Hesse, 2010). As noted by Janelle and Beuthe (1997), the absence of disaggregated data on detailed flows has often been a major obstacle to the analysis of their spatial determinants. Conversely, most research on transportation networks focuses dominantly on freight movements, capacity and connectivity problems in abstract spaces (e.g. graph theory, complex networks, routing and modelling), and carriers' strategies, with minor attention paid to the (changing) socio-economic characteristics of localities (Ducruet and Lugo, 2012). Such state of affairs also relates with the persistent divide between qualitative and quantitative approaches within transport geography as well as the difficulty identify underlying causal structures (Goetz et al., 2009).

Recent efforts have, however, expanded the understanding of the spatial fix of flows as well as the causal relationship between flows and the characteristics of cities and regions. This is notably true in air transport research where it is found significant correlation between the volume of air flows and some attributes of airport cities (e.g. centrality, economic or demographic size) in the United States (Neal, 2011), Europe (Dobruszkes et al., 2011), and China (Wang et al., 2011). Exceptions to the "rule" are often attributed to specific geographic situations and carriers' choices in terms of intermediacy (Fleming and Hayuth, 1994). Similar empirical research on rail and road freight flows remains far less developed due to the drastic lack of data on land-based intra- and interregional flows (McCalla et al., 2004). The study by Cattan (1995) on barriers effects in Europe using rail passenger flows is an important exception, in the tradition of Nystuen and Dacey (1961)'s work on telecommunication flows among Oregon cities. Indeed, researchers have rarely approached (high speed) rail traffic from an urban and regional perspective (Dobruszkes et al., 2012).

The maritime and ports sector offer contrasting evidences about the interplay between shipping flows and localities. The dereliction of port-city and port-region spatial and functional linkages is often believed to be an universal and ineluctable phenomenon (Hoyle, 1989). Throughout studies of port choice factors by shippers, liners, and terminal operators in the container business, elements such as local market size and hinterland's socio-economic characteristics are often low ranked compared with infrastructure, service quality and cost factors (Lee et al., 2007; Ng, 2009; Notteboom, 2009). Although there is no question that improved hinterland connectivity, technological revolutions in shipping and terminal operations, heightened port competition, transnational industrial shifts, and spatial-environmental pressures modified such linkages (Hoare, 1986; Todd, 1993; Norcliffe et al., 1996; Bennachio et al., 2002; Notteboom and Rodrigue, 2005; Hall and Jacobs, 2010), there is no evidence that those have completely disappeared. This is highlighted by in-depth case studies of particular cities where port and maritime functions keep their roles albeit in different forms than in the past, such as in Amsterdam (Wiegmans and Louw, 2010), Hamburg (Grossmann, 2008), and Hong Kong (Wang and Cheng, 2010) to name but a few examples. If the linear correlation between total port throughput and the demographic weight of port cities of the world has dramatically lowered since the 1990s, it has maintained and even increased in some regions (Ducruet and Lee, 2006) due to the diversity of urban-port trajectories, port systems configurations, and hinterland spatial patterns (Lee et al., 2008). Accordingly, the globally weak correlation between ports' total throughput volume and the number of maritime Advanced Producer Services in port cities does not contradict the fact that some specialized gateways keep concentrating both tertiary activities and traffics, such as Rotterdam and Houston (Jacobs et al., 2010).

Some drawbacks of existing research are thus purely methodological. Port impact studies, despite their in-depth scrutiny of ports' local linkages, have the problem not to be comparable from one place to another, thereby forbidding any serious identification of large-scale trends (Hall, 2004). Most studies of the socio-economic characteristics of port regions conclude to an absence of linkages with port traffics (De Langen, 2007) or to their impoverishment compared with non-port regions in Europe (Lever, 1995) and the United States (Grobar, 2008; Hall, 2009). However, such studies have in common to rely on total port throughputs thereby ignoring the wide diversity of port activities and traffics. The field survey by McCalla et al. (2001) towards manufacturers and wholesalers situated around Canada's major intermodal terminals may have concluded to weak industry linkages, but again there has been no attempt to link the results with the structure of freight flows. Conversely, studies focusing on port traffic structure and specialization rarely test the relation between flows and adjacent economies (Haezendonck, 2001).

Several arguments motivate this paper to search for sustained functional linkages between port activities and local economies. The first argument lies in the fact that different cargo types will have different affinities with the outlying region where port traffic takes place (see Marti, 1985). It is recognized that heavy industrial activities that use bulk raw materials "are generally adjacent to port sites" Rodrigue et al. (2009), despite important spatial shifts in this sector after the 1970s crisis (Dunford and Yeung, 2011). Based on customs data on the geographic distribution of port-related trading flows in France, Debrie and Guerrero (2008) demonstrated that containers reach farter destinations in the hinterland than other commodities, while smaller ports have geographically narrower hinterlands than bigger ports. The second argument is based on recent research pointing at noticeable port-region interrelations. For the Chinese case, Cheung and Yip (2009) demonstrated the positive influence of regional GDP and productivity on port traffic growth between 1995 and 2005. In advanced economies, container port traffics seem to have closer ties with the tertiary sector than with the industrial sector (Ducruet, 2009). Finally in Europe, the diversity of cargoes handled at ports is positively influenced by the urban size of port cities and the situation of the latter in the continental urban system, among other factors (Ducruet et al., 2010).

Application to ESPON and Japan port regions

Methodology

The main challenge of this section is to find significant interdependences between types of flows and types of regions taking place within geographically and economically relevant local areas. We first propose to consider the variety of traffic flows by main categories (see Table 1) as well as by the level of port traffic: domestic vs. international, import vs. export, and degree of commodity variety. One additional indicator was calculated on the basis of the work of Debrie and Guerrero (2008) who measured the spatial friction of different commodity types through a spatial interaction model using port-related customs data. Weighting the tonnage of each category allowed us to make the ratio between total weighted tonnage and total non-weighted tonnage. High indices mean that port traffic is composed of commodities that are generally not carried over long distances: they are more likely to be produced, transformed, and/or consumed in the vicinity of port facilities (e.g. liquid bulks and metals). Manufactured goods are more likely to travel longer distances due to their higher containerization rate allowing more intermodal solutions, while agricultural products have an intermediary status. The commodity variety index tells us about the overall profile of port traffic. The respective levels of international and import traffics can underline the role of different scales of flows and of their directionality, as some regions will export more than others and be more internationalized on average.

List of traffic and regional indicators

Type of indicator	Specialization	General characteristics
Port traffic	*Combustibles & solid minerals (coal, liquefied gas) *Crude oil & refined oil products *Chemical products (other liquid bulks) *Metal products (iron & steel, other general cargo) *Agricultural, forestry products and live animals *Minerals & construction materials (ores, other solid bulks) *Manufactured goods (containers, traded vehicles) *Passengers & trucks (ferry, ro-ro)	*Traffic size *Import versus export traffic *Domestic versus international traffic *Commodity variety ***Spatial friction
Local economy	**Employment in primary sector **Employment in construction sector **Employment in industrial sector **Employment in private tertiary sector **Employment in public tertiary sector	*Demographic size *Population density **Unemployment *GDP **GDP per capita

* index based on all regions' average ** index based on national average *** index based on individual regions

Defining and describing local economies has raised important methodological issues. Based on the concept of port cluster proposed by De Langen (2003), we have retained the sub-national administrative units for which socio-economic data was available. This definition of port regions is motivated by the fact that although local economies do not fully reflect the true extent of port hinterlands, they concentrate the highest proportion of port-related industries and logistics. Other and more distant areas may not be as port-related as the port region remains to be. The drastic lack of precise data on the location of port clients (i.e. shippers) and on the spatial distribution of port-related freight flows forbid us to push further the definition of port service areas. Attributing different sizes of spatial units to ports would have been risky due to the importance of sea-sea transhipment and land-based transit flows at several large

ports. While larger ports often have a more diversified traffic portfolio that should be reflected in a wider hinterland, there are many exceptions due to factors such as functional specialization and landward accessibility (Chapelon, 2006; Ducruet et al., 2010). All ports situated within the same spatial unit were merged to allow direct comparison between traffics and regional indicators. The core of the analysis is thus proposed from a regional perspective rather than from the perspective of individual ports' hinterlands.
Variables were transformed into indices using the location quotient method (####) illustrated by the following formula:

$$LQ = \frac{e_i/e}{E_i/E}$$

Where:
ei is the local traffic or employment in sector i divided by the total traffic or employment in the region;
Ei is the total traffic or employment in sector i for the world region or country divided by the total traffic or employment in the world region or country.

Port traffic indices were calculated with reference to the world region level, while socio-economic indices were calculated with reference to the national level, except for population, population density, and regional Gross Domestic Product. Such indices better express specializations than raw figures and percentages. They also facilitate cross-country comparisons while avoiding the bias of country-specific situations. The comparison of traffic and regional characteristics should answer the following hypotheses:

- H1: port traffic specialization and local economic specialization are somewhat interrelated;
- H2: the interdependence between traffic and local economy exists at different geographic levels;
- H3: common trends exist among advanced economies (ESPON, Japan, and NAFTA).

Testing such hypotheses necessitates a preliminary reflection about possible port-region linkages and their interpretation. The core of the problem is both spatial and functional. First, it is believed that a certain proportion of the activities generating port traffics is located in the same administrative unit than the port(s). It is impossible to evaluate this proportion so there might be important discrepancies in port-related linkages among the administrative units considered, especially when many port-related activities and port clients locate outside the administrative boundaries of the port region, or when the administrative unit is much larger than the actual port hinterland. Indeed, administrative units greatly vary in their geographic coverage, as rural areas are often larger than urban areas. Large ports located within such urban areas will thus be amputated in terms of hinterland coverage. This is particularly true for containers due to the inland shift of many logistics and distribution activities during the current "port regionalization phase" (Notteboom and Rodrigue, 2005). Nevertheless, it remains highly relevant to test the influence of large cities on traffic flows, because port-region linkages are not only about physical transfers but also refer to immaterial interdependencies, such as within the tertiary sector. Second, we expect that certain types of traffics will have some affinity with certain types of regions and economic sectors. The observed linkages will be considered relevant depending on the closeness of traffics and economic sectors. For instance, it can be expected that agricultural products will concentrate dominantly at regions where the primary sector is highly represented, while raw materials such as bulks may be more strongly linked with the industry sector. Containers, by their likely content (i.e. consumer goods), are better related with the manufacturing sector, but by their shipment mode, they also belong to the tertiary sector through the transport and logistics business. Another aspect is the directionality of flows and the stage in the value chain. The same commodities may have been either produced, consumed, or re-exported depending on the location where they are shipped, but this is not specified in port statistics. This raises important issues about the possible correspondence between material flows and local economies. For instance, raw materials relate with the primary sector when they are exported, but are closer to the industrial sector when they are imported and transformed. The impossibility knowing the proportion of import and export per commodity obliges using aggregated figures. The directionality of port traffic flows is only available for total traffic (i.e. inbound vs. outbound).

Despite such difficulties, it remains highly relevant to test the existence and nature of port-region linkages, notably within two drastically different contexts, namely Europe and Japan. These three main economic poles of the northern hemisphere are known to exhibit very distinct spatial patterns in terms of their respective economic geography and hinterland configurations (Ducruet, 2006; Lee et al., 2008; Rodrigue and Notteboom, 2010). While

Europe is better defined by the continental dimension of its transport systems, Japan has its main cities (markets) on the coast. Such configurations give more or less importance to inland logistics and hinterland accessibility. Even within Europe, there are noticeable differences in terms of hinterland configurations, notably between North and South as a reflection of differentials in development levels, historical backgrounds, and physical factors (Ducruet et al., 2010). We hypothesize that despite such differences, some invariants in port-region linkages might appear among those three areas. This argument is motivated by the path-dependency and co-evolution of local economic structure and port specialization. Although certain port hinterlands have expanded beyond the needs of the adjacent economy, the latter still has some influence on the distribution and nature of current freight flows. For instance, many large container ports are or have been large industrial ports, and the introduction of containerisation has not deleted the existing industrial base, even in a context of de-industrialization. The cost of building new port infrastructure and the economic advantages of agglomeration economies made that different development stages and innovation cycles are mixed and overlapping at certain locations. The difficulty of the proposed analysis is thus to identify the spatial fix in spite of numerous space-time distortions.

Data on port traffic was obtained from Eurostat for Europe and from the JETRO for Japan. Regional data was obtained from Eurostat for Europe and from JETRO for Japan. The administrative levels retained for the comparison are NUTS-2 for Europe (114 entities) and TL3 for Japan (43 entities). Based on such data transformed into indices, we run a Principal Components Analysis (PCA) in order to verify the statistical affinity among traffic and regional variables. Additionally, we look at the individual scores of regions on each principal component in order to appreciate the spatial distribution of the results.

Main results on the ESPON space

Core variables on employment and commodity traffics are kept "active" while additional variables remain passive, i.e. they do not influence the formation of factors but we can interpret what would have been their role in the formation of factors if they were included as active variables. Six regional variables and eight traffic variables thus base the main results showed in next table. The percentage of total variance reaches only 67% with the sixth factor, which means that due to low linear correlations among core variables, it is difficult to find high significant trends across Europe. Nevertheless, it is possible to comment the main factors based on the hypothesis that traffic specialization and regional specialization are somewhat interrelated:

Factor 1 (17.6% of total variance):

- coincidence between traffic specialization in raw materials / solid bulks and regional specialization in the primary, industry, and construction sectors. Although they are less significantly represented, chemicals traffics as well as traffic friction lean towards this group of variables. This is a very logical association since raw materials are mostly consumed and produced by those economic sectors, including transformation activities;
- coincidence between traffic specialization in higher valued goods (containers, vehicles), passengers, and regional specialization in the financial, retail, and public service sectors. Passive variables participating to this trend are regional GDP, population density, commodity diversity, and traffic size. To some extent, this is also a very logical association: higher valued, larger, and more diversified traffics concentrate at tertiary and trading regions, which are richer and more densely populated.

Factor 2 (14% of total variance):

- coincidence between traffic specialization in passengers and trucks (i.e. ferry, ro-ro) and regional specialization in the construction and primary sector. Retail and public service sectors lean towards this group of variables, as well as two passive variables, unemployment and traffic diversity. This association can be interpreted as matching port cities handling mostly local (intra-EU) passenger traffic rather than freight, without offering specific port-related activities locally due to the relatively lower importance of the industrial sector.
- coincidence between traffic specialization in metals and regional specialization in the industry and financial sectors. Extra-EU traffic, regional GDP, and population density (passive variables) also belong to this trend. In contrast with the previous trend on Factor 2, such profile seems to correspond to international regions having a strong industrial base and handling general cargo traffics connecting distant markets.

Variables / Factors		1	2	3	4	5	6
	Eigenvalues	2.5	2.0	1.5	1.3	1.2	1.1
	Variance (%)	17.6	14.0	10.5	9.0	8.3	7.8
	Cumulated variance (%)	17.6	31.6	42.1	51.1	59.4	67.1
Active variables	Primary sector	-0,65	-0,30	0,25	-0,12	0,15	-0,08
	Industry sector	-0,50	0,59	0,13	-0,18	-0,05	-0,23
	Construction sector	-0,35	-0,77	0,03	-0,16	-0,02	0,24
	Retail sector	0,42	-0,19	-0,29	-0,48	-0,14	0,38
	Financial sector	0,71	0,38	-0,23	0,17	0,12	-0,02
	Public services sector	0,41	-0,24	0,04	0,57	0,04	0,35
	Agricultural traffic	-0,38	0,06	-0,03	0,43	0,47	0,20
	Chemicals traffic	-0,19	0,22	-0,04	-0,29	-0,02	0,67
	Combustibles traffic	0,03	0,23	-0,01	0,01	-0,75	-0,02
	Oil & gas traffic	0,23	0,15	0,89	-0,01	-0,04	0,16
	Metals traffic	-0,33	0,35	-0,39	-0,25	0,25	0,10
	Manufactured goods traffic	0,44	0,12	-0,12	-0,33	0,43	-0,17
	Minerals traffic	-0,47	0,03	-0,52	0,39	-0,27	0,02
	Passengers & trucks traffic	0,25	-0,66	-0,16	-0,11	-0,03	-0,38
Passive variables	Unemployment	0,15	-0,35	-0,03	0,13	0,04	0,27
	Regional GDP	0,43	0,40	-0,22	0,19	0,05	-0,14
	Population density	0,48	0,27	-0,13	0,15	0,14	-0,12
	Commodity diversity	0,29	-0,40	-0,11	-0,09	-0,04	-0,32
	Traffic size	0,33	0,13	0,17	-0,13	0,03	0,02
	Inbound traffic	0,14	0,04	0,00	-0,05	-0,12	0,07
	Traffic friction	-0,10	0,16	0,62	0,03	-0,19	0,19
	Extra-EU traffic	0,14	0,41	0,28	-0,20	-0,12	0,07

Correlations between variables and main components in the ESPON PCA

Factor 3 (10.5% of total variance):

- coincidence between traffic specialization in oil and gas products and regional specialization in the primary sector (followed by industry). Among passive variables, traffic friction and extra-EU traffic are well represented in this group, followed by traffic size. Such trend may correspond to a profile of industrial cluster importing energy traffics from outside Europe for local transformation and redistribution. This is typically the role of large maritime Industrial Development areas (MIDAs) that emerged in the 1960s around most large European ports;
- coincidence between traffic specialization in metals, minerals, and regional specialization in the retail (and also financial) sector. Passengers traffic and manufactured goods (active variables) as well as regional GDP and population density (passive variables) lean towards this trend.

Trends / Factors	1		2		3	
Trend A	UKM5	North Eastern Scotland	FR83	Corse	DEA1	Düsseldorf
	UKF3	Lincolnshire	DE80	Mecklenburg-Vorpommern	GR42	Notio Aigaio
	GR24	Sterea Ellada	GR21	Ipeiros	UKF1	Derbyshire and Nottinghamshire
	BG33	Severoiztochen	GR22	Ionia Nisia	PT17	Lisboa
	BG34	Yugoiztochen	GR23	Dytiki Ellada	GR22	Ionia Nisia
	SE21	Småland med öarna	IE01	Border, Midland and Western	NL12	Friesland (NL)
	PT16	Centro (P)	FR25	Basse-Normandie	UKJ2	Surrey, East and West Sussex
	NL12	Friesland (NL)	UKN0	Northern Ireland	DE50	Bremen
	GR14	Thessalia	ITF6	Calabria	DE93	Lüneburg
	FR53	Poitou-Charentes	ITG2	Sardegna	NO07	Nord-Norge
Trend B	ITF6	Calabria	UKD3	Greater Manchester	NO05	Vestlandet
	GR30	Attiki	UKF1	Derbyshire and Nottinghamshire	DE94	Weser-Ems
	DK01	Hovedstaden	ITD3	Veneto	PT18	Alentejo
	DE50	Bremen	ITD5	Emilia-Romagna	ES62	Región de Murcia
	ITE4	Lazio	ES51	Cataluña	UKL1	West Wales and The Valleys
	ITC3	Liguria	NL41	Noord-Brabant	UKM2	Eastern Scotland
	SE11	Stockholm	UKM5	North Eastern Scotland	BG34	Yugoiztochen
	UKI1	Inner London	UKI1	Inner London	ITG1	Sicilia
	NO01	Oslo og Akershus	DEA1	Düsseldorf	UKM6	Highlands and Islands
	PT17	Lisboa	ES21	País Vasco	GR25	Peloponnisos

Position of ESPON regions on the main factors

In terms of specific regions, only the ten most representative ones have been kept in the table. We see on Factor 1 that the most dynamic profile (i.e. financial sector, richer, larger and more valued traffics, more densely populated) corresponds to a number of large coastal cities having kept dynamic port functions (Lisbon, Oslo, London, Stockholm, Genoa, Rome-Civitavecchia, Bremen, Copenhagen, and Athens-Piraeus). Such regions are thus mostly tertiary locations concentrating advanced producer services but at the same time, handling a variety of cargoes of which the most valued (finished goods). The opposite profile on Factor 1 corresponds to regions remotely located within Europe and also within their country, with smaller populations and smaller traffics. These regions are thus mostly agricultural and handle a majority of raw materials.

On Factor 2, there are many island regions relying on ferry and ro-ro traffic as well as the construction sector, which would indicate the importance of tourism functions, notably in the south. Other regions are more industrial and handle metals, showing a profile of "steel industry" as reflected in the importance of Dusseldorf, Amsterdam, Greater Manchester, and Scotland, i.e. traditional regions in this sector. Tourism is thus opposed to steel industries on Factor 2. Lastly, Factor 3 groups regions having a dominant function of liquid bulk imports and/or extraction, opposed to a majority of northern regions focusing on the trading of raw (solid) materials, recalling the tradition of the Hanseatic League in medieval and modern times.

Main results on Japan

For Japan, all variables have been kept active because it is one single country so that there are less variations and discrepancies than across Europe. In many ways, we found similar associations of variables than in Europe, with the difference that the first factors concentrate much more variance due to more significant correlations among variables.

Factor 1 (29% of total variance):

- coincidence between traffic specialization in manufactured goods, chemicals and regional specialization in the financial, retail, and public service sector. Other influent variables for traffics are traffic size, commodity diversity, and international traffic, and for regions demographic size, population density, and regional GDP. Just like in Europe, large, higher valued, and international traffics tend to concentrate at richer and more densely populated regions. It is exactly the same trend, with the difference that it has less statistical significance in Europe than in Japan, probably due to the wider diversity of local and national situations in Europe.
- coincidence between traffic specialization in combustibles (and to a lesser extent minerals and agricultural products) and regional specialization in the primary and construction sectors. Traffic friction also contributes heavily to this trend, meaning that traffics handled in such regions are more likely to be consumed / transformed locally. Once again, this trend is very much similar to the one found in Europe, with the important exception that in Japan, the industrial sector is not influent on factor 1.

Factor 2 (18% of total variance):

- coincidence between traffic specialization in combustibles, chemicals, oil and gas, and regional specialization in the industry sector. Other influential variables are inbound traffic, international traffic, and traffic friction as well as regional GDP. This profile typically echoes the large MIDAs in Japan developed in the 1960s in the form of port industrial clusters transforming the imported petro-chemical products;
- coincidence between traffic specialization in minerals, passengers (and to a lesser extent metals) and regional specialization in the public service, retail, and primary sectors. Another influential variable is unemployment. Perhaps those are regions handling mostly coastwise traffics without specific port-related industries in the vicinity. This opposition also echoes Factor 2 in Europe that is based on similar groupings.

Variables / Factors	1	2	3	4	5	6
Eigenvalues	6.6	4.1	2.1	2.0	1.5	1.4
Variance (%)	28.8	17.9	9.2	8.9	6.6	6.1
Cumulated variance (%)	28.8	46.7	55.9	64.8	71.4	77.5
Traffic size	0.627	-0.006	0.269	-0.478	-0.096	-0.054
Combustibles traffic	-0.294	0.454	0.239	0.330	-0.567	-0.306
Minerals traffic	-0.180	-0.385	-0.606	-0.231	-0.454	0.212
Manufactured goods traffic	0.849	0.073	-0.210	0.240	0.094	0.088
Agricultural traffic	-0.170	0.114	-0.248	0.267	0.500	0.643
Chemicals traffic	0.335	0.355	-0.030	-0.424	0.338	-0.171
Oil & gas traffic	-0.073	0.447	0.499	-0.089	0.164	0.348
Metals traffic	0.215	0.178	-0.031	-0.607	-0.223	0.301
Passengers & trucks traffic	-0.110	-0.558	0.165	0.057	0.507	-0.563
Inbound traffic	-0.128	0.480	0.239	0.601	0.128	0.183
International traffic	0.248	0.819	0.140	0.133	-0.322	0.141
Commodity diversity	0.253	-0.101	0.401	-0.420	0.176	0.207
Traffic friction	-0.594	0.387	0.578	0.076	0.000	-0.030
Demographic size	0.951	0.038	-0.010	0.029	-0.011	-0.013
Population density	0.889	0.029	-0.076	0.219	0.049	-0.003
Unemployment	0.068	-0.689	0.399	0.048	0.029	0.285
Regional GDP	0.697	0.362	-0.319	0.166	0.176	-0.186
Primary sector	-0.787	-0.303	-0.276	0.093	0.028	0.143
Industry sector	-0.037	0.843	-0.162	-0.311	0.176	-0.154
Construction sector	-0.671	-0.227	0.191	-0.053	0.017	-0.083
Retail sector	0.577	-0.492	0.468	-0.114	-0.147	0.071
Financial sector	0.917	-0.118	0.061	0.240	-0.069	-0.011
Public services sector	0.510	-0.553	0.174	0.383	-0.193	0.073

Correlations between variables and main components in the JAPAN PCA

Factor 3 (9% of total variance):

- coincidence between traffic specialization in minerals, agricultural products (and also manufactured goods) and regional specialization in the primary sector. Those are also richer regions with a noticeable concentration of employment in the industry sector. To some extent, it echoes the profile on Factor 1 for Europe;

- coincidence between traffic specialization in oil and gas (as well as combustibles) and regional specialization in the retail sector. Those regions are also marked by higher unemployment levels and larger, more diversified and more locally consumed traffics.

Trends / Factors	1	2	3
Trend A	Shimane	Kochi	Kochi
	Yamagata	Okinawa	Tokyo
	Akita	Aomori	Iwate
	Iwate	Hokkaido	Saga
	Aomori	Fukuoka	Shizuoka
	Kagoshima	Miyazaki	Miyazaki
	Tottori	Miyagi	Oita
	Fukushima	Ehime	Tottori
	Miyazaki	Kumamoto	Aichi
	Nagasaki	Kagawa	Kumamoto
Trend B	Kyoto	Shimane	Akita
	Shizuoka	Tottori	Fukushima
	Hokkaido	Ibaragi	Kagawa
	Chiba	Yamagata	Nagasaki
	Fukuoka	Fukushima	Osaka
	Hyogo	Shizuoka	Miyagi
	Aichi	Ishikawa	Chiba
	Kanagawa	Aichi	Hokkaido
	Osaka	Toyama	Kagoshima
	Tokyo	Mie	Okinawa

Position of JAPAN regions on the main factors

The position of Japanese regions on Factor 1 provides a clear opposition between the largest cities of the megalopolis (Tokyo-Yokohama, Nagoya, and Osaka-Kobe) and less urbanized, remotely located regions in the northern and western parts of the country. Factor 2 also has a relatively clear geographic logic, with central Japan (trend B) opposed to northern and western Japan (trend A). The latter regions thus make more use of coastwise traffic (ferry, ro-ro) due to the distance to/from core economic regions, and as a result of a national policy supporting environmental-friendly transportation within Japan (modal shift from road to sea). Factor 3 has lesser geographic rationale, as port-industrial clusters locate all over the country (e.g. Fukushima) and the opposite profile mixes both large cities and rural regions.

SYNTHESIS, CONCLUSIONS, AND RECOMMENDATIONS

This analysis of global maritime flows has provided a number of new evidences about the position of European ports and of Europe as a whole compared with other ports in other world regions, as well as about the external influence of Europe in the world through the vector of shipping. We summarize below our main findings and propose some cross-sectional conclusions that serve the formulation of some policy recommendations.

Port traffic evolution and concentration dynamics

- ESPON as a whole has experienced a similar evolution than NAFTA (decline of its relative weight in world traffics) due to the rapid growth of other regions through catching-up container dynamics, as well as a continuous increase of port traffic concentration internally. This stands in contrast with ASEAN+3 where traffic concentration occurred in parallel with a rapid and regular increase of its relative weight in world totals;
- according to port system evolution models, reaching high concentration levels provide a chance for secondary ports to catch traffic from congested load centres, so there is a need to verify whether the Motorways of the Sea strategy will fulfil this objective to make the European port system less concentrated, while carefully checking whether greater port concentration always means greater port competitiveness, and whether de-concentrating the port system (and in which ways) would benefit both larger and smaller ports.

Position of the ESPON space in global shipping flows

- Europe still nowadays enjoys a very central position in worldwide maritime flows, as seen with the "dependence" of many sub-regions on ESPON traffics. However there is a clear shift towards Asia-centred patterns of container flows between 1996 and 2006, and a reduction of strongest ties except with adjacent partner regions such as North Africa and Eastern Europe. Thus, there is a risk to see Europe becoming a simple "satellite" of Asia, among others, rather than a dominant pole in the world system;
- ESPON as a whole does not make much sense in the daily reality of shipping flows, but there are certainly ways for taking advantage of having a strongly connected

vicinity. Although North-South flows between Europe and Africa remain largely polarized by Western Europe, they can be the basis of stronger cooperation in the field of port and terminal operations as well as route rationalization. This idea anticipates the next analysis where Europe's profile appears often fragmented among scattered and small subgroups of ports, thereby crying out for an engagement in the harmonisation of the maritime space, notably in the Euro-Mediterranean area.

Single linkage analysis, nodal regions, and dominant ports

- Most of these analyses point at the fragmentation of Europe amongst relatively small and scattered "nodal regions" compared with the dominant Asian region and with other maritime ranges showing more spatial continuity. Although result vary throughout the years and according to specific commodity groups, they somewhat reflect several key factors such as the strong continental character of Europe (i.e. importance of landward connectivity, hinterlands, inland cities that are not included in the analysis), its morphology that influences vessel circulations (peninsula), and results in a variety and multiplicity of circulation patterns, with northern ports and southern ports belonging to distinct groupings. Another possible factor behind the results is the maintained mosaic of trade orientations among European countries and regions, but this factor could not account for the comparatively less integrated Asian region, which appears much more homogenous. This has a lot to do with the fact that Asia is using dominantly maritime transport while in Europe, land-based transport is vital and the implementation of short-sea shipping policies remains rather limited. Rotterdam appears as the pivotal hub for many commodities as it extends its influence towards a majority of northern European ports: this directly reflects its dual role as both maritime hub and load centre (continental gateway).
- The extent to which such fragmentation is a strength or a weakness compared with other regions remains to be demonstrated. Yet, one may argue that European ports may extend their influence in the global network based on further impetus given to the maritime and ports sector, not only within Europe itself but in relation with nearby partners as mentioned earlier. An "extended maritime policy" may well reduce the overwhelming influence of Asia and the fragmentation of Europe. Such policies, however, depend on macroscopic factors such as production location and trade routes, as well as on the established trucking industry, but there is room for rethinking the role

of sea transport in European economic development beyond sole demand-driven arguments. In particular, the further development of intra-European liner services could strengthen European integration and limit environmental impacts, as well as land-based detours caused by over-concentration at large hub ports: 40% of French exports still shift towards external ports such as Antwerp and the Benelux instead of passing through Le Havre or Marseilles.

Weight and share of ESPON-related shipping flows at external ports

- Most of the results confirm the high concentration of Europe-related flows in the vicinity, notably along North and West African coasts, as well as in Eastern Europe (Russia, Ukraine, Georgia). Such patterns are not unique to maritime flows, but they point at the necessity considering such vicinities as de facto integral parts of the European space of flows. Although many of these flows are in fact unidirectional (e.g. energy exports from Maghreb ports to Western Europe) and reflect more post-colonial linkages than real integration processes, they are important in the framework of a possible common maritime policy. Already several Maghreb ports are included in the MEDA-MOS project (e.g. Bejaia) following a port reform and concessions in Algeria established in recent years, while some European large port operators invest at Tangier Med among other Mediterranean transshipment hubs. However, the Maghreb itself, which foreign trade occurs dominantly by sea (95%), remains poorly integrated internally and follows a competition strategy whereby each country develops its own hub port (Tangier, Djen Djen, Enfidha), which in turns weakens integration opportunities and reinforces the fragmentation of flows.
- Possible recommendations based on the weight and share of Europe in world maritime flows can also focus on world regions where Europe is still badly influential and almost absent for certain commodity types, such as Latin America, South and East Africa, and Oceania, which are more polarized by NAFTA and ASEAN+3 regions respectively. This has a lot to do with the establishment of preferential trading links with those regions (agreements).

Geographic specialization of ESPON ports' maritime forelands

- The internal diversity of European ports' maritime forelands is somewhat blurred in the results of the classification, due to the strong influence of East Asian flows. Only secondary ports show some "preference" for other regions (e.g. Africa, North America, Latin America) and this tends to disappear over time due to the continued expansion of Asian influences, especially in the container business. When all commodities are included in the analysis, the diversity is more visible, with northern ports turned towards North America, and southern ports turned towards Africa and/or Latin America. This simplified picture of the reality suggests that all large European port cities are specialized in East Asian trades;
- It seems difficult to influence the distribution of forelands for ports as the main agents of change are macro factors and the decision factors of shipping lines. The distribution of forelands simply reflect preferential trading relations with the rest of the world, in this case pointing as a rather monopolistic influence (East Asia) for containers and a more balanced picture on the basis of all commodities. A comparison with more years (e.g. 1970s, 1980s, and 2010s) as well as on the basis of more precise world regions (e.g. maritime ranges instead of large "blocks") would help further understanding the exact influence of Asian trades and the permanency of other trading links despite the growing Asian influence.

Centrality and attractiveness of ESPON ports in global maritime flows

- In many analyses over time and across commodity types, Rotterdam appears as the most central port either in the world or in Europe. We identified a recurrent higher centrality of northern ports in the global network compared with southern ports, which remain bound to more localized traffics despite their comparable performance in terms of total tonnage. Thus, many ports handle large tonnages but are not well positioned in the network. In addition, the number of links (K) to other ports does not always reflect upon the true centrality (BC) on the level of the entire network(s);
- Further research on such issues of centrality should motivate decision-makers in launching European-wide studies of multimodal accessibility of European cities on a global level, taking into account not only separated air or maritime flows but also the position of cities in land-based networks. Because many of the most central ports are also important load centres and continental gateways, there are ways to improve the

analysis towards more complete measures of centrality and accessibility in multimodal transport systems.

Territorial linkages of port traffic specialization

- The last analysis clearly confirmed the very logical association between types of traffics and types of regional economies in Europe and Japan, which share very similar trends of port-region functional linkages. Although an additional analysis on NAFTA port regions is ongoing and could not be made ready for the final report due to data issues, it will be interesting to push further the comparison of such trends. The nature of port-region linkages thus differs across regions and traffic specialization is largely influenced by local demand. It also confirmed that major port cities have the most dynamic profile compared with rural and remotely located areas;
- In terms of recommendation, the fact that not in volumes but in shares, port traffics keep very strong associations with regional (local, coastal) economies in Europe (and this is confirmed by the Japanese case) despite the evolution of logistics chains and hinterlands, strongly cries out for an engagement in further analyses of port clusters in Europe. The strong influence of local economies on the nature and structure of port traffics means that ports remain essential to economic life, and this can base further opportunities for economic development within and between regions. In addition, the analysis can be made at a thinner level (NUTS-3 in Europe) so as to verify more in-depth the nature of port-region linkages, so as to identify specific value chains and niches where the role of ports is vital. A very important option for Europe would be to determine based on such analyses where and how are port activities more important than other activities in supporting local economic life and regional competitiveness. Yet, the low but visible association of economic success and traffic dynamist with unemployment concentration also points at important socio-economical effects that should also be taken into consideration in the attempt replicating success stories from one city to another.

LIST OF REFERENCES