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Inland accessibility and foreland specialization of European regions

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Abstract

This paper investigates the relationship between containerized transport supply, measured by the number of weekly services, and inland accessibility at the level of European NUTS3 regions. It employs AIS tracking data to estimate the number of maritime services to main overseas markets, and OLS regression analysis to investigate its relationship with inland accessibility. The results show that the frequency of maritime services with East and South Asian forelands are generally more linked with the inland accessibility than the rest of overseas markets. An important part of the variations, which are not related to inland accessibility, is attributable to transshipment strategies of shipping companies, economic niches of peripheral regions, and to competition with other modes of transport.

Keywords: *foreland, AIS data, inland accessibility, hinterland, OLS regression.*

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Abstract

This paper investigates the relationship between containerized transport supply, measured by the number of weekly services, and inland accessibility at the level of European NUTS3 regions. It employs AIS tracking data to estimate the number of maritime services to main overseas markets, and OLS regression analysis to investigate its relationship with inland accessibility. The results show that the frequency of maritime services with East and South Asian forelands are generally more linked with the inland accessibility than the rest of overseas markets. An important part of the variations, which are not related to inland accessibility, is attributable to transshipment strategies of shipping companies, economic niches of peripheral regions, and to competition with other modes of transport.

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1. Introduction and theoretical background

The heterogeneity of maritime transport supply in regions can be understood as the visible manifestation of two complementary dynamics. On the one hand, there are factors related to demand such as the size of the local market made up of economic activities and population. On the other hand, there are a series of dynamics resulting from strategies pursued by transport companies, which are obviously related to the former but to other structural factors of the foreland as well (i.e. organization of their own transport network). These two dimensions, which are necessary conditions for the success of (maritime) transport terminals, have been conceptualized as centrality and intermediacy. Both are necessary for the success of transport hubs, but their combination can vary considerably from one case to another Fleming and Hayuth (1994). Within the context of containerized transport, a high share of transshipment characterizes pure hubs, when intermediacy within the shipping network is the main advantage. On the contrary, gateway ports, where the transshipment rate is lower, are rather characterized by their centrality, namely the geographical proximity vis-à-vis inland markets. It should be however noted that gateways can hardly be “pure” since their large local markets greatly contribute to enhance their intermediacy both within inland and maritime networks, making them attractive locations for transshipment activities as well. In the academic literature of port studies, this issue is not new. A similar debate took place in the aftermath of World War II, on the relative importance of maritime and land-based factors on

the success of ports. Amphoux (1949, 1951) and Weigend (1956) emphasized the prominence of maritime-related factors on the cargo-generating potentials of Le Havre and Hamburg. The success of both ports was not unrelated to the strength of their locally-based shipping companies and, more broadly, to the trade policies implemented by France and Germany. By contrast, the fates of other ports within the Northern Range, such as Antwerp and Rotterdam, seemed to be much more related to inland factors such as the historical know-how of their local merchants and traders and the high density of shippers in their hinterlands, spreading far beyond national borders (Boerman, 1951). This academic debate was later relativized by those who considered ports as broader systems in which inland, maritime and port-related elements were interrelated but not necessarily in the same proportions (Vigarié, 1964, Robinson, 1970). In the recent decades, the further integration of transport modes allowed by containerization has somewhat blurred the lines between land and sea related factors within the context of a global intermodal transport system. To secure a good access to the hinterlands, containerized shipping lines have been increasingly involved in inland transport, often by investing in deep-sea terminals and sometimes by providing inland transport services (Franc and Van der Horst, 2009). Other intermediaries such as freight forwarders have supported this integration as well, by providing integrated door-to-door services (Ducruet and Van der Horst, 2009).

Few works have succeeded to empirically measure the relationship between centrality and intermediacy, mainly because of the lack of data. One of them showed that the rate of transshipment of container ports in the Mediterranean mainly depends on the throughput and on the deviation from the main Europe-Asia maritime route (Zohill and Prijon, 1999). Today, when containerization seems to have reached its stage of maturity (Guerrero and Rodrigue, 2014) the main challenge for a container port is not just to cumulate high levels of centrality and intermediacy regarding inland markets and shipping networks, but also to maintain and improve their position within value chains (Robinson, 2002). To support the adherence of the local people and economic actors to port expansion projects, ports are also expected to attract activities and jobs related to the maritime flows within the context of international supply chains (Hall and Jacobs, 2010). The existence of frequent services with a wide range of overseas regions port could allow an efficient integration of its inland customers in global production systems. But port performance issues are rarely considered from the point of view of the shippers (inland customers) for whom the frequency of services and their geographical variety are central.

The purpose of this paper is to help to fill this void by a systematic analysis of the contribution of inland potential demand, measured by accessibility to population, to the concentration of container services in Europe by taking in account the diversity of overseas regions involved in maritime trade. While we show that inland accessibility well reflects the

geographical concentration of services, we also identify other factors as well. Indeed, we attempt to understand why in some regions the maritime transport supply seems to be less linked than we might expect from its inland market potential. The segmentation of maritime transport supply by overseas regions could deliver some explanation about these deviations.

The rest of this paper is structured as follows. Section 2 presents data and method, which are applied in Section 3 to describe and understand the relationship between maritime services and inland accessibility. We conclude in section 4.

2. Data and method

2.1 Data: database on maritime transport supply

This research was carried out using a set of Automatic Information System (AIS) positions, in order to count the number of containerized services to/from each European NUTS3 region. The implementation of this new tracer technology in the ship's bridge begins with the IMO A.917 (22) resolution (Harati-Mokhtari et al., 2007) and it is currently compulsory for all vessels over 300 GT's, which report call, departure and vessel data to the port authorities by mean of this devices. This database has been used by many authors to describe maritime transport trade networks for several different classes of vessel (Kaluza and Kölzsch, 2010).

A sample of vessel paths was built with the following criteria: (a) not to consider containerships with less than 1000 TEUs to eliminate short range navigation activity noise; (b) consider vessels built before 2007, in order to obtain an equilibrated amount of AIS positions stored per ship; (c) eliminate anchorage, strait or canal positions; and (d) prioritize for the final sample vessels that perform inter-continental activity. This selection procedure guarantees, as a corollary, that at least the most important ports (AIS call – berthing – positions) will be taken into account.

The analysis was conducted by splitting each vessel class sample into two years: 2009 and 2010 AIS positions. So for each year, the sequence of vessel calls defines subsequently another sequence of port of departure-port of arrival pairs. Hence, it can be built, using a programming language with vector calculus features (postgresql), a structure of nodes and edges that will allow performing calculus of complex network parameters over this general cargo and containership AIS sets.

An additional layer of meaning was added to the entire set of worldwide call positions, in order to differentiate world trade areas. The division considered can be seen in [figure 1](#), and is roughly based on the geographical regions considered by containerized shipping companies. The final sample composition and its main network features can be seen in [Table 1](#). According to total world fleet supply estimated by UNCTAD (Wilmsmeier and Hoffmann, 2008), database used covers approximately 80% of containership existing fleet. It can be seen a

growth in vessels analyzed from 2009 to 2010, with the correspondent increases in total AIS positions.

[Please insert figure 1 and table 1 about here]

A very important difference can be seen in the number of different ports considered for containerhips. It decreases for containerhip sample (from 749 in 2009 to 527 in 2010). There are some quantitative approximations, made using complex networks measuring methodologies (Gonzalez-Laxe et al., 2012) explaining part of this behaviour as an outcome of the demand crisis happened in 2008, which caused a severe impact in main containerized lines, having effects in the mean connectivity of world gateways, and causing a conjunctural concentration during 2009-2010 of all the remaining active supply lines in less containerized terminals.

2.2 Data: NUTS-3 aggregation of maritime data

Starting from the 2010 version of NUTS3 available at Eurostat, a bijective identification between administrative coastal units and ports has been performed in order to proceed to the analysis: the maximum throughput of all the ports belonging to a NUTS3 unit, has been considered as a proxy of the throughput of the entire NUTS3 region (feasible given the statistical properties of the maximum estimator). Figure 2 is illustrative of how it was made the first step of this attempt to identify ports with those geographical units. Using GIS software it can be seen the superposition between ports and regions along the English Channel. For example in FR232 we can see port complex of Le Havre (633), Antifer (589) and Dieppe (5061). This fact suggest the following identification criteria: the port with maximum throughput in the considered period is the representative of its native NUTS 3, in case of NUTS 3, FR232 region, called Seine-Maritime, will be identified with all network parameters of Le Havre. The size of NUTS 3 appears to be adequate to perform the identification between hinterland parameters and port connectivity as it will be shown in this paper.

Thus, by this method, each NUTS 3 coastal region is associated with the structure of the foreland (network and performance parameters) of its most representative port, and in particular with a unique value of this port's throughput. In a second stage, by postgresQL programming tasks, the total throughput for each geographical unit will be divided according to the share TEUs moved towards (or coming from) each world partition, taking this parameter as a proxy of the partitioned foreland. This last algorithm will allow obtaining an index of trade importance of each world region with each NUTS 3 unit. Tables 2 and 3 present the data on the maritime services aggregated by their level of accessibility and their volume.

[Please insert figure 2 and tables 2 and 3 about here]

2.3 Data: road accessibility to population

When studying the links between maritime activity and accessibility to inland markets, the question of the delineation of the hinterlands of the ports is a difficult issue. Even when taking in account large spatial units (i.e. countries, Nuts-2 regions) some large seaports influence the size and shape of hinterlands. Reviewing the recent literature, Chapelon (2006) propose a first measure of the economic potential of the port cities on the basis of the accessibility parameters, not considering the activity of the ports but just the hinterland influence. Later, Guerrero (2014) and Notteboom (2010) show that the size of hinterlands varies a lot from one port to another, particularly in relation to their volume, the nature of cargo handled, and the distance towards clients and competing ports. Unfortunately, empirical evidence on the actual hinterlands is only available through enquiries that do not exist on comprehensive, Europe-wide basis. For these reasons we have decided to use an indicator of accessibility to population, knowing that it is an imperfect proxy of the actual hinterlands.

Practically, we use a measure of accessibility implemented by S&W for the European Spatial Planning Observatory Network (Spiekermann and Schurmann, 2007, Espon, 2009). This indicator is based on two elements: (1) population in NUTS 3 regions and (2) the effort in time to reach them by road, which is the largely dominant mode of pre and post maritime carriage. The accessibility model measures the minimum time between all NUTS 3 regions by road. The potential accessibility of a NUTS 3 region is calculated by summing up the population in all other European regions, weighted by the transport time to reach them. Compared to the mere consideration of the potential of the region where the port is located, this method allows to take in account the potential of every region, in particular those that are close to the port.

3. Results

3.1. Network vs hinterland differentiation

To evaluate the respective importance of the parameters of hinterland access and maritime connectivity, the variables road access and volume, which are highly correlated, have been converted by Principal Component Analysis into two uncorrelated variables (figures 4 and 5). The first component, associated with the volume and hinterland potential, accounts for 68.5% of the total variance, and has been considered as an indicator of centrality. The second component, explaining the rest of the variance (31.5%), is considered to be a proxy of the intermediacy of the regions within the maritime network. Using the coordinates of the two factors, ports have been aggregated in clusters with Agglomerative Hierarchical Clustering. Five categories of ports are distinguished on the basis of their centrality and intermediacy. “Pure” Mediterranean hubs such Algeciras, Gioia Tauro and Marsaxlokk, with large volumes

and low or almost inexistent hinterland, are clustered in a same subgroup together with Piraeus and Limassol. Unsurprisingly, the largest European gateways such Rotterdam, Antwerp and Hamburg are characterized by high levels of centrality and intermediacy.

[Please insert figures 4 and 5 about here]

To provide a description of the foreland orientation of ports, a second Principal Component Analysis has been done on the table of percentages of ports with each of the 12 overseas regions, weighted by the volume (figures 6 and 7). The two main factors represent 51% of the foreland variability of ports. The first one, explaining 29% of the variations is strongly correlated to the shares of Asian and West African forelands which are generally opposed. The second factor, explaining 22% of the variability of foreland orientation of ports, is defined by the opposition between European and North African forelands against American ones. Ports have been aggregated in seven categories. This time, an unequal orientation to African and Asian forelands spreads them in three different categories.

[Please insert figures 6 and 7 about here]

3.2. Does inland accessibility provide a good estimation of port volume?

To explain the geography of European supply of container transport, we simply assessed the linear correlations between transport supply and road accessibility to population at the NUTS 3 level (table 4). The correlation is significant ($R^2=.33$), which means that 33% of container supply differences between NUTS 3 regions are described by the road accessibility to population. This is partly due to the importance of the container supply of Northern Range ports that are close to the economic core of Europe, where most of population and wealth is concentrated. However, several other factors, like the strategies of shipping lines (hub & spokes networks) and the proximity of certain European regions to main container routes also explain this geography. In order to distinguish the inland and maritime dimensions, a Principal Component Analysis has been applied to both variables.

According to the model, inland accessibility thus explain to a large extent the spatial variation in European shipping services. This type of analysis naturally raises, however, the question of the deviations from the predictions

The relationship is particularly strong with Asian forelands (Far East, South-East Asia) meaning that these regions are rather served by metropolitan ports located near large urban areas or heartland Europe. The relationship with West Africa is good as well, but in this case it is negatively correlated to accessibility, meaning that peripheral regions are more specialized than central ones. This is partly due to containerized cargo related to niche markets (i.e. counter-season fruits, timber, agricultural products) where peripheral ports far

from the European core are also important. In the particular case of France, the strong ties of secondary ports with West Africa are partly inherited from the colonial period.

[Please insert table 4 about here]

3.2. Results of the OLS Regression

For each geographical aggregate, an approximation of the foreland dependence with respect to the NUTS3 road accessibility parameter (ROAD_ACC) and the NUTS3 hierarchy in terms of shared-with-foreland supply lines (LogVOL), is built, by using an OLS approximation.

In order to improve the accuracy of this approach, two kind of models are computed for each foreland aggregate: one just with the two dependent variables (simple model); and another one (extended model) trying to catch up the effects of the specific features that each European macro-region (Island, Northern Range, Mediterranean, British Islands, Baltic Sea areas and Atlantic Arc) is able to induce, by adding them as a dummy_variable additional dependent regressor.

The results are expressed in the tables 5 and 6, with which several important outcomes can be highlighted:

- The 12 forelands are able to produce 10 meaningful relations, sometimes with the ROAD_ACC parameter acting as the main controller (case of West Africa and Oceania), in other cases with the LogVOL parameter as the key element to catch the meaning of the relationship analyzed (Caribbean, South America Pacific, Indian Ocean, South East Asia and Far East). In one case, for the simple model computed for Far East foreland, the two dependent variables ROAD_ACC and LogVOL do succeed in achieving joint significance (which should be the ideal model sought).
- The relations in which ROAD_ACC is the significant regressor are elusive, but if appearing, they could allow a highly suggestive set of possible interpretations:
 - For the influence of road access and volume of TEUs shared with West Africa, the extended model suggest that belonging to a peripheral EU region (coef=-0.001) improves the network influence with respect this foreland aggregate. Said in another words: for each additional unit of ROAD_ACC gained, 0.1% of influence units with respect West Africa foreland could be lost.

In this case, it must be noted the negative influence of the Atlantic Arc on the West Africa foreland (coef=-0.171), hence setting the European Mediterranean macro-region (West Med range) as the main service area for the containerized trade with West Africa, with important global hubs as Lagos (Nigeria), Abidjan (Iv. Coast), or Dakar (Senegal).

This coefficient also confirms that the remarkable box-transshipment activity of Sines (Portugal, Atlantic Arc) is still centered exclusively in the services to East Asia-Northern Range lines.

- o There's a slightly positive effect for the influence of Australasia foreland with respect being well located in terms of ROAD_ACC (coef=0.0002), which must be interpreted as a sign of the capacity for the best connected NUTS3 regions to establish containerized relations even with the farthest forelands.
- The relations in which LogVOL is the significant regressor appear more frequently:
 - o The Caribbean foreland do prefer European small-sized containerized terminals to perform trade operations (coef=-0.054), i.e., each additional TEU moved by a NUTS3 region with some Caribbean node, yields a penalty of $e1(-0.054)=-14.7\%$ units of influence with the box trade on this area.
 - o The South America Pacific, Indian Ocean, South East Asia and Far East still prefer the Northern Range European hubs to perform their containerized trade operations, with different significant intensities (coefficients of 0.069, 0.042, 0.069, 0.025, respectively).
- In the South America Atlantic model, there is an evidence of the high connectivity with respect to European Atlantic hubs that can be seen in the significant 0.118 coefficient.
- The case of the simple model for the Far East positions, without including the modulation coming from European macro-regions dummy-variables, allows a richer interpretation than in the extended case (although less powerful in terms of ROAD_ACC influence): a joint positive effect both of road connectivity and throughput capacity of the NUTS3 region can be detected by the common positive influence of the two regressors (0,0003 for ROAD_ACC and 0,028 for throughput). This higher correlation would result from two dynamics. On one hand, shipping lines may give priority to the gateways with fast and easy access to European heartland, in order to partly offset the length of the maritime voyage. On the other hand, the increasing size of container vessels on Europe-Asia trade also emphasizes the need for concentrating the calls on a few large ports in order to achieve economies of scale. Although Mediterranean hubs are used for serving Southern Europe and Africa, Northern Range gateways (Rotterdam, Antwerp, Hamburg) –located at the vicinity of Europe's heartland- are extensively used in the the trade with East Asia.

[Please insert tables 5 and 6 about here]

Figures 8 and 9 present the residuals of the simple model for South East Asia. The main overestimations (negative residuals) can be founded mostly in the core European regions with

high accessibility to markets but with a lower share of direct trade with South East-Asia, either because they are close powerful gateways (ex. Felixtowe in Southern England), or because their foreland mix is highly diversified. That is the case of the top-ranked Antwerp and Bremerhaven, where all forelands are well represented, particularly those of North America and Caribbean. The underestimations of the model (positive residuals) follow a more complex pattern, partly resulting from historical ties of ports resulting from colonial relationships of the countries (i.e. Southampton, Amsterdam) or from hubbing strategies of shipping companies (ie. CMA at Marsaxlokk and Evergreen at Taranto). We also see, in a lesser extent, excess supply in highly industrial peripheral regions such Bilbao and Gdansk.

[Please insert figures 6 and 7 about here]

4. Conclusions

This paper attempts to measure the linkage between maritime transport supply and inland accessibility in Europe, both for container and general cargo services. The results of this paper support the expectation that maritime transport supply is strongly dependent on the demographic size and economic potential of hinterlands. More specifically, the findings here suggest that inland accessibility to population explains at least the 33% of the geographic variations in the maritime transport supply for containers. Hence, it should be noted that the relationship between accessibility and maritime transport is strong, ensuring to the shippers a minimum amount of cargo, but it also varies considerably depending on the overseas market served.

The East and South-East Asia markets seem to be more linked to inland accessibility than the other forelands. This relation has been amplified along the last years with the increase in the commissioning of New-Panamax and Triple-E vessel classes, exclusively operating the Europe-Asia pendulum services, and marginalizing some secondary ports within these routes. It's commonly accepted that this increasing vessel size (and the derived new round-the-world services due to the Panama Canal widening) is going to change the hub-spoke relations currently established in the central/peripheral ports, and at this precise moment, European hubs like Le Havre or Algeciras are losing direct connections indeed.

In the American markets three different pattern emerges regarding the transatlantic trade: for the North Atlantic (NAA) foreland, the European Atlantic Arc façade (ATL) shows potential for taking additional advantages of an improved network of inland corridors connecting this peripheral area with the European Backbone; for the Caribbean hubs, the European subsidiary and small ports have the best opportunities to establish new trade links with some of the strong hubs located in this area (Kingston, Caucedo, Cartagena, Altamira, etc.); for the countries located in the South Atlantic (SAA) foreland, there are some evidence of some kind of penalty linked with traders who are native English speakers.

Regarding African forelands (NAF, WAF and IND), the difference between center and periphery is less clear, due to the specific nature of the trade (primary sector and raw materials), in which the European secondary ports play an important role. There are also evidences of a inertia in the colonial relations with certain countries like France or Portugal.

The work explains an accurate GIS methodology to put in relation port activity with hinterland flows, using a very simple indicator: the number of direct links with different overseas regions. But it opens a wide field of study which might be completed, in further research, adding on the foreland side, the port specialization and the specific network features; and on the hinterland side parameters such GDP, industrial indexes, etc...

This work raises questions about the opportunities for peripheral regions having good connections with specific forelands if they can take advantage of their situation, for example by choosing suppliers in countries with low labor costs. Since many of these peripheral regions have large port capacities there is potential for the development of new traffic. However, this approach is not without risk, since sudden changes on the strategies of shipping companies may have repercussions on the entire production network, increasing the vulnerability of these regions to external shocks.

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Tables

Table 1 – Sample composition

		Containerships (supply in TEUs)	
	Time scope sample	2009	2010
Number of vessels analyzed		2,032	2,144
Number of AIS positions analyzed		126,920	145,736
Vessel capacity	Maximum	15,550	15,550
	Minimum	450	1,057
	Average	4,533	4,730
Total fleet supply present in sample		9,211,236	10,142,327
Total world fleet supply estimated*		10,760,173	12,142,444
Number of different ports of call (World sample)		749	527
Number of different ports of call (Europe)		162	124

Source: own calculations from AIS data from Lloyd's Registry Database (2010)

Table 2 – Breakdown of maritime connections, by location

Port region By location (Road access. Index)	Europe (EUR)	North Africa (NAF)	West Africa (WAF)	South America Atlantic (SAA)	North America Atlantic (NAA)	Caribbean (CAR)	Oceania (OCE)
Core (>100)	36 415	18 852	4 880	3 684	9 184	11 190	1 461
Intermediate (50-100)	11 307	6 312	2 473	772	3 204	2 879	341
Peripheral (10-50)	7 309	4 127	1 744	598	1 821	1 596	158
Ultra-Peripheral (<10)	811	669	65	21	85	39	14
Med Hubs (transshipment>60%)	5 018	3 315	1 030	421	1 186	846	193
Total	60 860	33 275	10 192	5 496	15 480	16 550	2 167

Port region By location (Road access. Index)	North America Pacific (NAP)	South America Pacific (SAP)	Indian Ocean (IND)	South- East Asia (SEA)	Far East (FAE)	World
Core (>100)	4 867	2 713	14 312	28 072	14 362	85 666
Intermediate (50-100)	1 514	407	4 446	8 117	3 494	17 353
Peripheral (10-50)	1 089	280	3 322	5 639	2 417	1 704
Ultra-Peripheral (<10)	14	14	168	92	18	12 009
Med Hubs (transshipment>60%)	312	142	2 040	3 033	1 316	18 659
Total	7 796	3 556	24 288	44 953	21 607	244 053

Source: Own calculations from AIS data from Lloyd's Registry (2010) and ESPON (2006)

Table 3 – Breakdown of maritime connections, by size

Port region By size (number of connections)	Europe (EUR)	North Africa (NAF)	West Africa (WAF)	South America Atlantic (SAA)	North America Atlantic (NAA)	Caribbean (CAR)	Oceania (OCE)
XL (>25K)	33 043	10 263	5 107	3 086	8 652	9 174	1 049
L (>10K-25K)	15 421	5 137	2 370	913	3 229	2 769	506
M (>2K-10K)	10 896	680	2 124	1 393	3 361	4 014	578
S (>0.05K-2K)	1 407	17 139	575	88	214	512	26
Total	60 953	33 331	10 208	5 512	15 504	16 631	2 175

Port region By size (number of connections)	North America Pacific (NAP)	South America Pacific (SAP)	Indian Ocean (IND)	South- East Asia (SEA)	Far East (FAE)	World
XL (>25K)	4 434	2 045	13 678	25 572	12 741	128 844
L (>10K-25K)	1 812	491	6 881	13 244	6 107	58 880
M (>2K-10K)	1 456	776	3 539	5 875	2 609	37 301
S (>0.05K-2K)	89	191	155	222	133	20 751
Total	7 801	3 609	24 323	44 993	21 624	246 664

Source: Own calculations from AIS data from Lloyd's Registry (2010) and ESPON (2006)

Table 4 – Correlations between the main variables

Variables	ROAD-ACC	VOL(Log)	ISLAND-0	ISLAND-1	NR-0	NR-1	MED-0	MED-1	BRI-0	BRI-1	BALT-0	BALT-1	ATL-0	ATL-1	%EUR	%NAF	%WAF	%NAA	%SAA	%CAR	%OCE	%NAP	%SAP	%IND	%SEA
ROAD_ACC																									
VOL(Log)	0.33																								
ISLAND-0	0.12	0.04																							
ISLAND-1	-0.12	-0.04	-1.00																						
NR-0	-0.67	-0.25	-0.28	0.28																					
NR-1	0.67	0.25	0.28	-0.28	-1.00																				
MED-0	0.40	-0.01	-0.08	0.08	-0.44	0.44																			
MED-1	-0.40	0.01	0.08	-0.08	0.44	-0.44	-1.00																		
BRI-0	-0.21	-0.02	0.70	-0.70	-0.22	0.22	-0.39	0.39																	
BRI-1	0.21	0.02	-0.70	0.70	0.22	-0.22	0.39	-0.39	-1.00																
BALT-0	0.24	0.21	-0.10	0.10	-0.09	0.09	-0.16	0.16	-0.08	0.08															
BALT-1	-0.24	-0.21	0.10	-0.10	0.09	-0.09	0.16	-0.16	0.08	-0.08	-1.00														
ATL-0	0.19	0.26	-0.20	0.20	-0.18	0.18	-0.32	0.32	-0.16	0.16	-0.07	0.07													
ATL-1	-0.19	-0.26	0.20	-0.20	0.18	-0.18	0.32	-0.32	0.16	-0.16	0.07	-0.07	-1.00												
%EUR	-0.22	-0.20	-0.08	0.08	0.22	-0.22	-0.30	0.30	0.10	-0.10	0.13	-0.13	-0.06	0.06											
%NAF	-0.13	-0.11	-0.12	0.12	0.13	-0.13	-0.40	0.40	0.13	-0.13	0.12	-0.12	0.17	-0.17	0.84										
%WAF	-0.33	-0.22	0.21	-0.21	0.21	-0.21	0.06	-0.06	0.16	-0.16	0.00	0.00	-0.59	0.59	0.16	-0.18									
%NAA	-0.17	0.00	-0.12	0.12	0.12	-0.12	-0.03	0.03	-0.07	0.07	-0.08	0.08	0.23	-0.23	-0.13	-0.21	-0.10								
%SAA	-0.07	-0.16	-0.22	0.22	0.08	-0.08	0.13	-0.13	-0.31	0.31	0.07	-0.07	-0.02	0.02	0.09	0.07	0.09	0.06							
%CAR	-0.04	-0.40	-0.03	0.03	0.04	-0.04	0.13	-0.13	-0.01	0.01	-0.22	0.22	-0.09	0.09	-0.32	-0.44	-0.02	0.37	-0.10						
%OCE	0.19	-0.08	0.11	-0.11	-0.12	0.12	0.07	-0.07	0.09	-0.09	-0.14	0.14	-0.03	0.03	-0.17	-0.10	-0.09	-0.22	0.10	-0.09					
%NAP	0.19	0.06	0.06	-0.06	-0.10	0.10	-0.02	0.02	-0.09	0.09	0.20	-0.20	0.16	-0.16	-0.39	-0.28	-0.32	0.08	-0.21	0.04	-0.19				
%SAP	0.03	-0.35	0.08	-0.08	-0.11	0.11	0.25	-0.25	0.01	-0.01	-0.43	0.43	-0.09	0.09	-0.39	-0.32	0.00	-0.11	-0.04	0.59	0.10	-0.10			
%IND	0.16	0.53	0.04	-0.04	-0.20	0.20	0.00	0.00	0.05	-0.05	0.01	-0.01	0.16	-0.16	-0.29	-0.10	-0.33	-0.31	-0.16	-0.51	0.38	0.02	-0.24		
%SEA	0.32	0.61	0.02	-0.02	-0.22	0.22	-0.03	0.03	-0.05	0.05	0.19	-0.19	0.32	-0.32	-0.39	-0.08	-0.48	-0.31	-0.28	-0.54	0.08	0.33	-0.31	0.74	
%FAE	0.39	0.44	0.01	-0.01	-0.30	0.30	0.08	-0.08	-0.11	0.11	0.22	-0.22	0.24	-0.24	-0.35	-0.09	-0.37	-0.29	-0.30	-0.44	-0.12	0.50	-0.25	0.36	0.82

Source: own calculations from Lloyd's Registry Database (2010) and Espon (2006)

Table 5 – Simple and extended model for foreland aggregates' influence (part 1)

	%EUR coef	p> t	%NAF coef	p> t	%WAF coef	p> t	%NAA coef	p> t	%SAA coef	p> t	%CAR coef	p> t
EXTENDED MODEL												
Constant	0.4726	0.0071	0.3237	0.0035	0.3992	0.0047	-0.2048	0.2353	0.1265	0.0254	0.3282	0.0016
ROAD ACC	0.0000		0.0005	0.2706	-0.0008	0.0158	-0.0002	0.3674	-0.0004	0.0918	0.0003	0.4027
VOL(Log)	-0.0349	0.1855	-0.0323	0.2508	0.0000		0.0000		-0.0094	0.2696	-0.0539	0.0040
ISLAND-0	-0.0618	0.3423	-0.1304	0.0812	0.0666	0.0575	0.0000		0.0179	0.4326	-0.0274	0.5651
ISLAND-1	0.0000		0.0000		0.0000		0.0000		0.0000		0.0000	
NR-0	0.0000		0.0000		-0.0686	0.1961	0.0690	0.1794	-0.0342	0.1631	0.0000	
NR-1	0.0000		0.0000		0.0000		0.0000		0.0000		0.0000	
MED-0	-0.0892	0.0713	-0.1351	0.0070	-0.0414	0.2557	0.0725	0.0704	0.0000		0.0174	0.5914
MED-1	0.0000		0.0000		0.0000		0.0000		0.0000		0.0000	
BRI-0	0.0371	0.6530	0.1071	0.2346	-0.0993	0.1033	0.0532	0.2484	-0.0717	0.0158	0.0308	0.5917
BRI-1	0.0000		0.0000		0.0000		0.0000		0.0000		0.0000	
BALT-0	0.0815	0.4703	0.0000		0.0000		0.0557	0.3437	0.0375	0.3014	-0.0931	0.2419
BALT-1	0.0000		0.0000		0.0000		0.0000		0.0000		0.0000	
ATL-0	-0.0577	0.4084	0.0000		-0.1706	0.0001	0.1175	0.0103	0.0000		0.0000	
ATL-1	0.0000		0.0000		0.0000		0.0000		0.0000		0.0000	
F	1.8140		3.1342		7.0258		1.6823		1.8722		2.2311	
P>F	0.1140		0.0148		< 0.0001		0.1435		0.1029		0.0542	
R2	0.1704		0.2249		0.4430		0.1600		0.1749		0.2016	
Adj-R2	0.0765		0.1532		0.3800		0.0649		0.0815		0.1113	
Model	0.2215		0.3771		0.1949		0.0409		0.0247		0.1319	
	0.1704		0.2249		0.4430		0.1600		0.1749		0.2016	
Residual	1.0784		1.2995		0.2450		0.2145		0.1166		0.5224	
	0.8296		0.7751		0.5570		0.8400		0.8251		0.7984	
rootMSE	0.1426		0.1551		0.0680		0.0636		0.0469		0.0993	
SIMPLE MODEL												
Constant	0.4526	< 0.0001	0.2621	0.0054	0.1589	0.0006	0.0781	0.0305	0.0608	0.0243	0.2713	< 0.0001
ROAD ACC	-0.0005	0.2089	-0.0003	0.4447	-0.0005	0.0309	-0.0002	0.1840	0.0000	0.8547	0.0002	0.4307
VOL(Log)	-0.0276	0.2896	-0.0165	0.5841	-0.0143	0.3284	0.0050	0.6686	-0.0093	0.2886	-0.0581	0.0014
F	2.0498		0.6590		4.0983		0.9046		0.7356		5.6985	
P>F	0.1381		0.5213		0.0217		0.4104		0.4837		0.0055	
R2	0.0671		0.0226		0.1257		0.0308		0.0252		0.1666	
Adj-R2	0.0344		-0.0117		0.0950		-0.0032		-0.0090		0.1374	
Model	0.0872		0.0379		0.0553		0.0079		0.0036		0.1090	
Model (%)	0.0671		0.0226		0.1257		0.0308		0.0252		0.1666	
Residual	1.2126		1.6387		0.3846		0.2475		0.1378		0.5453	
Residual (%)	0.9329		0.9774		0.8743		0.9692		0.9748		0.8334	
rootMSE	0.1459		0.1696		0.0821		0.0659		0.0492		0.0978	

Source: Own calculations from AIS data from Lloyd's Registry (2010) and ESPON (2006)

Table 6 – Simple and extended model for foreland aggregates' influence (part 2)

	%AUS coef	p> t	%NAP coef	p> t	%SAP coef	p> t	%IND coef	p> t	%SEA coef	p> t	%FAE coef	p> t
EXTENDED MODEL												
Constant	0.0153	0.6438	-0.0177	0.5630	-0.1874	0.0559	0.0529	0.5475	-0.1874	0.0559	-0.0552	0.4389
ROAD ACC	0.0003	0.0434	0.0000		0.0002	0.4551	0.0000		0.0002	0.4551	0.0002	0.3860
VOL(Log)	-0.0051	0.3124	-0.0026	0.6489	0.0695	< 0.0001	0.0417	< 0.0001	0.0695	< 0.0001	0.0254	0.0169
ISLAND-0	-0.0073	0.5884	0.0236	0.0964	0.0096	0.7306	-0.0099	0.6280	0.0096	0.7306	0.0000	
ISLAND-1	0.0000		0.0000		0.0000		0.0000		0.0000		0.0000	
NR-0	0.0126	0.3888	0.0000		0.0091	0.8110	-0.0245	0.3393	0.0091	0.8110	-0.0148	0.6053
NR-1	0.0000		0.0000		0.0000		0.0000		0.0000		0.0000	
MED-0	0.0000		0.0000		0.0000		-0.0149	0.4735	0.0000		0.0000	
MED-1	0.0000		0.0000		0.0000		0.0000		0.0000		0.0000	
BRI-0	0.0214	0.2180	-0.0219	0.1645	0.0000		0.0000		0.0000		-0.0101	0.6662
BRI-1	0.0000		0.0000		0.0000		0.0000		0.0000		0.0000	
BALT-0	-0.0307	0.1591	0.0423	0.0815	0.0382	0.5533	-0.0502	0.2572	0.0382	0.5533	0.0354	0.4086
BALT-1	0.0000		0.0000		0.0000		0.0000		0.0000		0.0000	
ATL-0	0.0000		0.0218	0.1181	0.0575	0.1233	-0.0137	0.6432	0.0575	0.1233	0.0207	0.3963
ATL-1	0.0000		0.0000		0.0000		0.0000		0.0000		0.0000	
F	1.1991		1.4760				3.8569		6.4132		3.5620	
P>F	0.3213		0.2129				0.0029		< 0.0001		0.0049	
R2	0.1195		0.1202				0.3039		0.4206		0.2874	
Adj-R2	0.0198		0.0388				0.2251		0.3550		0.2067	
Model	0.0057		0.0074				0.0646		0.2647		0.0664	
	0.1195		0.1202				0.3039		0.4206		0.2874	
Residual	0.0417		0.0544				0.1480		0.3645		0.1646	
	0.8805		0.8798				0.6961		0.5794		0.7126	
rootMSE	0.0280		0.0317				0.0528		0.0829		0.0557	
SIMPLE MODEL												
Constant	0.0210	0.1656	0.0240	0.0038	0.1246	0.0006	-0.0405	0.1437	-0.1074	0.0172	-0.0437	0.1396
ROAD ACC	0.0001	0.0827	0.0001	0.1425	0.0002	0.2218	0.0000		0.0003	0.2503	0.0003	0.0272
VOL(Log)	-0.0059	0.2396	0.0000		-0.0352	0.0029	0.0408	< 0.0001	0.0759	< 0.0001	0.0285	0.0046
F	1.7661		2.2101		4.8688		22.6361		18.4101		10.2337	
P>F	0.1802		0.1425		0.0112		< 0.0001		< 0.0001		0.0002	
R2	0.0584		0.0367		0.1459		0.2807		0.3925		0.2642	
Adj-R2	0.0253		0.0201		0.1159		0.2683		0.3711		0.2384	
Model	0.0028		0.0023		0.0399		0.0597		0.2469		0.0610	
Model (%)	0.0584		0.0367		0.1459		0.2807		0.3925		0.2642	
Residual	0.0446		0.0596		0.2334		0.1529		0.3823		0.1699	
Residual (%)	0.9416		0.9633		0.8541		0.7193		0.6075		0.7358	
rootMSE	0.0280		0.0321		0.0640		0.0513		0.0819		0.0546	

Source: Own calculations from AIS data from Lloyd's Registry (2010) and ESPON (2006)

Figures

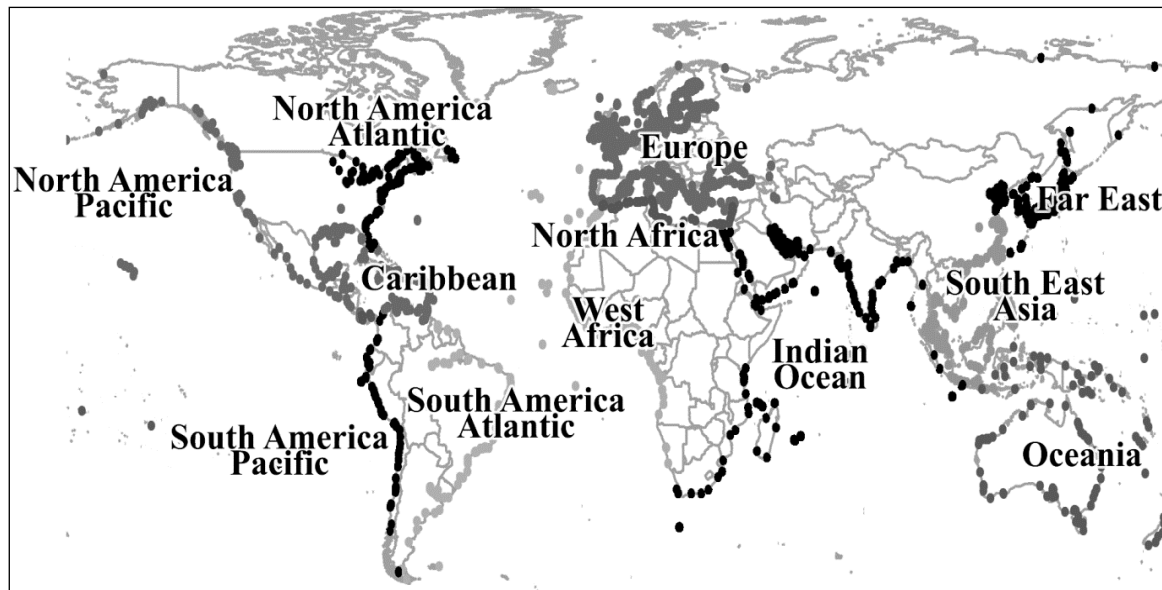


Figure 1 – Foreland aggregates used in this study

Source: Own calculations from AIS data from Lloyd's Registry (2010)



Figure 2 – NUTS-3 Regions and ports identification used in this study

Source: Own calculations from AIS data from Lloyd's Registry (2010) and Espon (2006)

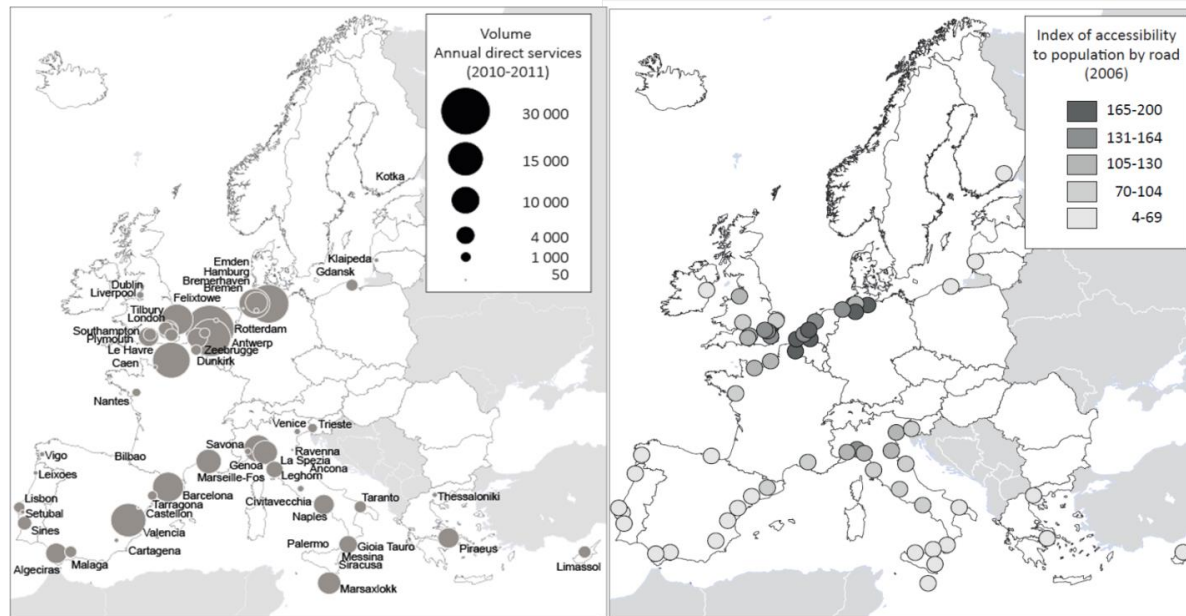


Figure 3 – Volume and index of accessibility of the port-regions

Source: Own calculations from AIS data from Lloyd's Registry (2010) and Espon (2006)

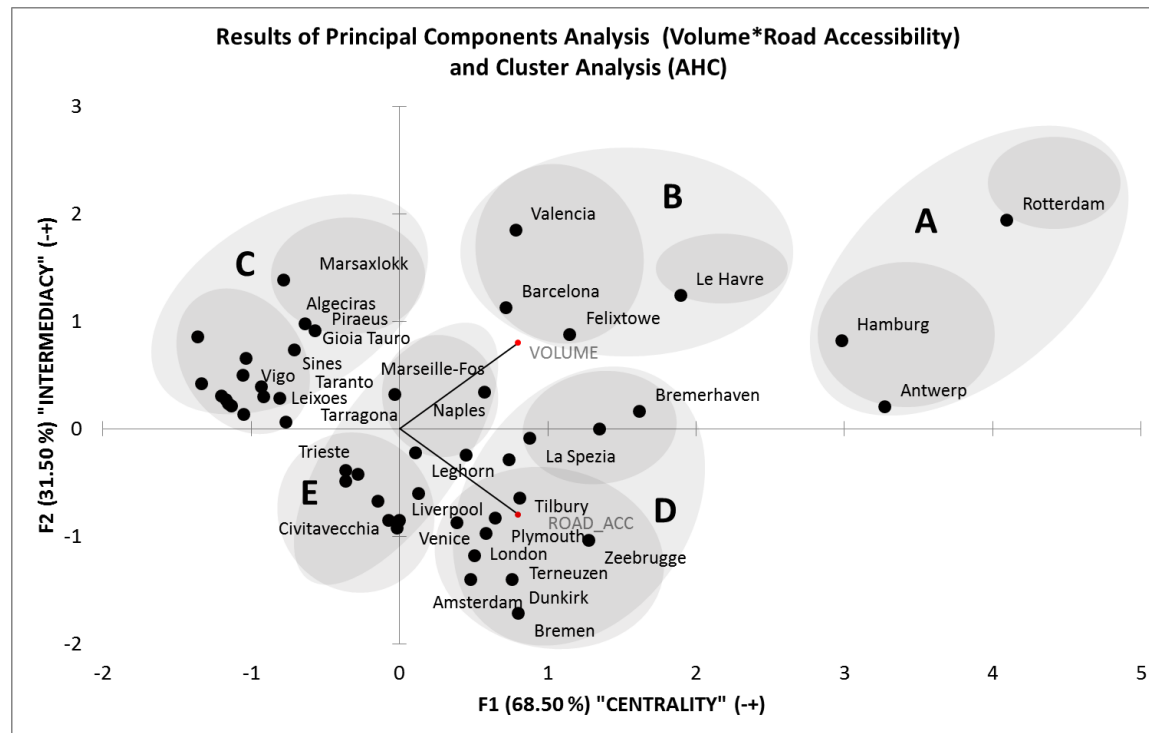


Figure 4 – Principal Component Analysis (Volume*Road Accessibility) and Cluster Analysis (10 types)

Source: Own calculations from AIS data from Lloyd's Registry (2010) and Espon (2006)

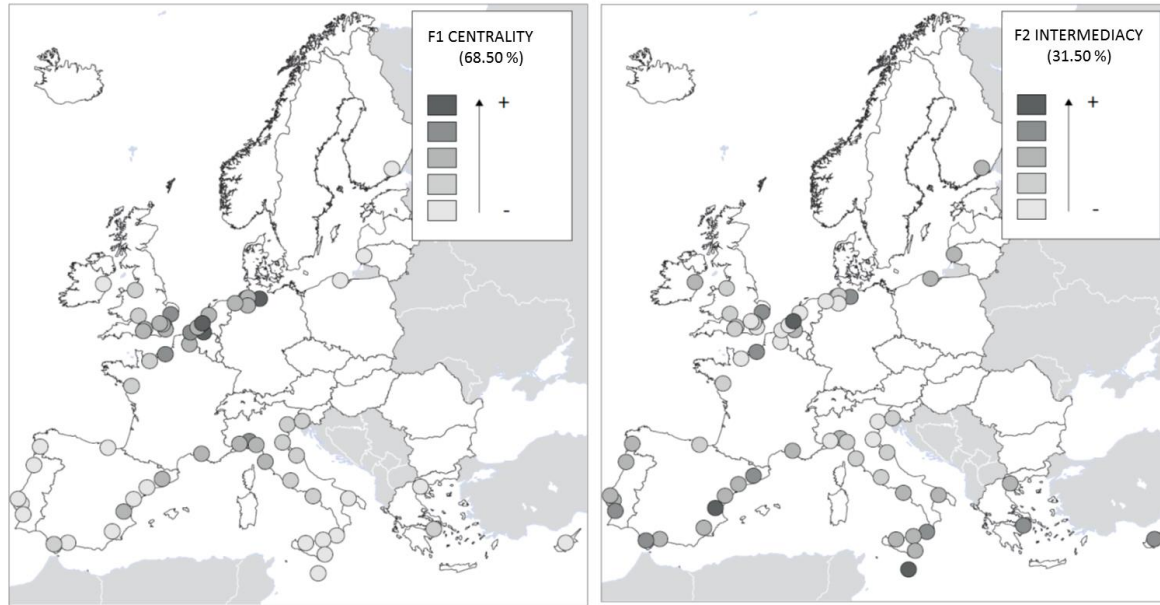


Figure 5 – Principal Component Analysis (Volume*Road Accessibility)

Source: Own calculations from AIS data from Lloyd's Registry (2010) and Espon (2006)

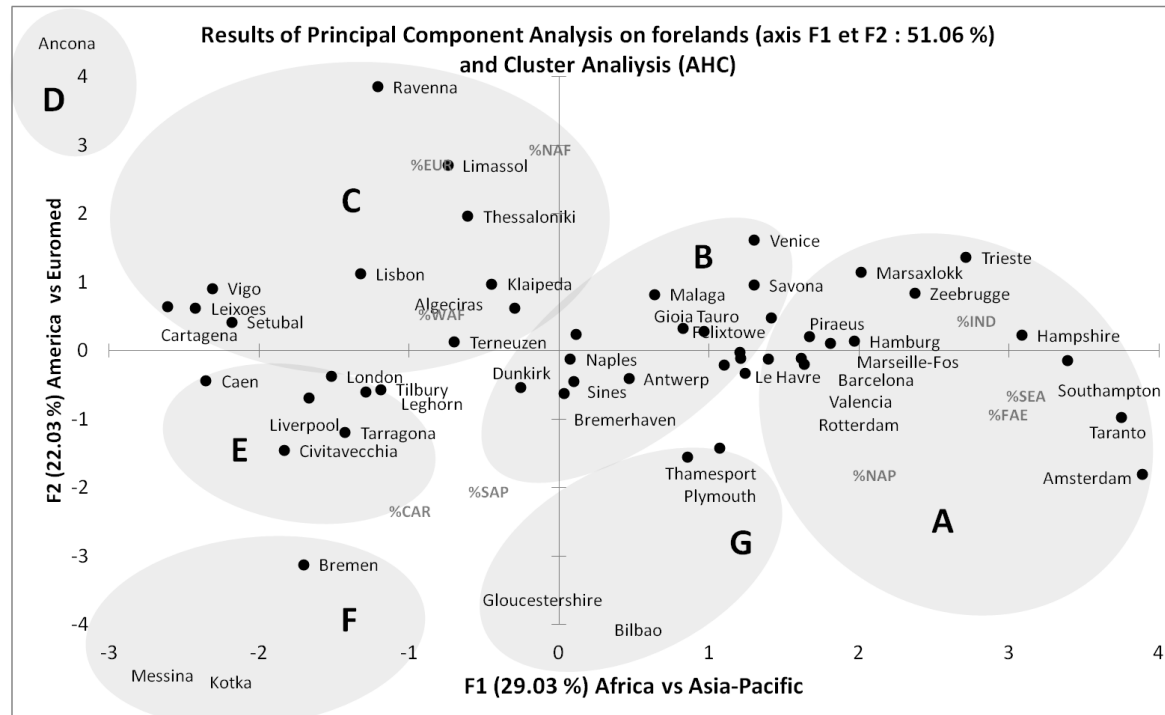


Figure 6 – Principal Component Analysis (share of different forelands on the total) and Cluster Analysis (6 types)

Source: Own calculations from AIS data from Lloyd's Registry (2010) and Espon (2006)

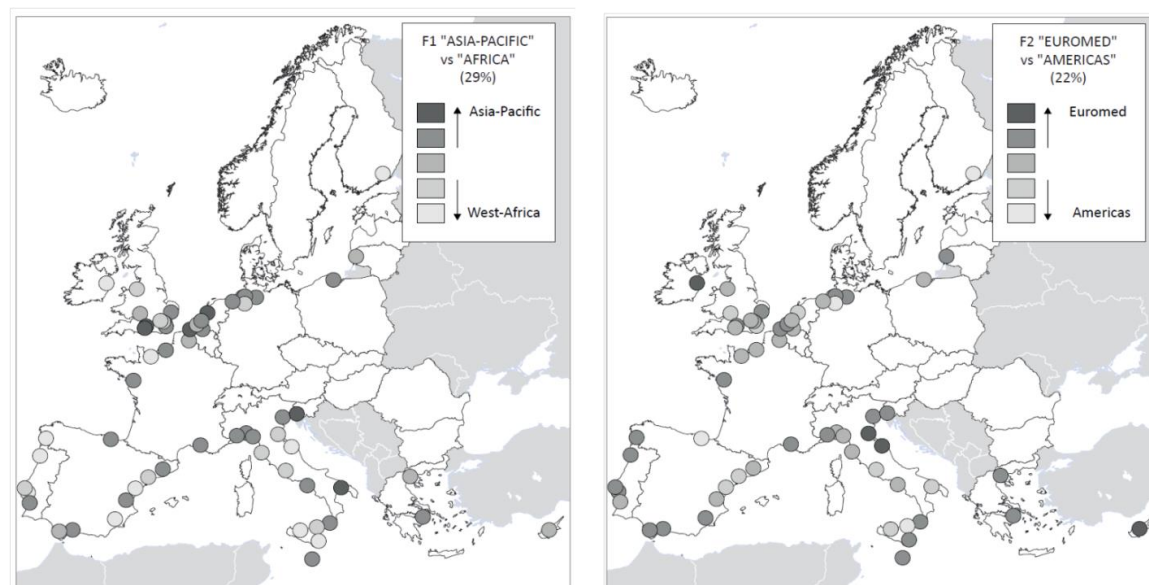


Figure 7 – Principal Component Analysis (share of different forelands on the total)
Source: Own calculations from AIS data from Lloyd's Registry (2010) and Espon (2006)

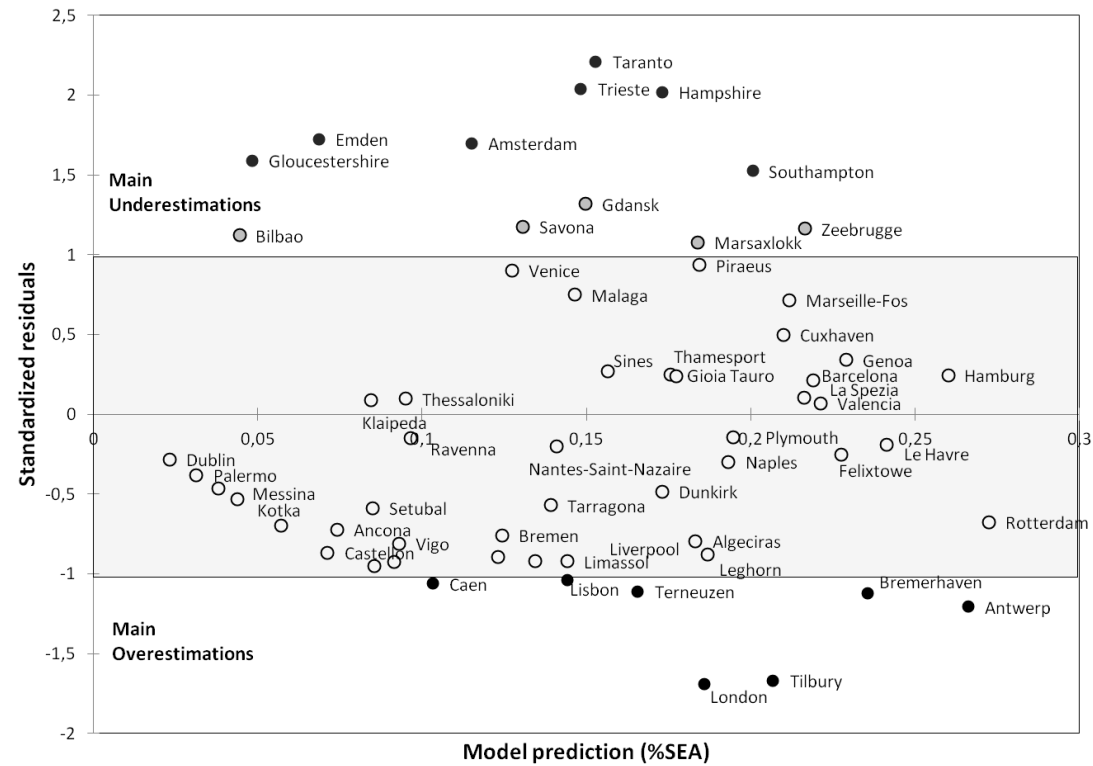


Figure 8– Standardized residuals of the Simple Model %SEA=F(Vol, Road access)
Source: Own calculations from AIS data from Lloyd’s Registry (2010) and Espon (2006)

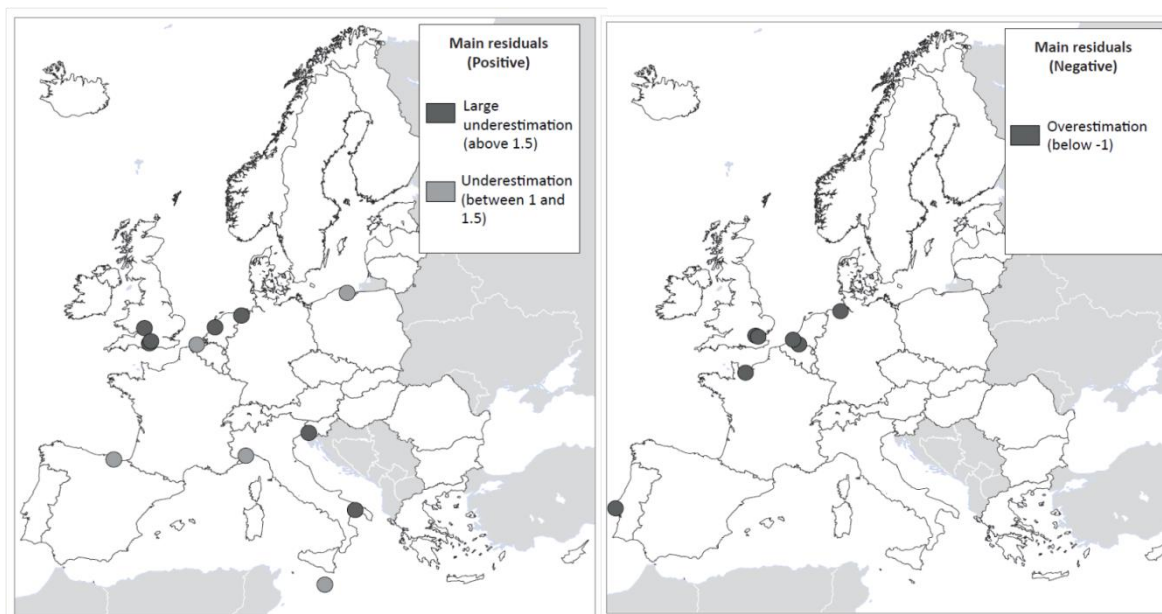


Figure 9– Main residuals of the Simple Model $\%SEA=F(\text{Vol}, \text{Road access})$

Source: Own calculations from AIS data from Lloyd's Registry (2010) and Espon (2006)