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FRENCH DEEP-SEA HINTERLANDS: SOME EMPIRICAL EVIDENCE OF THE SPATIAL IMPACT OF CONTAINERISATION

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ABSTRACT

Two distinct types of ports handle French deep-sea cargo: global ports of Northern Range and Marseilles serve a great number of overseas regions (forelands) and secondary ports mainly serve niche markets. In this paper we demonstrate that global ports serve also larger hinterlands, but their superiority over secondary ports depends on the types of cargo handled. The results of a spatial interaction model demonstrate that most of types of cargo flows are strongly distance-constrained. This evidence indicates that, despite a deep transformation on forelands, the secondary ports subsist because they partly depend on niche markets and local economies generating substantial amounts of non-containerised cargo flows. Some implications of this finding are suggested.

Key Words: Hinterland, Foreland, Containerisation, France, Spatial Interaction Model

1. INTRODUCTION

The concepts of hinterland and foreland were mainly developed before containerisation (Sargent, 1938, Amphoux, 1950). Both concepts refer to the same continental regions served by ports (Weigend, 1956). As seen in Figure 1, a single region [A] is simultaneously the hinterland of one port [a] and it is also part of the forelands of other ports [b and c]. In this schematic situation the hinterland is a spatially continuous area and foreland is a discontinuous set of land areas interconnected by maritime links. This model also postulates exclusive hinterlands. However, that is not always the case in reality. As early as 1918, Demangeon observed substantial overlapping between the hinterlands of the ports of Antwerp, Amsterdam and Rotterdam (Demangeon, 1918).

The organization of maritime links varies depending on the type of cargo: bulk or general cargo. The former is mainly transported in tramp ships that convey big amounts of a same cargo, they are not regular, depending on the contracts of transport, are an uncertain factor in the definition of forelands. General cargo, conveyed in liner ships, generate more solid links between ports, structuring their forelands.

From 1960s to 2000s container revolutionized liner shipping, particularly in the case of manufactured goods. In containers, many kinds of cargo can be transported on a same ship and each container can be easily transferred from one means of transport to another without

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unpacking. Containerisation leads to significant economies in handling and maritime transport (De Neufville and Tsunokawa, 1981). However, the high capital cost of container ships and handling tools push for its maximum utilisation. This predisposes spatial concentration of freight flows at one or two big ports by region, marginalizing all other ports, as demonstrated by Mayer (1978). According to him, the combined effect of development of container shipping and the completion of interstate highway network increases the competitive advantages of main ports, also called “load centres”. These ports tend to be located close to large markets and/or to main maritime routes.

The spatial impact of containerisation has been an ongoing area of study for transportation geographers. Hayuth (1981) formalised for the first time the load centre concept, by developing a spatial model inspired from those of Taaffe *et al.* (1963) and Rimmer (1967). It explains how the hub-and-spokes network development leads to concentration of cargo flows in a few ports, inland centres, and transport routes.

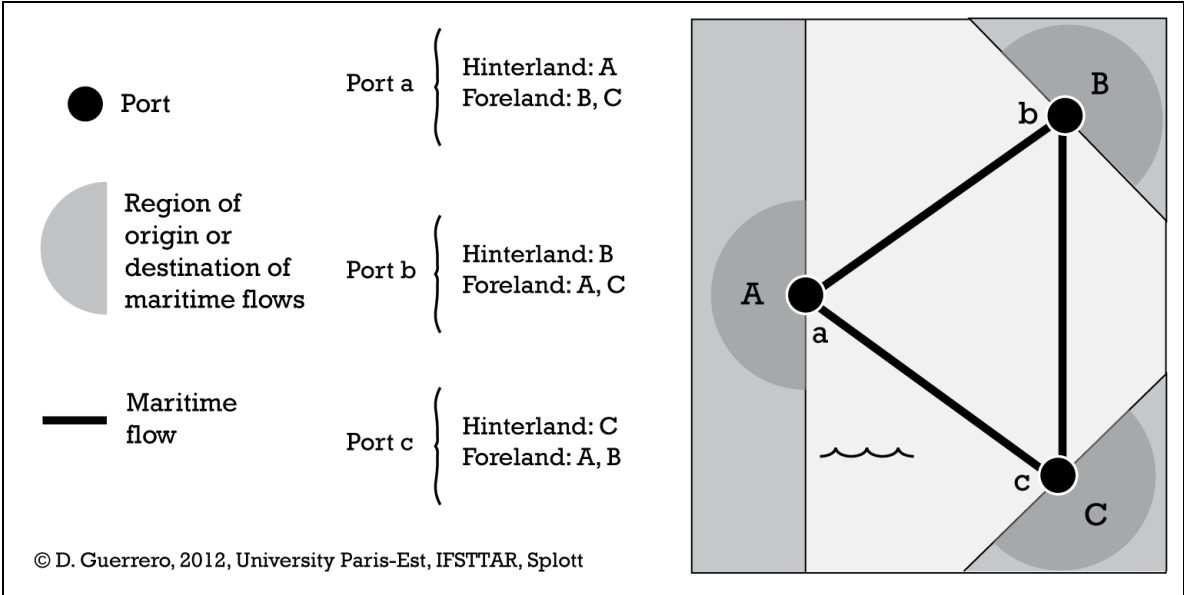


Figure 1. Schematic representation of hinterlands and forelands

Several regional studies brought empirical evidences of the consequences of containerisation on hinterlands and forelands. Hoare (1986) found largely overlapping hinterlands of British ports. He argued that containerisation leads shippers to concentrate trade and services to particular overseas destinations at particular ports. Similarly, Slack (1990) found, in a continental context of the U.S., that the development of rail services across the country contributed to the concentration of an increasing share of Far Eastern Trade on the ports of the West coast to the detriment of those of the East coast. In both the cases, shippers try to minimise the maritime segment of their exports, even if it implies longer inland haulages. The increase of inland haulage can be compensated by overall cost saving through speed of flow and inland handling costs (Hoare, 1986).

The purpose of this short review of maritime literature is to provide definitions of hinterlands and forelands explaining how they have been transformed by containerisation. The detailed reasons for these turn-arounds are not our central concern. We search to understand how

containerisation produced spatial changes in the specific context of France, a continental country of Western Europe served by three distinct port ranges (Northern Range, Mediterranean, Atlantic) and where inland transport network is well developed.

2. FRENCH FORELANDS AND CONTAINERISATION

In France, le Havre and Marseilles are the main ports. In the 1950s and 1960s scholars demonstrated that these two ports served more overseas regions than the other ports (Amphoux, 1950, Vigarié, 1964). Later, in the early 1980's, Marcadon (1988) showed that most of small and middle-sized ports only served one or two overseas regions at most, mainly niche markets linked to tramp or short sea shipping. The trade handled by small and middle-sized was mainly oriented to the intra-European short sea shipping (U.K, Scandinavian countries) and to the French former colonies in Africa. Between these two distinct packages of ports remained an intermediary category of middle-sized ports of Dunkirk, Bordeaux, Nantes and Sète that serve less overseas regions than the main ports, but much more than the other ports. The resistance of this intermediary category of ports could be partly explained by inequalities in containerisation rates between the regions of the World in the early 1980s. Marcadon evokes the example of the ports of Sudeste (Brazil), where containerisation was less developed. The French Shipping company CGM offered adapted services to the handling capacities of South American ports; containerised lines served the East Coast, mixed ships served the West Coast.

In the 2005, containerisation was much more developed in France than it was in the early 1980's. Most of French deep sea flows of manufactured goods are now transported by container. In 2005², the main container ports of France were Le Havre (2,1 M TEUs) on the Northern Range, Marseilles (0,9 M TEUs) on the Mediterranean, and the foreign Northern Range ports of Antwerp (6,5 M TEUs) and Rotterdam (9,2 M TEUs), that handle a part of French container flows. Other much smaller container ports are Dunkirk and Rouen (0,2 M TEUS each) in the Northern Range, and Nantes-Saint-Nazaire (0,2 M TEUs) and Bordeaux (0,1 M TEUs) in the Atlantic.

Big ports generate more cargo flows than little ports, for all regions of origin and destination. To analyse the specific orientation of ports to/from overseas regions avoiding the size effect, we use a specialisation index (I_i) on French maritime trade. The index can be formulated as follows:

$$I_i = \sum_{j=1}^n \frac{p_{ij}}{(p_i \times p_j) / P_{ij}}$$

The principle behind this specialisation index is to make a relative comparison between the traffic of an individual port with the average total of all ports³. It's a similar method of those employed by scholars to measure directions of trade from ports to overseas regions (Alexandersson and Norstrom, 1963, Bird, 1969). Figure 2 shows the specialisation index of the main ports and sets of ports handling French maritime imports and exports, for all cargo

² Source : CI Online.

³ The Appendice 1 presents an the spatial distribution of French extra-EU maritime trade in the World.

and for the specific case of manufactured goods. Values greater than 1 indicate over-representation of a foreland in the traffic of a port, regarding to the share of this foreland for the set of ports. For example (Figure 2, matrix [a]), the index of the ports of Brittany (“Bretagne”, Western France) with South America is 3 for imports, meaning that the share of this overseas region in the traffic of these ports is 3 times greater than the average.

Le Havre and the Foreign Northern Range ports handle substantial amounts of cargo of a great number of overseas regions, both for imports and exports, and are therefore the closest to being regarded as truly global ports (Figure 2, matrices [a] and [b]). Most of small and middle-sized ports are specialised in Europe and Africa forelands, both on imports and exports. Marseilles and Dunkirk are in an intermediate position: they are rather close to the small and middle-sized ports for imports, and seem to be more “global” for exports.

In the case of manufactured goods, mostly containerised, Marseilles logically joins the group of global ports for both imports and exports (Figure 2, matrices [c] and [d]), handling significant amounts of cargo with main deep-sea markets of East Asia and North America.

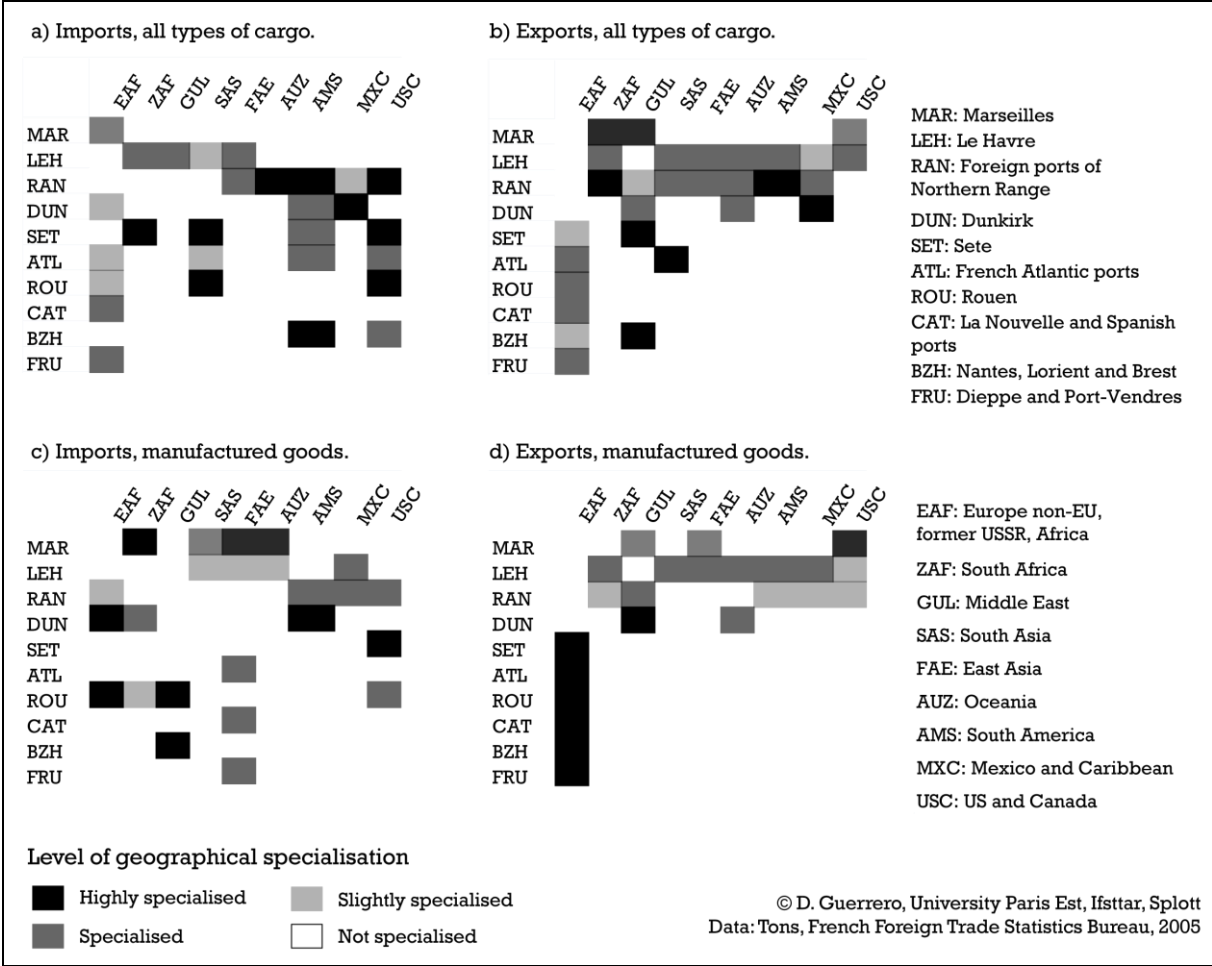


Figure 2. Geographical specialization of ports in forelands

Finally, a clear hierarchy can be observed between global container ports and secondary ones. The latter are specialised in tramp or short sea shipping markets, mainly linked to Africa,

Europe (non-EU countries) and the Middle East. These results are consistent with those of Gouvernal et al. (2010), confirming that the majority of deep-sea consignments pass through main container ports. The comparison of the forelands of 2005 with those of the early 1980's, show dramatic changes, essentially driven by containerisation.

The first change is the increase of the gap between global and secondary ports. The structure of forelands follows more and more the hierarchy of container shipping: the more diversified forelands are those of the main container ports (Northern Range ports and Marseilles). These ports are global because they handle trade between France and most of overseas regions. The intermediary category of middle-size ports no longer exist. The hub and spokes networks of container transportation tend to marginalise ports that are not close to the main routes or main hinterlands.

A second change is the decline traffic of many overseas regions served by the port of Marseilles, especially for imports. Beyond labour factors (strikes) that usually lead explanations, there is a deeper reason linked with the geographical position of Marseilles towards main maritime routes of container shipping. Figure 3 shows the traffic of TEUs for a selection of European ports, separating hinterland and transshipment ones. The traffic of the port of Marseilles, located at the North of Mediterranean, is essentially generated by its hinterland. Shipping companies increasingly serve Marseilles by feeder from the transshipment ports of the South of Mediterranean (Gouvernal et al., 2005).

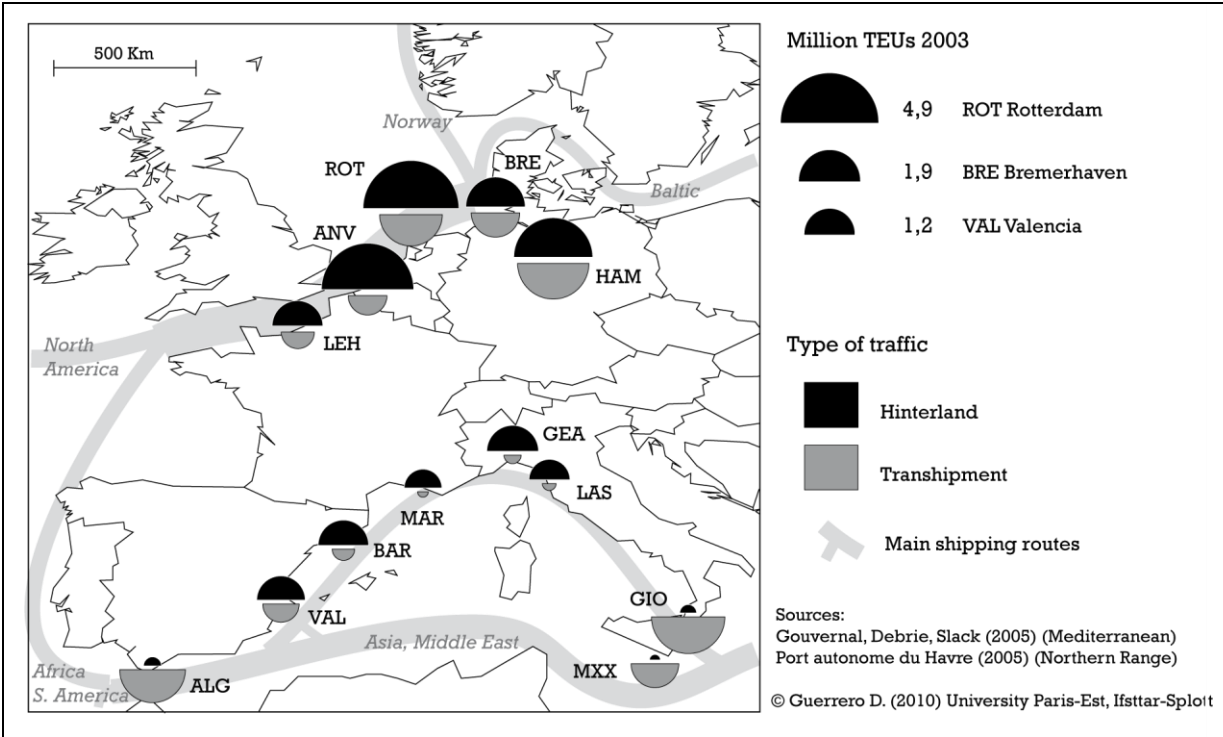


Figure 3. Traffic of main container ports of Western Europe

In 1980s, Charlier showed, in a French context, that global ports also had larger hinterlands (Charlier, 1981, 1991). He also demonstrates that overlapping between distinct hinterlands only takes place at the margins, that he called “competition margins”. This finding in France

was slightly different from the “substantially overlapping” hinterlands found by Hoare for British ports at the same period. Since Charlier’s studies in the 1980s, there is little evidence about French hinterlands, and the little that does exist has been written in French (Debie and Guerrero, 2008). The purpose of this paper is to help to fill this void by analysing the current division of the French hinterlands between global and secondary ports.

The rest of this article is structured as follows. Section 2 details our hypotheses and provides an overview of the data and methods used. It examines how French hinterlands are shared between global and secondary ports. Section 3 introduces a spatial interaction model to measure the differences between of hinterlands for different types of cargo. Section 4 explores the link between hinterland and foreland for the two main French container ports, Le Havre and Marseilles, for trade with U.S. and East Asia. Section 5 presents the conclusions and some implications for policy makers.

3. ANALYSING FRENCH HINTERLANDS: DATA AND METHODS

When studying maritime flows at the scale of a country the question of the delineation hinterlands is a difficult issue. Even considering only the ports located inside France, some big ports such as Le Havre and Marseilles obviously serve wider territories. Moreover, there are other ports located outside France (like Antwerp and Rotterdam) that also handle French cargo flows.

Unfortunately, in the Western Europe there is not a large scale geographic database of freight flows as in the United States (PIERS). Empirical evidence on freight flows is only available through enquiries (ECHO survey about shippers) that do not exist on comprehensive, E.U.-wide basis. For these reasons we have decided to work on the basis of national data, knowing that it is an imperfect proxy of a much wider phenomenon.

Information about freight flows is available from databases produced by French Foreign Trade Statistics Bureau (January 2006), providing disaggregated and exhaustive data of the value and weight of trade (in euros and tons). We collected data of Foreign Trade Flows for 1995, 1999, 2003 and 2005. The completion of the internal European Union market on the 1st January 1993 with its removal of customs formalities (the traditional source of statistical data on international trade) between Member States enforced the adoption of a new data collection system, Intrastat, as the basis for statistics on intra-EU trade. The introduction of Intrastat involved a methodological break with the past and reduced the quality of the statistics. But these changes have not affected much the customs formalities for extra-EU trade (imports and exports). For these reasons we decided to work only with French maritime extra-EU trade. This narrows the focus of this paper to deep sea freight flows.

The year 2005 was chosen for this study. In 2007, with new simplifications of Customs declarations, Trade data in tons is no more available.

The spatial units used are the *départements*⁴, French equivalent of Chinese “*xiàn*”, U.S. Counties, Japanese “*ken*” or European NUTS-3. We selected the 94 mainland *départements*, excluding those of Corsica and Overseas French Territories.

Custom's offices located in French ports were aggregated to ports (Figure 4). Information about ports of foreign countries that handle French foreign trade is only delivered at the level

⁴ The Appendice 2 presents an the spatial distribution of French extra-EU maritime trade in the *départements*.

of countries. Then, we have decided to work with two types of port entities: (a) 16 individual ports located in France, and (b) 5 foreign country's port sets, that handle together, 98% of the value and 97% of the tons of French foreign Trade.

The truck time-distances between centroids of *départements* and ports used in the spatial interaction model have been extracted from ESPON inter-NUTS-3 distance database created by Spiekerman and Wegener in 2005.

French Foreign Trade Statistics Bureau (2005) distinguishes 10 different types of cargo. There is no specification between “liner” service, which operated on a fixed geographic itinerary and publicly advertised sailing schedule, and “tramp” service, which operates on an irregular or chartered schedule. In this paper we consider that liner cargo mainly consists of manufactured goods, usually of high value, including machinery, vehicles. Containerised shipping is a subcategory of liner service.

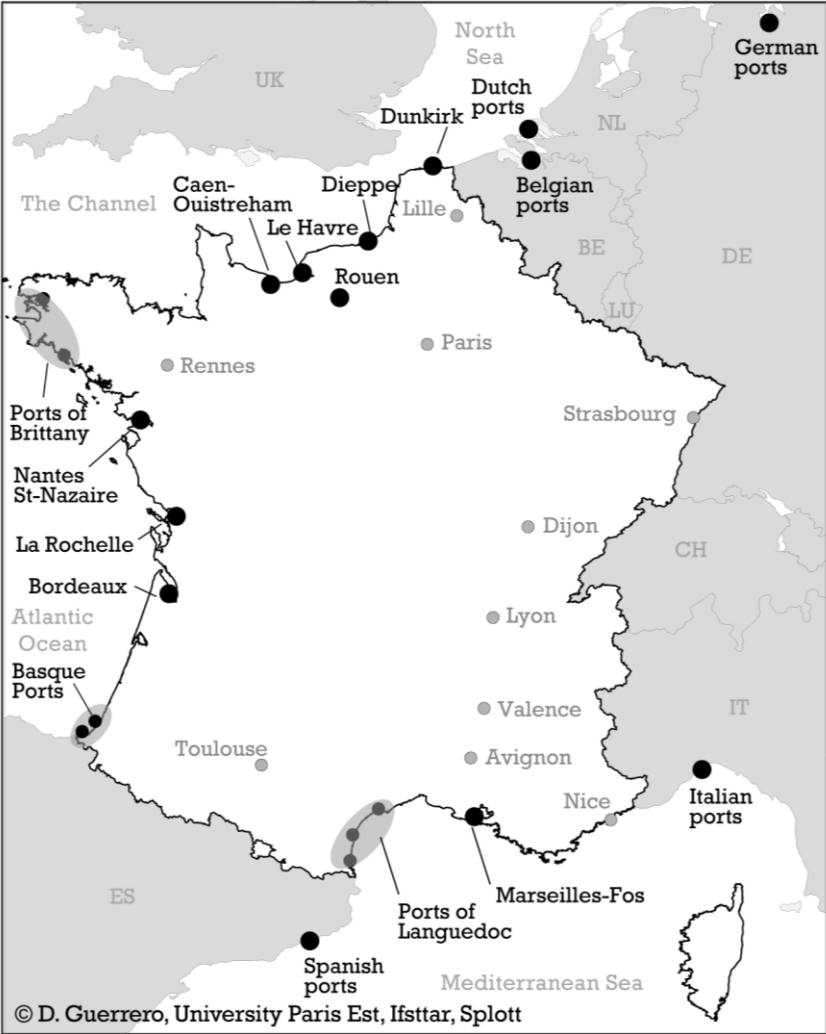


Figure 4. Ports (and sets of ports) handling French extra-EU Trade (2005)

A cluster analysis has been applied to French *départements*, to map their main orientation to ports. The method employed is an ascendant hierarchical classification, realised from a cross table of ports and *départements*. The metric used is distance to chi square, in order to limit the mass effects linked the biggest ports. This method of classification allows characterizing of

each département regarding the average French profile, depending on the ports or the sets of ports that handle its maritime cargo flows.

A spatial interaction model is employed to analyse the hinterlands for different types of cargo. It allows us to explain the spatial distribution of flows between the ports and the départements, regarding volumes of trade (in tons) of départements and ports and to distance between both. The spatial interaction model used is formulated as follows:

$$\frac{A_i \cdot O_i \cdot B_j \cdot D_j}{d_{ij}^\alpha}$$

Where O_i is the total maritime traffic of the département or the port called i ; D_j is the total maritime traffic of the département or the port called j (see table 1); d_{ij} is the distance between i and j ; α is the distance decay parameter; and A_i and B_j are the balancing factors ensuring that the origin i and destination j constraints are satisfied. When a département or a port sends freight traffic, it is referred to as “ i ,” and when a département or a port receives this traffic, it is referred to as region “ j .”

The choice of measure of distance influences the results of the spatial interaction model. Truck-time-distance has been selected because it seems to be more consistent with the situation of France, where road *transport* plays a largely dominant role in *port's modal split*. Moreover, the explanatory power of the model is slightly higher with truck time-distance, compared to Euclidean distance.

The data finally used is a matrix of freight flows, measured in annual tons moved. The value of r^2 is the part of the total variance explained by the model. It is a measure of the goodness of fit of the model to explain the spatial distribution of flows between the ports and the départements. An r^2 of 100% would indicate that the regression line perfectly fits the data, namely the spatial distribution of flows between ports and départements can be perfectly predicted by the total traffic of each port, total traffic of each département, and the distance that separates both. A second r^2 has been calculated as a measure of variance specifically explained by distance.

A Poisson regression has been used to fit the spatial doubly constrained model (Fotheringham and O’Kelly, 1989, D’Aubigny et al.,2000).

Table 1. Matrice origin-destination of flows between ports and départements

To	Port1	Port2	Port...	Portj	Dept1	Dept2	Dept...	Deptj	Total
From									
Port1	0	0	0	0	I11	I12	...	I1j	Tport1
Port2	0	0	0	0	I21	I22	...	I2j	Tport2
Port...	0	0	0	0	...	...	...	...	...
Porti	0	0	0	0	Ii1	Ii2	...	Iij	Tporti
Dept1	I11	I12	...	I1j	0	0	0	0	Tdept1
Dept2	I21	I22	...	I2j	0	0	0	0	Tdept2
Dept...	...	...	...	...	0	0	0	0	...
Depti	Ii1	Ii2	...	Iij	0	0	0	0	Tdepti
Total	Tport1	Tport2	...	Tportj	Tdept1	Tdept2	...	Tdeptj	T

A SHARED TERRITORY BETWEEN GLOBAL AND SECONDARY PORTS

France can be divided in four types of hinterlands, depending on the ports that handle their cargo (Figure 5):

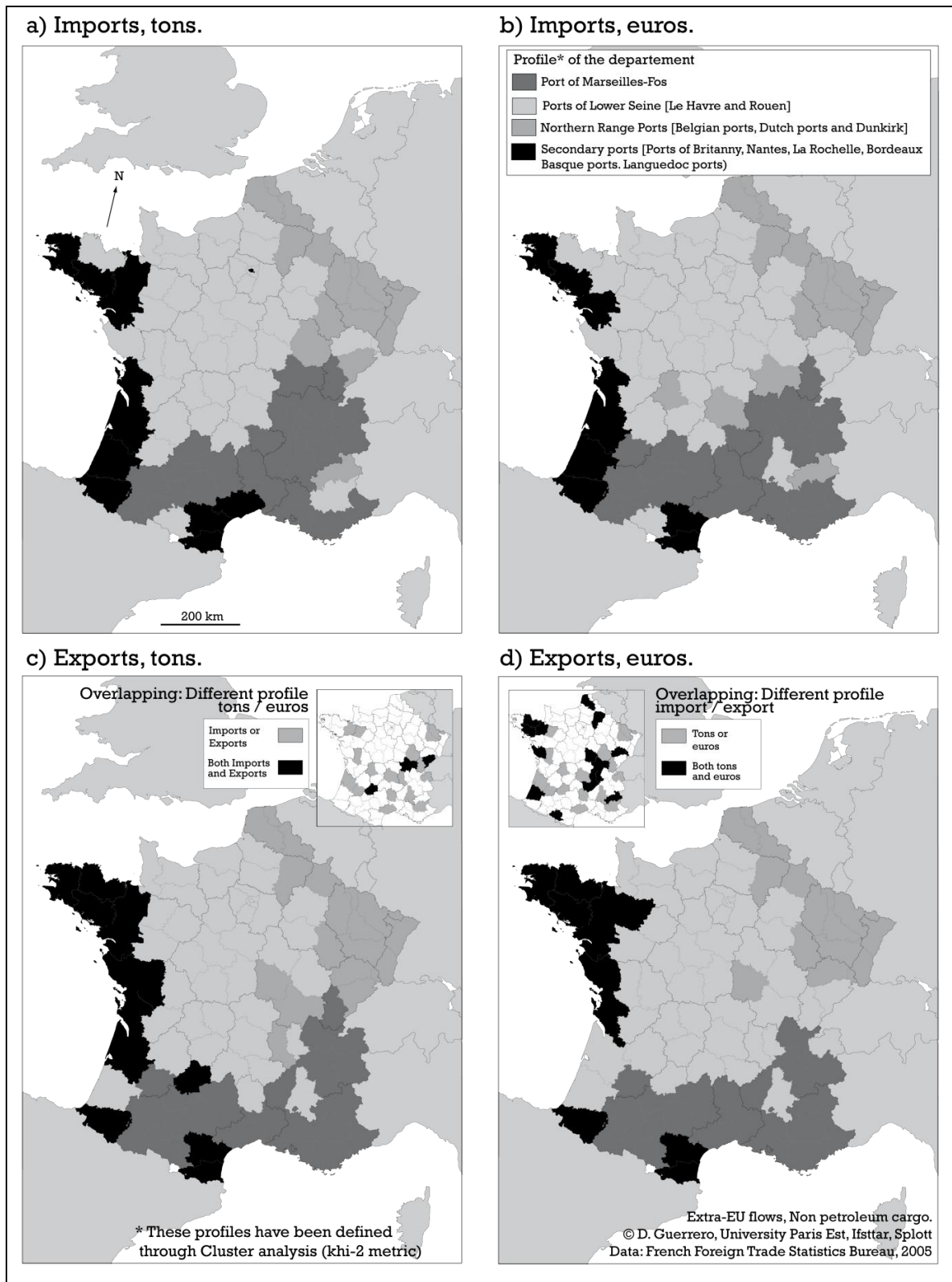


Figure 5. French hinterlands of global and secondary ports

Those of the Lower Seine ports (Le Havre and Rouen) are analysed together. These ports handle high share of the cargo of the départements located in North-West and the Center of France. These two ports are largely complementary, the first handling general cargo mostly in containers, the second handle bulk cargo. Rouen is an urban upstream port that mainly handles bulks. It is the main European port for exports of wheat grown in the French Northern Plains. Le Havre serves the industry of its surroundings (i.e. Renault) and also the region of Paris that concentrate a very high share of French population and GDP. Both ports handle substantial amounts of petroleum products, but this traffic has been excluded from this analysis, because their enormous volume will have a too strong influence on the result of the model compared to other types of cargo.

The hinterland of the port of Marseilles covers the départements located in Southern France, almost until Lyon at East, and until Toulouse to the West, both city regions generating substantial amounts of general cargo. Important amounts of bulks are generated by chemical industry, metallurgy and agriculture. Marseille has good maritime connections with Northern Africa, East-Asia (ex. Taiwan, with CKYH alliance⁵) former USSR countries, and the Middle East.

The foreign ports of the Northern Range and Dunkirk, share common hinterlands in the North and East of France: they handle a high share of maritime cargo generated by the départements located on the northern and eastern boundaries of France and much larger areas around Strasbourg, Dijon and in some cases until Lyon.

The secondary ports hinterlands have essentially local hinterlands, and sometimes even less. These ports are essentially located on the Atlantic coast and in the Mediterranean close to the boundary with Spain. Their traffic is generated essentially by a little number of activities: agriculture, animal farming, forestry products, chemical products and building materials.

Globally, hinterlands vary little depending on the measure considered: weight or value. More important variations can be found when imports and exports are compared. The core of the hinterlands of global ports remains rather unchanged; what really change are the margins. Overlapping between the hinterlands of global and secondary ports is often the result of complementarity: the first rather handle manufactured cargo flows, the second bulks, mainly related to agriculture and animal farming. Overlapping between the hinterlands of global ports is much likely to be the result of real competition. This competition takes place essentially in Eastern France and mainly concerns the areas of Dijon and Lyon. Secondly, the area around Lille and the border regions located close to Belgium are shared between Belgian ports and Dunkirk, and the Lower Seine ports, as outlined before by Charlier (1996, 2011). The influence of Dutch ports is much stronger on the region of Strasbourg, well connected to Rotterdam by the Rhine waterway. Most of time hinterlands are spatially continuous, but some exceptions exist, mainly around Lyon, that seems to be an area where rude competition takes place between all the global ports.

⁵ Cosco/K Line/Yang Ming/ Hanjin

Table 2. Results of the spatial interaction model

Type of cargo	α	Explanatory power of	Specific explanatory power
		model (mass and distance)	of distance
		r^2	$r^{2'}$
Agricultural products	-3,1 ^{***}	92%	78%
<i>Import</i>	-1,8 ^{***}	71%	42%
<i>Export</i>	-3,9 ^{***}	97%	90%
Animal Food	-2,2 ^{***}	83%	67%
<i>Import</i>	-2,1 ^{***}	86%	66%
<i>Export</i>	-2,4 ^{***}	81%	59%
Fertilizers	-3,8 [•]	91%	83%
<i>Import</i>	-4,0 [•]	93%	88%
<i>Export</i>	-3,8 [•]	90%	77%
Solid Mineral Fuel	-3,8 ^{***}	82%	50%
<i>Import</i>	-3,8 ^{**}	79%	50%
<i>Export</i>	-3,1 ^{***}	61%	36%
Petroleum products	-4,4 [•]	97%	92%
<i>Import</i>	-4,4 [•]	97%	91%
<i>Export</i>	-4,3 [•]	99%	98%
Ores and waste materials of the metallurgical ind.	-5,1 [•]	94%	83%
<i>Import</i>	-5,6 [•]	95%	87%
<i>Export</i>	-3,8 [•]	85%	69%
Metallurgical products	-3,3 ^{***}	89%	72%
<i>Import</i>	-3,8 ^{***}	84%	57%
<i>Export</i>	-3,0 ^{***}	92%	75%
Building Materials	-2,6 ^{***}	87%	74%
<i>Import</i>	-2,9 ^{***}	83%	64%
<i>Export</i>	-2,4 ^{***}	91%	77%
Chemical products	-2,1 ^{***}	82%	62%
<i>Import</i>	-3,3 ^{***}	88%	77%
<i>Export</i>	-1,3 ^{***}	80%	43%
Manufactured goods	-1,4 ^{***}	69%	38%
<i>Import</i>	-1,5 ^{***}	76%	44%
<i>Export</i>	-1,4 ^{***}	65%	30%
<i>Total cargo with petroleum products</i>	-3,0 ^{***}	93%	83%
<i>Import</i>	-3,3 [*]	94%	84%
<i>Export</i>	-2,7 ^{***}	92%	81%
<i>Total cargo</i>	-2,7 ^{***}	86%	75%
<i>Import</i>	-2,7 ^{***}	83%	72%
<i>Export</i>	-2,6 ^{***}	88%	75%
*** Very Significant ** Significant		● No significant	
* Slightly Significant			
Extra-EU French Maritime Flows between départements and ports (2005)			

VARIETY OF HINTERLANDS DEPENDING ON THE TYPES OF CARGO

All types of cargo flows are not equally constrained by distance. The doubly constrained spatial interaction model is used to measure these differences. The distance-decay parameter (α) can be interpreted as a measure of the decrease of flows between ports and départements with distance, other things being equal. A distance-decay parameter of 0 means that the inland location of a shipper doesn't have influence on port choice. A distance-decay parameter of -5 means that the nearest port is systematically selected. This "distance decay" or "friction of distance" effect vary depending on the type of flows being examined, manufactured cargo as opposed to ores, for example.

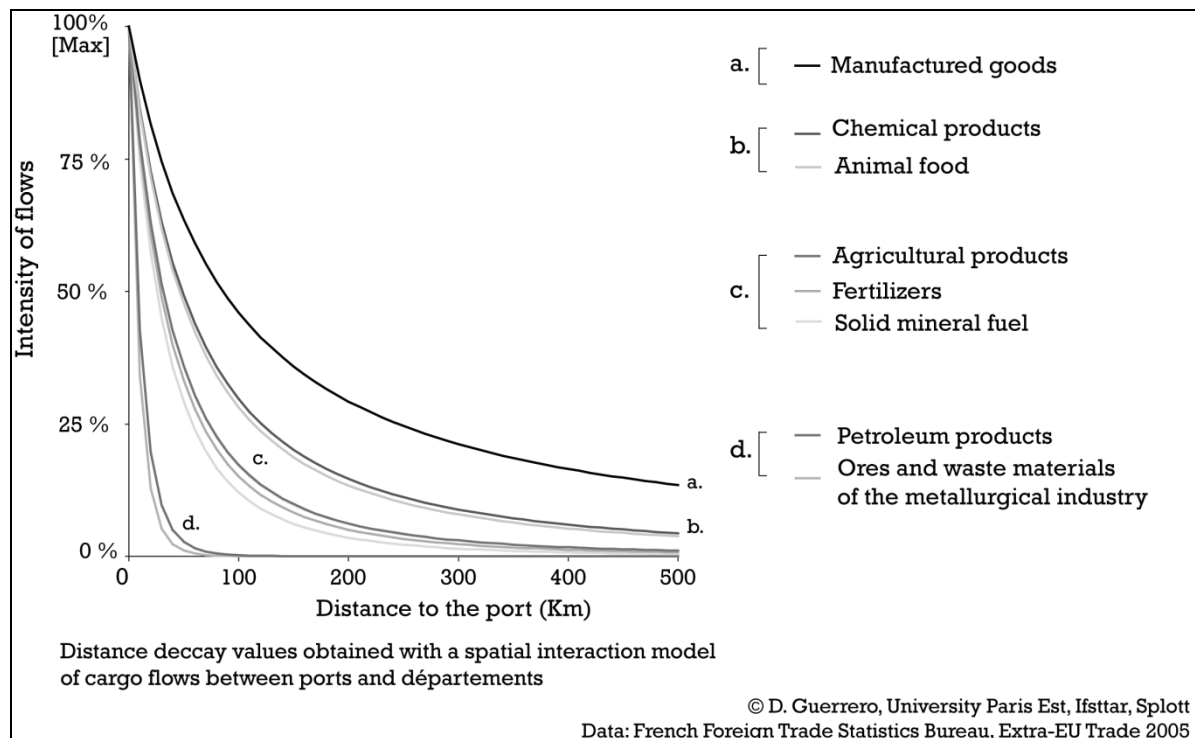


Figure 6. Relationship between the distance to the port and the intensity of cargo flows

Table 2 shows the results of spatial interaction model. The average value of distance-decay parameter (α) for all types is -2,7 (flows in tons, without petroleum products), which means a rapid decrease of the intensity of inland flows when distance increases. The results for imports (-2,7) and for exports (-2,6) are slightly equal and can be compared with the spatial patterns observed in the maps analysed above (Figure 5). The results of the spatial interaction model show that French hinterlands are strongly distance-constrained. The maritime flows of the départements tend to be handled by the nearest ports. From the point of view of ports, links with local areas tend to be more intense. This finding is consistent with the concept "primary hinterlands" introduced by Morgan (1948), but in the case of French ports local areas are not necessarily captive, as will be showed later in this paper.

Estimated distance-decay parameters vary significantly between types of cargo (see Figure 6). The highest (α) values have been obtained respectively with flows of ores and waste materials of metallurgy ($\alpha = -5,1$) and petroleum products ($\alpha = -4,4$). Other highly distance-constrained flows are those of solid mineral fuel ($\alpha = -3,8$), fertilizers ($\alpha = -3,8$), metallurgical

products ($\alpha = -3,3$) and agricultural products ($\alpha = -3,1$). The (α) values obtained for the other types of cargo are weaker than the average: building materials ($\alpha = -2,6$), animal food ($\alpha = -2,2$) and chemical products ($\alpha = -2,1$). The inland flows of manufactured products⁶ are the less distance-constrained ($\alpha = -1,4$). The value of friction obtained in France on manufactured flows is slightly higher than those obtained in the models of Pitts (1994) and Levine et al. (2009) for U.S. container imports and exports.

For all types of cargo, the explanatory power (r^2) of the combined effect of mass (tons generated by ports and départements) and distance is high (between 69% for manufactured goods and 94% for ores and waste materials of the metallurgical industry). Moreover, the variance specifically explained by distance ($r^{2'}$) bring interesting information about the degree of overlap between hinterlands of ports, avoiding the mechanical effect of mass.

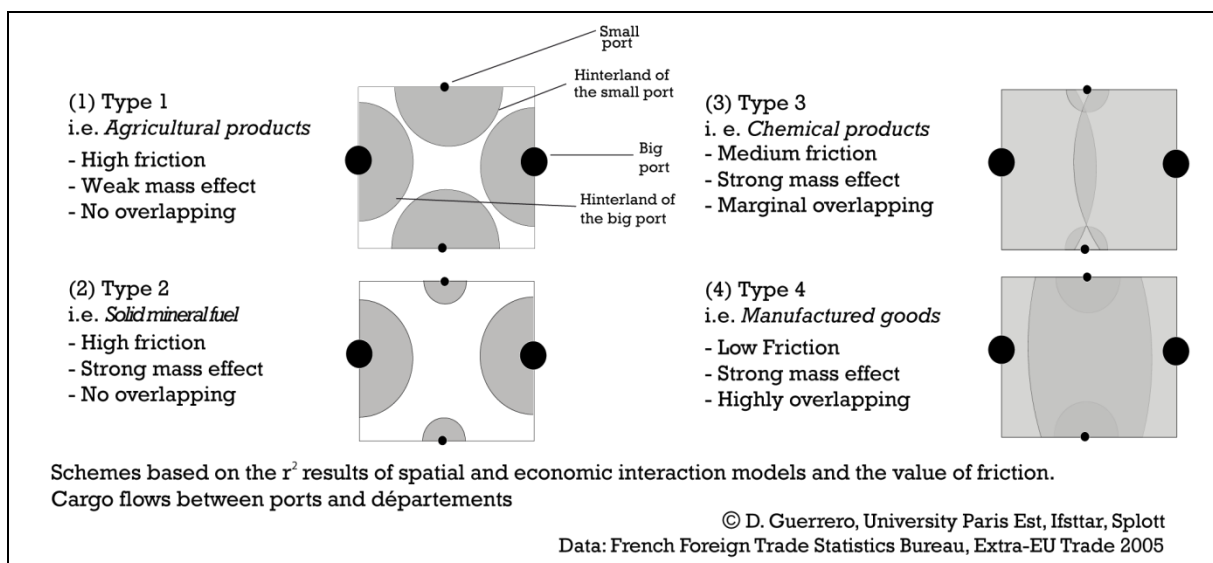


Figure 7. Typology of hinterlands based on the results of geographic and economic model

High values of $r^{2'}$ can be interpreted as captive hinterlands, because most of variance is explained by distance, that is, flows are handled by the nearest port. On the contrary, low values of $r^{2'}$ indicate that distance explains a little part of the spatial distribution of flows, meaning substantially overlapped hinterlands, where competition between ports could virtually take place. Using both values of friction (α) and the part of variance specifically explained by distance ($r^{2'}$) for distinguishing and grouping types of cargo flows, one can generalise with respect to the size of ports and the extent and overlapping of hinterlands. The result is a typology of hinterlands that has four basic types (Figure 7):

- In the first type, hinterlands can be defined by a **weak mass effect and a strong friction** (for example agricultural products). The size of the département doesn't matter, because these activities generating these cargo flows don't need to be too close to markets or populations. On the contrary, it is in low densely populated

⁶ The Appendice 3 presents French hinterlands of manufactured cargo, using the same method of the figure 5.

départements that most of flows are generated. The size of ports doesn't matter. Either small (ex. ports of Languedoc) or large ports (ex. Rouen) can handle this cargo, which mainly consists of dry bulks. Ships are tramping and convey full loads. Shippers search to minimize inland haulage, because this kind of cargo cannot absorb high inland transport costs.

- The second type of hinterlands has **strong mass effect and high friction** (for example petroleum products). Short flows predominate, because of the high friction, or cost of overcoming distance. This is particularly true at the level of port industrial zones. In the main port industrial zones of Marseilles-Fos, Le Havre and Dunkirk most of the traffic is conveyed across relative short distances.
- The third type of hinterland has **strong mass effect and medium friction** (for example chemical products). Related to the latter, this kind of cargo is shipped over longer distances, to the industries and market located in inland départements (for example Lyon area) but there is little overlapping between hinterlands.
- The fourth type of hinterlands has **strong mass effect and weak friction**. It's that of manufactured cargo flows, where scale economies of container ports play an important role and cargo is relatively valued high. This type of hinterland is strongly influenced by the relative location of the consumer concentrations and national markets. The inland départements that generate the most important manufacturing flows are those of Paris and big cities (more than 200 000 inhabitants), where wholesalers are overrepresented (Guilbault and Gouvernal, 2010). Largest départements and global ports have the largest flow volume, and also some of the longest haul.

The results of the spatial interaction model suggest several things. First, the size of ports and départements are primary variables in explaining the pattern of export flows through ports in the model. Large ports tend to have the largest number of port calls, the most destinations served, and the best and fastest infrastructure. The trend towards load centering and hubbing by the shipping lines has helped to encourage this trend. Inland urban areas are also important, because they generate increasing amounts of cargo, specially manufactured flows. At the same time, however, and more important for the purposes of this paper, distance remains a strong factor in the flow of cargo via seaports. Most types of cargo experience strong levels of distance-decay for exports and imports. Manufactured goods, mostly containerised, remain distance-constrained, but in a lesser extent than the other types of cargo. This seems to suggest that distance matters both on containerised and non-containerised cargo, but the domination of big ports in manufactured goods (that is, containerised) is much important than for the other types of cargo. This tempers the arguments that say that inland distance no longer matters in the seaport used (Van Klink and Van den Berg, 1997).

The model as proposed does not explain a minor proportion of the variance in the dataset. There are probably some variables, other than volume and distance, which have some effect on spatial structure of flows between ports and départements. Things such as further information on the maritime portion of the voyage, that were not included in the present dataset, might help increase the explanatory power of the model. In any event, it seems rather to be true that there are distinct catchment areas for different overseas regions. This idea is supported by Robinson (1970) who drew different tributary areas to the port of Vancouver for trade with Japan and United Kingdom. He found, in a North-American context, that hinterlands and forelands were strongly linked, and should be analysed simultaneously.

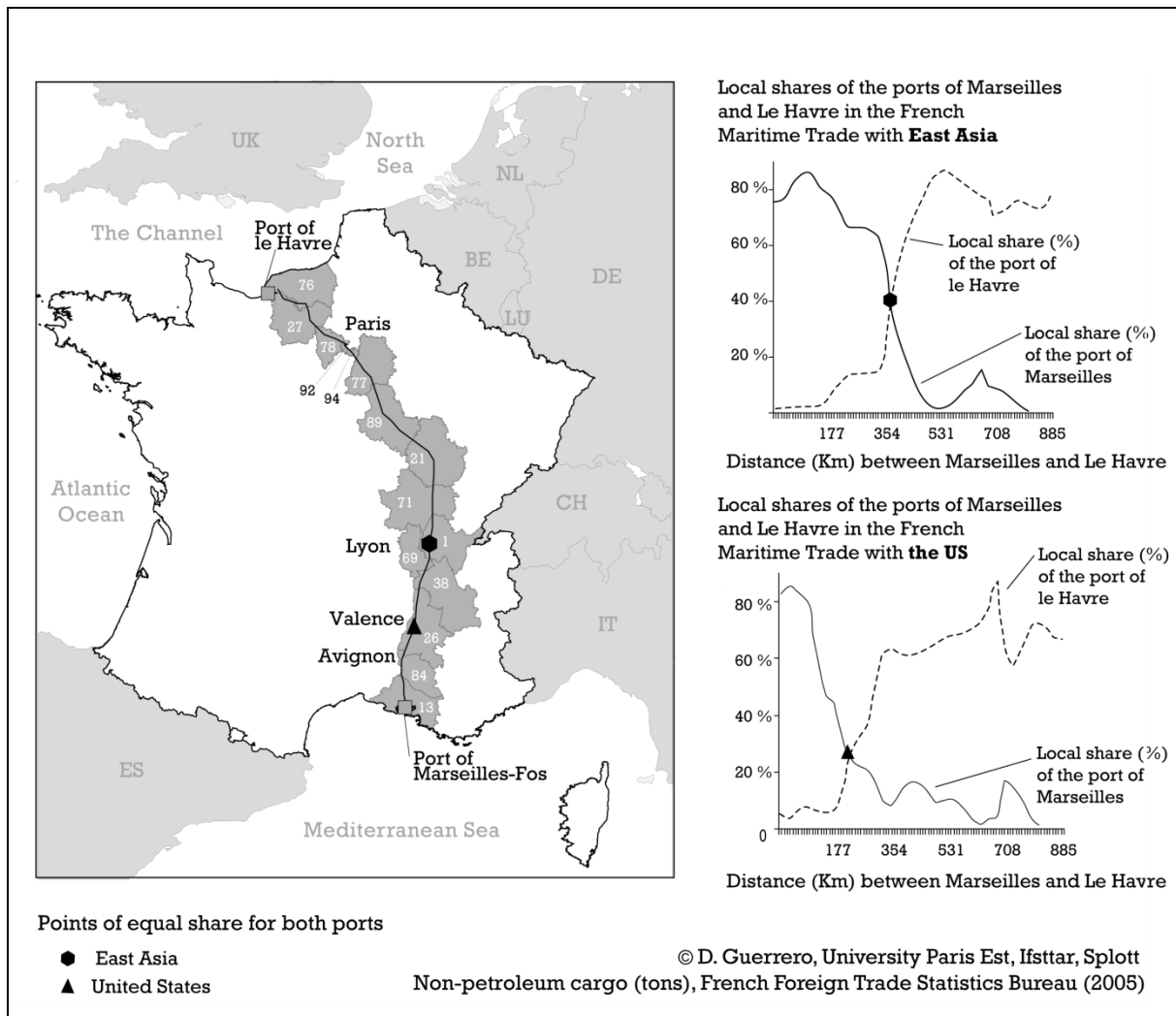


Figure 8. Hinterlands of Le Havre and Marseilles. Trade with East Asia and US

4. THE LINK BETWEEN HINTERLANDS AND FORELANDS: A FOCUS ON MARSEILLES AND LE HAVRE

Following Robinson's idea of a *continuum* hinterland- foreland, we analyse in a similar way the hinterlands of the French global ports: Le Havre and Marseilles. We narrow the focus on a longitudinal transect that follows the inland highway between both ports. The graph represents the local share of each port in the total maritime trade of the *département*.

For the trade with East Asia, the shares of both ports are very high on their primary hinterlands. Marseilles largely dominates the first 300 km, then it decreases dramatically from Lyon and increases slightly in the Paris region. In the case of Le Havre the domination over other ports is less clear in the primary hinterland, where it shares the territory with the port of Rouen. Its share increases between 300 and 500 km, concerning the region of Paris and beyond. Near Lyon, the hexagon-shaped symbol indicates that the shares of both ports are equal.

For the Trade with the United States, the lengths of the hinterlands of the two are very unequal.

Marseilles only dominates the first kilometres, then it decreases dramatically from Avignon. Le Havre keeps a high share of the U.S. maritime trade of départements until Lyon and beyond. Between Valence and Avignon, the triangle-shaped symbol indicates that the shares of both ports are equal.

This analysis validates the hypothesis of the continuum hinterland-foreland for French global ports. Marseille's peripheral location at the southern end of France railroad has meant, in effect, that the port's competitors, rather than being on the same coastline are in fact at the northern end of the highway-or at least in the industrial heartland and major Canadian market. The southward extension of the hinterland of Le Havre for U.S maritime trade can be easily explained its very frequent maritime services (Frémont and Soppé, 2007). Moreover, Le Havre is the last port of call for most of services between Northern Europe and North America. For this foreland, French shippers often prefer Le Havre, even if it represents larger inland haulage than Marseilles.

The situation is slightly different for East-Asian trade, even if Le Havre has unquestionably more frequent maritime links, this advantage is partially compensated by shorter transit times from Marseilles. The inland distance appears to be the factor that tips the balance in favour of one port or another.

5. CONCLUSIONS

Our research was aimed at bringing evidence about the shape and the extent of current French hinterlands. Our results show that ports are not isolated of their hinterlands, the main cargo flows take place between ports and local regions. The combined effect of the size (volume of cargo generated by ports and départements) and distance accounts for at 86 % of the variation in total flows and 69 % in manufactured flows. The rest is probably due to foreland differentiation seen above, strategies pursued by transport operators and governments concerning the ports they manage and/or for which their authorize development, specific geographies of niche markets and hub strategies (including direct rail links) and other specificities that cannot be reflected in a global model. Be that as it may, the importance of distance in explaining hinterlands indicates that current inland connections are stable and path dependent over the long term.

Our results are particularly interesting in the light of Charlier (1981) finding that French hinterlands remain largely constrained by distance. Thus whereas the share of the hinterlands between gateways and secondary ports remains unchanged for all cargo, only the first can attract manufactured cargo flows. These seemingly contradictory results are in fact consistent one with another. On the field of containerised cargo, a select group of advantaged ports has benefited of containerisation at the expense of many other ports, both large and small. On the field of bulks and short sea shipping there has been an equalization provoked by the development of niche markets, mainly driven by agriculture, forage and forestry products.

There are several implications of this conclusion. First, port authorities must do difficult choices of deciding how and where to concentrate marketing efforts. Sometimes, port authorities put effort on competition margins without caring enough on the immediate hinterland wrongly supposed captive. This analysis finds that immediate hinterlands are not so captive (cf. Le Havre), then the demand of local shippers must be taken seriously.

Second, hinterlands go beyond national borders (cf. Belgian and Dutch ports in Northern France). As argued earlier by Baird (2004) partially common hinterland for global ports suggests the need for a more cohesive European policy for these ports in particular.

Last but not least, the model has also quantified the values of friction for different types of cargo. This is an important finding as it provides empirical support for making scenarios about the impacts of the abandon of secondary ports on economic activities such animal feeding. The stronger influence of friction relative to other factors in these hinterlands provides an empirical justification for giving priority to secondary ports in public policies.

ACKNOWLEDGMENTS

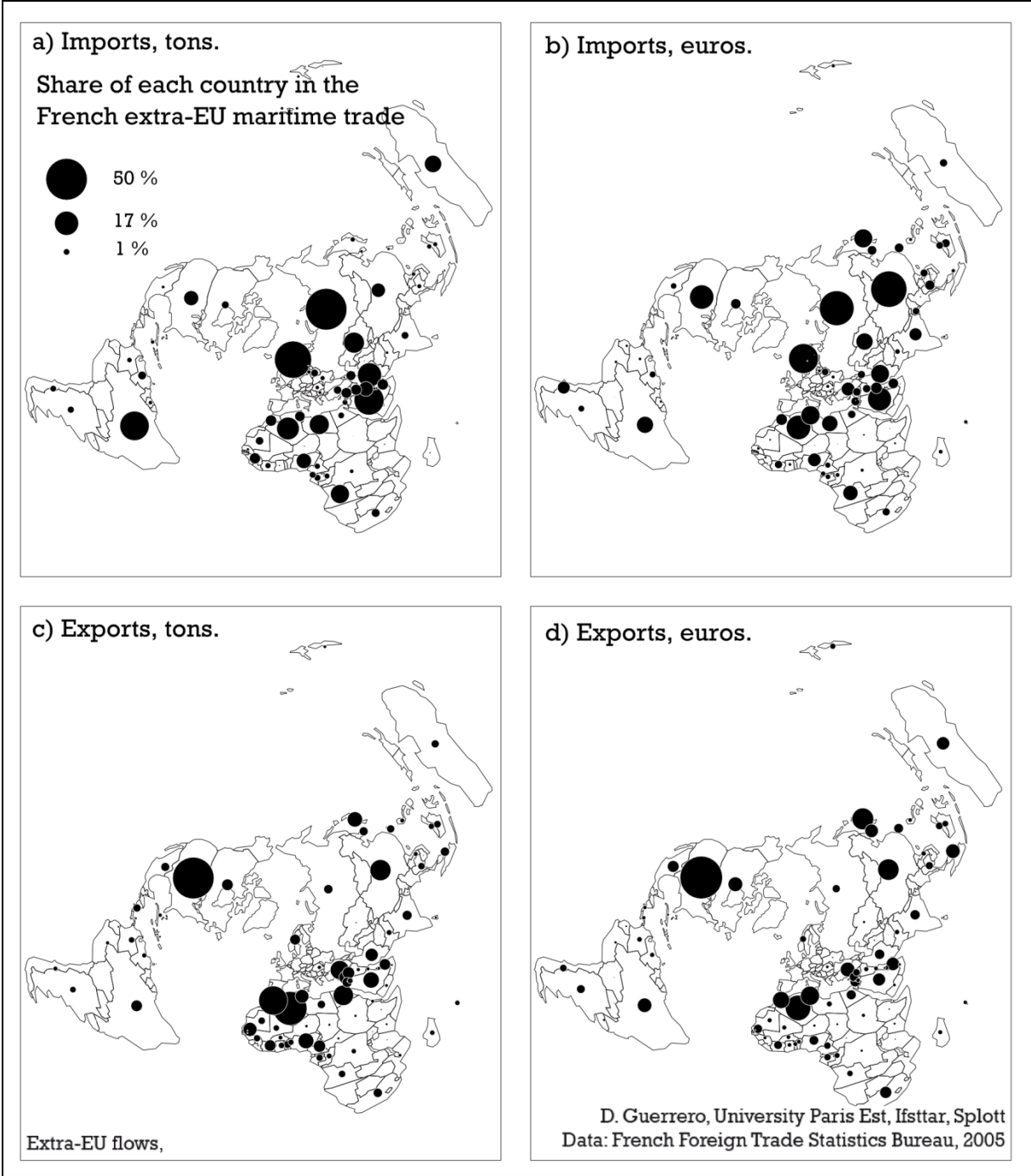
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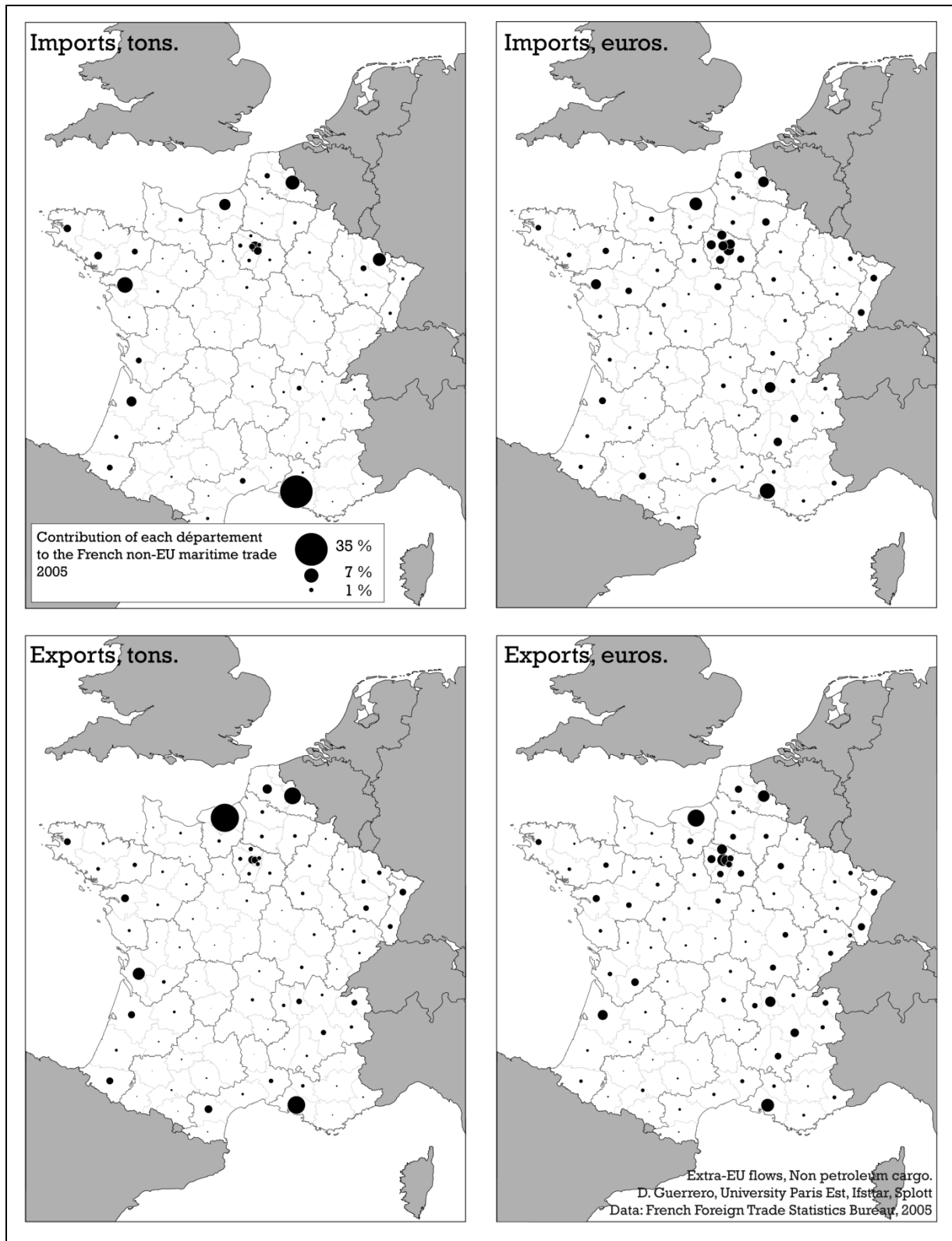
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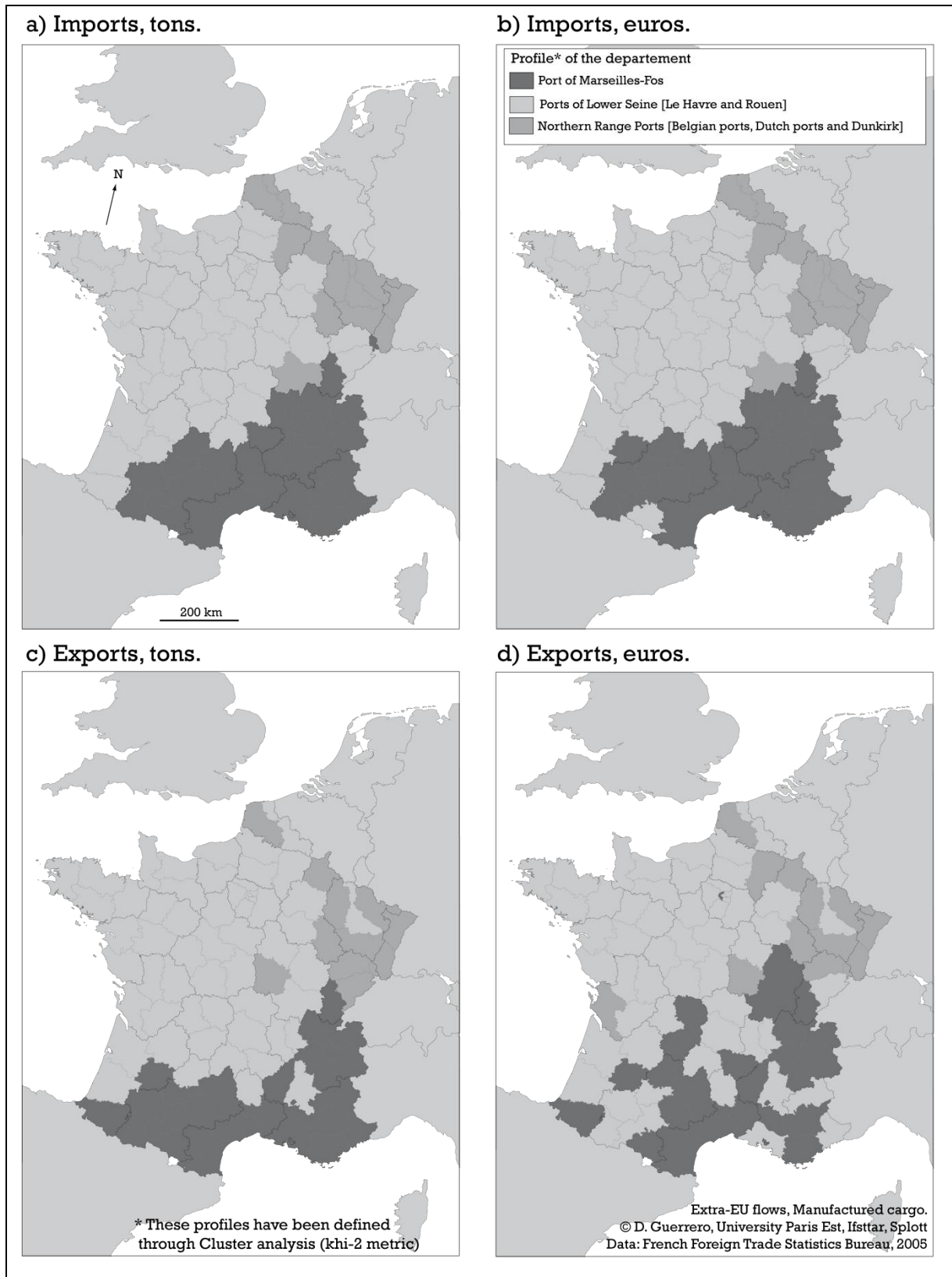
APPENDICES



Appendice 1. Spatial distribution of French extra-EU maritime trade (2005).



Appendice 2. Volumes of maritime trade generated by départements (2005).



Appendice 3. Hinterlands of manufactured cargo (2005).