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David Guerrero

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David Guerrero[1]

[1] *Université Paris Est, Ifsttar, Ame-Splott*
14-20 Bd Newton 77447
Champs-sur-Marne, France

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ABSTRACT

In this paper is examined the spatial distribution of international trade flows between the French NUTS-3 regions and West-European ports. The research question focus on the impacts of the quality of inland and maritime connections on the scope of hinterlands. The results of a spatial interaction analysis show that distance remains a strong barrier for port choice but slightly less than in the past. Its effect is significantly lower when intermodal connections -such regular barge or rail services-are available. A case study focused on East Asian trade shows that factors related to maritime connectivity such the frequency of containerized services at ports and their ability to accommodate large vessels also contribute to limit the distance impedance. However these effects considerably vary depending on the value density of cargo.

Keywords: port, hinterland, containerization, spatial interaction models, intermodality

Corresponding author:
david.guerrero@ifsttar.fr

1. INTRODUCTION

In this paper spatial interaction models are used to measure the impact of the quality of land and maritime connections on hinterlands, i.e. the market areas of ports. It is focused on the case of France, an developed country served by the two main European port ranges, where hinterland data is available at a detailed geographical level. A former work (Guerrero 2014) is updated and expanded in several ways. First, cargo heterogeneity is taken in account by distinguishing four groups of flows based on their value density. Second, intermodal connections between ports and inland regions are considered. Third, an origin-constrained model is used to measure the impact of maritime transport supply at ports on hinterland's scope.

Understanding the impacts of transport connections on hinterlands is important from several perspectives. First, a better assessment can be done of the consequences of major shifts in maritime transport, such the recent introduction of mega-vessels or changes in service frequency, on hinterlands. Second, the influence of intermodal connections on hinterland expansion can be estimated, for different types of shippers. This could be helpful for planners and policy makers aiming to evaluate the impact of infrastructure improvements on specific industries and regions. From the perspective of regions relying on distant suppliers or clients, securing access to one or several ports, at a reasonable cost, is a key issue for their economic development. In the specific context of France, this is particularly true for retail and manufacturing industries highly dependent on distant inputs (e.g. automobile, household appliances, agri-food sector). Access to ports is also a major issue for firms doing most of their sales overseas such those in the fields of wine and spirits, electronic or luxury products.

This paper also aims to assess the importance of geographical proximity in port choice. It seeks to test if the preference of shippers for closer ports has diminished or not in the recent years, in favor of other forms of proximity (Hall and Jacobs 2010; Torre and Rallet 2005). To assess the link between geographical proximity with changes in maritime industry, a case study is carried out on the trade with East Asia. The article is strongly focused on the relevance on the quality of inland and maritime transport connections in the interpretation of the changes on hinterlands. Less attention is paid to other aspects explaining port choice such the strategies of shipping companies and terminal operators, border effects, or governance issues. Nevertheless, these factors have an impact on hinterland friction, so they receive some attention as well.

The rest of the paper is structured as follows. A review of literature is provided in the next section. Section 3 presents data and method. Section 4 provides detailed results of spatial interaction models for different years, testing the effects of both inland and maritime transport connections. Section 5 presents the conclusions and some implications for port actors and policymakers.

2. BACKGROUND

This article aims to contribute to two types of studies in port geography: (a) those related to containerization and its impact on hinterlands, (b) those more specifically related to distance impedance and barriers.

2.1. *Containerization and hinterland expansion*

Containerization has challenged the hypothesis of captive hinterlands that are spatially concentrated around ports. New kinds of liner shipping services such those organized as hub-and-spokes networks, involving increasing concentration of flows and then . As a matter of fact, the overall efficiency of shipping networks increasingly relies on the individual efficiency of a small number of nodes, generally a few in each world region (Ducruet and Notteboom 2012). For pure hubs, efficiency simply relies on sea-sea transshipment activities, but for the vast majority of ports the interconnection with hinterland should also be achieved (Hayuth 1992; Robinson 2002).

Between 1960s and 2000s, container has enabled important changes in liner shipping, making possible the transport of almost any kind of cargo on a same ship. For shippers, it offered the opportunity to ship low volumes of cargo at low cost. For carriers and terminal operators, it offered the opportunity to concentrate flows and achieve economies of scale. Each container can be easily transferred between ships and terminals or another means of transport without unpacking. These characteristics, made possible by standardization, allowed significant economies in handling activities and maritime transport (Neufville and Tsunokawa 1981; Cullinane and Khanna 2000). However, the high capital cost of container ships and handling tools necessitate a push for its maximum utilization. This push can only be achieved when the ships are sailing at their full capacity. However when the demand is weak, such during the past ten years, shipping lines should reorganize themselves in alliances in order to optimize their transport capacities, avoiding -as far as possible- empty slots.

In the recent period (2007-2017), the emergence of mega-vessels and the development of alliances have drastically affected ports. Larger vessels imply higher container volumes at each call, requiring infrastructure upgrading, and also improved coordination with efficient inland connections. A recent work has showed that a single call between Europe and the Far East now typically generates an annual container volume of 300,000 TEU (Notteboom *et al.* 2017). There are less services, concentrated in fewer ports per range, and inducing changes all along the supply chain, particularly on the land side. One of the aims of this work is to better assess the impacts of these shifts on the hinterlands.

As shipping lines compete for achieving economies of scale in maritime transport, ports struggle for securing hinterland access, which is becoming more than ever a key element in their competitiveness. This idea is well summarized by the concept of port regionalization (Notteboom and Rodrigue 2005). It implies strong integration of ports with both inland and maritime segments. Ports are viewed as nodes within intermodal networks and competition takes place between transport chains instead of between ports (Robinson 2002). Inland terminals are used to alleviate congestion and lack of space at ports, and high capacity intermodal connections by rail and barge are developed. Attracted by lower land costs and high levels of accessibility, logistic zones emerge around these inland terminals, offering services such the fulfillment of customs formalities, depots for empty containers, cargo consolidation, inventory management or pre-assembly of components. Although the regionalization process is essentially driven by market forces (2005), public actors also play an active role in the inland expansion of port systems (Wilmsmeier *et al.* 2011). The direction of regionalization, initially considered from the sea to the land is debated. It is not systematically driven from ports, but it also can be driven from the land (intermodal operators, public organizations) to the sea (Monios and Wilmsmeier 2012a). In a recent work based on the successful case of Venlo-Rotterdam, Raimbault et al. (Raimbault *et al.* 2016) further adds on the complexity of the model, by demonstrating that both directions can be at play simultaneously. As compared to the situation observed in the Netherlands, it should be noted that the scope of regionalization process in France is more limited, partly because of the lower volumes handled by its ports. To address this issue, the recent reforms of French ports (2006-2016) have largely promoted the association of maritime and waterway ports, and allowing them to be directly involved in dry port development (Lacoste and Douet 2013; Debrie *et al.* 2017).

2.2. *Borders and other sources of impedance*

Despite a stronger integration in the context of port regionalization, important barriers remain to hinterland expansion. Recent works continue to underline the importance of borders and distance in the configuration of European hinterlands, showing their unequal effects depending on the geographical position of countries: coastal or landlocked. The former are more constrained by inland distance than the latter. While coastal countries are tied to their national logistics networks, landlocked ones have historically expanded their logistics networks beyond in order to get access to the sea (Kashiha *et al.* 2013). The impact of borders on hinterland flows would also be more or less strong depending on the ports considered, borders are more easily crossed to reach Belgian or Netherlands ports.

Border effects also considerably vary depending on the direction of flows. Therefore, the effect of the alpine border would be stronger for Italian ports than for those of the Northern Range, both competing for the North Italian market (Ferrari *et al.* 2011). This asymmetry would result not only from the different levels of service of ports but also on the unequal level of skills of the actors involved on hinterland connections on both sides of the Alps (Acciaro *et al.* 2017). The latter differences are not just limited to language proficiency but also commercial skills and the ability to cope with different cultures.

Another factor which still heavily shape the hinterlands is the geographical proximity between ports and inland markets. This has been proven to be true in several regional contexts (Malchow and Kanafani 2004; Xu and Ito 2017; Itoh 2013; Charlier 1990; Guerrero 2014; Wang *et al.* 2017; Garcia-Alonso and Sanchez-Soriano 2010; Tiller and Thill 2017). However, its impact on inland flows varies considerably depending on the shape of the countries: large countries with broad inland regions such the United States tend to exhibit lower friction values (Pitts 1994) than much smaller coastal countries such France or Italy (Ferrari *et al.* 2011). In the latter, the relatively high values of friction partially result from the few alternatives to road haulage, this is different from the US context where there is an extensive use of rail intermodal transport.

Last, but not least, recent works have pointed out the development of port-centric logistics, implying container stripping at ports and re-distribution of imported goods from port-based distribution centers (DCs). One of the advantages of this location would be the reduction of inland transport costs, allowed by the elimination of empty inland running of containers (Mangan *et al.* 2008; Ng and Liu 2014). However, when the inputs of DCs are sourced not exclusively from overseas, the location at ports, generally at the margins of countries, may be sub-optimal with regard of the location of clients (Monios and Wilmsmeier 2012b; Acciaro and McKinnon 2013). Another limitation of port-centric logistics is that the reduction of transport cost obtained by the elimination of empty returns of containers would be partly offset by the increase of volume of cargo resulting from the use of pallets and individualized packages (Acciaro and McKinnon 2013). The distribution of the load of one single container of densely packed goods would even require several trucks (McKinnon 2014). Finally, the impact of port-centric logistics on hinterlands would be mixed. On one hand, it involve an increasing weight of distribution activities in port surrounding areas, implying a kind of captivity *vis-à-vis* specific ports. On the other hand, the increased efficiency of inland transport would contribute to the intensification of long haulage flows, and then to an increasing competition between ports. However, given its relative newness, and it's still limited development in France compared to other countries such UK or the Netherlands, its impacts on friction are likely to be minimal.

In this article the friction is used as a measurement of trade impedance between regions and ports (for a compelling conceptual framework on trade impedance see Tiller and Thill (2017)). The last work on French hinterlands based on 2005 data is updated. The 2008/2009 crisis, changes on production and distribution systems such manufacturing off-shore and the generalization of e-commerce would have considerable impacted the organization of the catchment areas ports. In such a context an update of the former works devoted to French hinterlands appears to be necessary.

3. DATA AND METHOD

3.1. *Data*

To measure the variations of hinterlands for different types of flows a database has been built with information from French Foreign Trade Statistics. The data, provided in a disaggregated and exhaustive fashion, delivers information on the value and weight of trade between French NUTS-3 regions and European ports (see Figure 1). Data on 2008 (exports) and 2012 (imports and exports) is used. An important methodological break has occurred in foreign trade data collection in 2007 (Guerrero 2014), meaning that comparisons between the periods before and after 2007 are problematic. Moreover, due to changes in procedures on data collection between 2007 and 2010, important data problems have been observed, particularly for imports. It is for that reason that temporal comparisons have only been made for exports.

Figure 2 depicts the market shares of the ports serving the five French macro-regions during the 1999-2012 period. The top container ports of Le Havre, Marseilles-Fos and Benelux ports attract between 60% and 80% of the trade generated by each macro-region. While Le Havre captures most of the exports from Western France and the Paris region, Benelux ports dominate the strongly industrialized North East. Marseilles-Fos handles almost a half of the trade generated by the South-East, but the local share of Benelux ports has increased in the recent period. Unsurprisingly, during the overall period, secondary ports have been losing ground against the top container ones.

The spatial units used in the model are the French NUTS-3 regions, also known as départements. 95 NUTS-3 regions have been considered, excluding those of Overseas French Territories. Customs offices located in French ports were aggregated into ports.

Information about ports of foreign countries handling French foreign trade is only available at the country level. Then, ports have been divided into two types: (a) 16 individual ports located in France and (b) 5 foreign country port sets, which handle together 98% of the value and 97% of the tonnes of French foreign trade. The truck time-distances between centroids of NUTS-3 regions and ports used in the spatial interaction model have been extracted from ESPON inter-NUTS-3 distance database (Spiekermann *et al.* 2006). To measure the impacts of intermodal connections, two datasets have been created with high capacity waterway links (Voies Navigables de France) and rail intermodal services in 2012 (Naviland Cargo). Data on shipping services between East Asia and European ports has been obtained from International Transport Handbook in 2012, edited by Ocean Commerce Ltd, headquartered in Japan.

3.2. *Method*

A doubly constrained spatial interaction model has been used to model the geographical distribution of trade flows between the NUTS-3 regions and the ports, by testing variables related to the interactions between both. In its basic form factors related to the cargo volumes generated by the NUTS-3 region and to the port, and a distance variable are fitted. The doubly constrained spatial interaction model used is formulated as follows:

$$I_{ij} = A_i \cdot O_i \cdot B_j \cdot D_j \cdot d_{ij}^{-\alpha} \cdot IWT_{ij} \cdot RAIL_{ij}$$

where O_i is the total maritime traffic of the NUTS-3 region called i, D_j is the total maritime traffic of the port called j; d_{ij} is the distance between i and j; α is the friction parameter; and A_i and B_j are the balancing factors ensuring that the origin i and the destination j constraints are satisfied. A NUTS-3 region is referred to as i and a port is referred to as j. $\cdot IWT_{ij}$ and $RAIL_{ij}$ are two dummies indicating when at least one weekly intermodal service is available between a NUTS-s region and a port.

However, doubly constrained models doesn't allow to model factors exclusively related to ports. To overcome this limitation, an origin-constrained spatial interaction model has been fitted to the data. This involved fitting a factor representing the NUTS-3 regions and variables representing port attractiveness and distance. It has been assumed that the volume of trade generated by each NUTS-3 region is fixed. The total volume captured by each port is not fixed, however, and it has been estimated on the basis of the frequency of services and the average size of vessels calling at the port. It can be formulated as follows:

$$I_{ij} = \cdot O_i \cdot VFREQ_j \cdot VSIZE_j \cdot d_{ij}^{-\alpha} \cdot IWT_{ij} \cdot RAIL_{ij}$$

where O_i is the total maritime traffic of the NUTS-3 region called i, $VFREQ_j$ is the number of weekly services with East Asia for the port called j, $VSIZE_j$ is the average size of vessels serving East Asia for the port called j, $\cdot IWT_{ij}$ and $RAIL_{ij}$ are two dummies indicating when intermodal infrastructure or services are available between regions and ports.

The choice of measure of distance influences the results of the spatial interaction model. The truck time-distance has been selected because it seemed to be consistent with the French context, where road transport plays a largely dominant role in the ports modal split. Moreover, the explanatory power of the model appeared to be slightly higher when the truck time-distance was used, as compared to the distance as the crow flies. The data finally used is a matrix of freight flows, usually measured in annual tonnes moved. As the o/d matrices contained many zero values, a Poisson regression has been used to fit the spatial doubly constrained model (Flowerdew and Lovett 1988; Fotheringham and O'Kelly 1989; D'Aubigny *et al.* 2000).

The friction parameter (α) is interpreted as a measure of the decrease of flows between ports and NUTS-3 regions with distance, other things being equal (see Tiller and Thill (2017) for a compelling discussion on distance impedance).

A friction parameter lower than 1 means that the friction parameter is less than proportional to distance. A friction parameter of 1 means that the friction parameter is proportional to distance. The higher the friction the more limited is the scope of the hinterlands. A friction of ∞ would imply that the area of the hinterland is equal to zero. The friction parameter provides an overall indicator of a combination of factors which vary with distance, to which subsequent reference will be made. In this paper it is also considered as a proxy of the sensitivity of shippers to transport cost depending on the types of commodities.

4. RESULTS OF THE MODEL

A doubly constrained spatial interaction model has been used on flows on different years to measure how the sensitivity of different kinds of shippers to distance has evolved, particularly since the 2008 crisis, which is supposed to have widen the gap between largest ports and the secondary ones (Notteboom 2010). To take in account the heterogeneity of cargo, four datasets have been considered depending on the density of value of flows.

4.1. *A recent relaxation of the distance constraint*

Table 1 reports the estimates of a doubly constrained spatial interaction model without dummies for four subsamples of cargo flows based on value density, in 2008 and 2012. It shows that inland distance has a negative relationship with port choice, and its effect is slightly stronger for low value cargo (Group 1). For the latter, the preference for nearer ports has even increased between 2008 and 2012. This change in friction partly results from a relative specialization of large ports in higher value cargo, mostly containerized, meaning that smaller ports usually located closer to the shippers, catch a higher proportion of them.

The other groups of flows, implying cargo of higher value, have evolved in the opposite direction. Inland distance is valued less negatively than in 2008. Factors others than inland transport cost such time or reliability seem to become comparatively more important in port choice. Moreover, as stated by Kashiha et al. 2017,price increase resulting from higher transport costs will probably have little effect on the final demand of high value goods. The trend towards load centering and hubbing in container shipping lines has helped to encourage this trend. Large distribution centers and warehouses, mostly located at large urban areas mostly located inland are also crucial, because they concentrate increasing amounts of cargo, mainly manufactured. This might indicate that distance is a factor to contend with for both containerized and non-containerized cargo, but the dominance of large ports in containerized goods is much important than for the other types of cargo, thus confirming the prominent role of economies of scale allowed by containerization.

Despite the substantial differences which exist between the methods, it is worthwhile to put these results in perspective by comparing them with those obtained in other countries. France turns out to be in an intermediate position, somewhere between the U.S. context where friction is relatively weak (Levine *et al.* 2009) and the strong one in Northern Italy (Ferrari *et al.* 2011). These differences result of several factors, such distinct types of organization of inland connections to ports, uneven geographical configurations or institutional frameworks.

4.2. *A significant impact of intermodal connections on hinterland expansion*

Table 2 shows the results of a doubly constrained spatial interaction model including modal dummies in 2012 for imports and exports. It shows that the preference for nearer ports is stronger for exports than for imports. The availability of waterway and rail connections significantly reduces the impedance of inland distance. But the impacts greatly vary depending on imports and exports and on the value density of cargo flows.

Inland waterways have a significant and strong impact on all the groups of flows except those of low value, both for imports and exports. This result is counter-intuitive to what would usually be thought of as a slow transport system for low value cargo such cereals or raw materials. However, inland waterways turn out to be increasingly used for the supply of imported high value goods to heavily congested metropolitan areas such Paris. Moreover, some manufacturers in electronics and home appliances sectors are using waterway transport to strategically delay their deliveries to retailers, to save warehousing costs, and having the possibility to accelerate the flow by shifting from waterway to road in case of emergency.

The impact of the availability of intermodal rail services on flows is also significant, but less than in the case of inland waterways. Its influence is more limited for exports, being particularly high for both lowest and highest value ones. For the latter, the use of intermodal rail services imply certain advantages such for example extra periods for parking at intermodal terminals.

To gain insights into how economies of scale in shipping affect friction information on the shipping services at ports have been included into a new version of the model focused on East Asian trade.

4.3. *The quality of maritime transport supply at ports also contributes to hinterland expansion*

To test the impact of port-related factors an origin-constrained interaction model has been used. Table 3 summarizes the friction values, which unsurprisingly vary depending on the value density of cargo, both for imports and exports. The higher the value density the lower is the sensitivity to inland distance. The frequency of services has a significant impact on all groups of flows but its contribution varies considerably between imports and exports. For the former, the impact of frequency is higher for high value flows. For exports the higher impact is rather on low value added cargo. These important results confirms the impact of the quality of maritime transport supply on transport distance (Wilmsmeier and Martinez-Zarzoso 2010; Guerrero *et al.* 2016).

Vessel size also has a significant and positive impact on flows, meaning that the ports where large ships calls are less constrained by inland distance than the others. There are no substantial differences depending on the value density of cargo.

As in the previous versions of the model, intermodal services also significantly contribute to reduce the impedance of inland distance. In the case of the trade with East Asia, rail intermodal services affect all groups of flows both for imports and exports. Waterway connections have a much more significant impact on imports than on exports.

5. CONCLUSION

In this paper the geographical distribution of flows between French NUTS-3 regions and ports has been modeled. Using doubly and origin constrained models, we examined how distance and transport connections affect the port choice for flows of different value density. The major results of this study may be interpreted as follows:

First, it was shown that the friction associated to inland distance is valued more negatively when the value density of flows is low. For this group of flows, the distance constraint has even increased between 2008 and 2012. However for the other groups of flows, mostly containerized, distance is valued less negatively, and its impact has slightly diminished between 2008 and 2012. This shift is illustrative of the hinterland expansion of the largest container ports concentrating most of the calls of large container vessels. In view of the fast increase of vessel size in the recent years and the order books of shipping lines, this trend is expected to further port concentration.

Second, our study confirmed that the availability of intermodal connections to ports strongly attenuates the distance impedance. Quite surprisingly, the impact of inland waterways appears to be higher for cargo groups of high value density, and theoretically less sensitive to inland transport costs. Conversely, rail services has stronger impact on low value cargo than on the other groups. In the case of East-Asian trade, the contribution of intermodal connections is more significant on imports than on exports, and impacts are generally stronger when the value density of cargo is high. This has been demonstrated in aggregated fashion. To properly understand how intermodal connections contribute to change modal choice behavior, market areas of inland terminals should be studied in detail. Indeed, the relevance of intermodal transport for shippers can greatly vary depending on their location not just within a NUTS-3 region, but even between different locations within a large urban area ((Nierat 1997)).

Third, the characteristics of maritime supply at ports, in terms of frequency and vessel size, strongly affect the port choice behavior. In the case of imports from East-Asia, the sensitivity to frequency of services is positively correlated with the value of cargo. In the case of exports, there is no clear relationship between frequency and value. The fact of being called by large vessels has proven to be determinant in hinterland expansion, both for imports and exports. This confirms the relationship between the scale economies achieved in maritime transport with hinterland expansion. Between 2012 and 2017 the size of vessels on the trade Northern Europe - East Asia has increased from 9.2 to 15.6 thousand TEUs (Toutain *et al.* 2017). This has probably resulted in a further decrease of the inland distance impedance on the hinterlands of ports. For other deep sea routes, such North-South ones, the growth in vessel size has been more limited. To assess the impacts of these different evolutions on shippers, more research is needed, particularly through qualitative surveys on sectors highly dependent on deep sea transport. Also, such an analysis raises the complex issue of the benefits and disadvantages of distant sourcing.

This study showed that both geographical proximity and the quality of transport connections, have a strong influence on port choice, even in a developed country like France. In developing countries, where transport costs are much higher, their effect is expected to be stronger. Yet, in many developing regions, such in Africa or Latin America, contestable hinterlands are very limited, so port choice issues may not always be relevant. In Africa, significant investments have been done in the recent years to develop inland corridors to ports (Pelletier and Alix 2011; Fraser and Notteboom 2014; Dooms and Farrell 2017), eventually contributing to expand contestable hinterlands.

Furthermore, in view of the extant literature on port geography (Ng and Ducruet 2014), these results demonstrate that the ports chosen for deep sea flows could vary considerably depending, not just on the location of the shipper, but also on the overseas regions. Hence shippers are more likely to choose transport chains passing through ports with direct services or with higher frequency. Port authorities or terminal handling operators could then adopt different pricing strategies depending on the overseas regions they serve, in order to attract customers beyond the extent of their usual spheres of influence.

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TABLES

Table 1. Results of a doubly constrained model. All Overseas regions.

Exports, 2008	**Group 1**	**Group 2**	**Group 3**	**Group 4**
α Inland distance (Log)	-1.433***	-1.3061***	-1.6609***	-1.3506***
	(0.1716)	(0.0809)	(0.1667)	(0.1154)
Observations	1505	1129	753	941

Exports, 2012	**Group 1**	**Group 2**	**Group 3**	**Group 4**
α Inland distance (Log)	-1.7841***	-0.9745***	-0.8857***	-0.6156***
Observations	1787	1223	1317	1505

Source: Author's calculations (2017) based on French Foreign trade data.

Table 2. Results of a doubly constrained model. All Overseas regions

Imports, 2012	**Group 1**	**Group 2**	**Group 3**	**Group 4**
α Inland distance (Log)	-1.6237***	-0.8505***	-0.5516***	-0.6777***
	(0.0634)	(0.0623)	(0.0896)	(0.0799)
IWT_{ij}	0.2227	0.8372***	1.4753***	1.0947***
	(0.1527)	(0.1069)	(0.1684)	(0.1217)
$RAIL_{ij}$	-0.3898	0.382**	0.3898**	-0.0026
	(0.2458)	(0.1606)	(0.1982)	(0.1706)
Observations	1975	1505	1317	1303

Exports, 2012	**Group 1**	**Group 2**	**Group 3**	**Group 4**
α Inland distance (Log)	-1.8566***	-1.0267***	-0.9127***	-0.6712***
	(0.0738)	(0.0955)	(0.077)	(0.0823)
IWT_{ij}	-0.234	0.6161***	1.0382***	0.8945***
	(0.164)	(0.154)	(0.1288)	(0.1383)
$RAIL_{ij}$	1.7614***	0.5712**	0.4026**	0.9689***
	(0.2435)	(0.1931)	(0.1435)	(0.1643)
Observations	1787	1223	1317	1505

Source: Author's calculations (2017) based on French Foreign trade data.

Table 3. Results of an origin-constrained model. East Asia

Imports, 2012	**Group 1**	**Group 2**	**Group 3**	**Group 4**
α Inland distance (Log)	-1.1997***	-0.9982***	-0.8228***	-0.6166***
	(0.0631)	(0.0808)	(0.0914)	(0.1143)
$VFREQ_j$	0.0876***	0.0923***	0.1332***	0.1898***
	(0.0137)	(0.0923)	(0.1332)	(0.1898)
$VSIZE_j$	0.0003**	0.0005***	0.0005***	0.0004***
	(0)	(0.0001)	(0.0001)	(0.0001)
IWT_{ij}	0.715***	1.0946***	1.504***	2.331***
	(0.1367)	(0.1682)	(0.1795)	(0.2087)
$RAIL_{ij}$	1.1326***	0.8528***	0.4397**	1.1915**
	(0.1453)	(0.1757)	(0.1968)	(0.3674)
Observations	1505	931	941	802

Exports, 2012	**Group 1**	**Group 2**	**Group 3**	**Group 4**
α Inland distance (Log)	-1.6355***	-1.4447***	-1.0773***	-0.745***
	(0.0817)	(0.1132)	(0.12)	(0.1248)
$VFREQ_j$	0.1259***	0.086***	0.0964***	0.0853***
	(0.0189)	(0.0217)	(0.0226)	(0.0231)
$VSIZE_j$	0.0003**	0.0004***	0.0006***	0.0005***
	(0)	(0.0001)	(0.0001)	(0.0001)
IWT_{ij}	0.1043	-0.2879	0.421*	1.1791***
	(0.1827)	(0.2213)	(0.245)	(0.2422)
$RAIL_{ij}$	1.1614***	2.6034***	1.4051**	0.9741***
	(0.2166)	(0.1869)	(0.2287)	(0.2344)
Observations	1129	820	901	713

Source: Author's calculations (2017) based on French Foreign trade data.

FIGURES

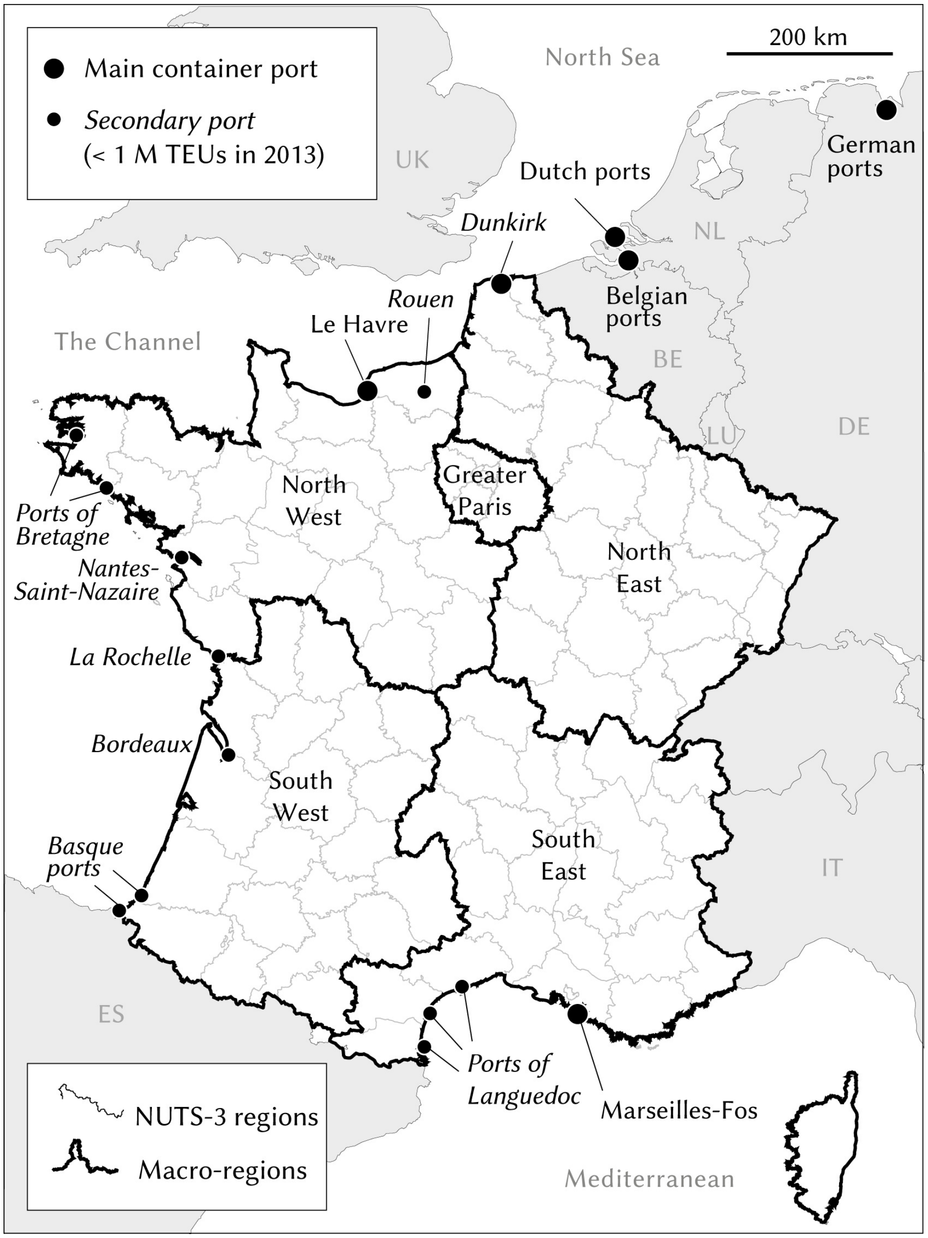

Figure 1. Area of study

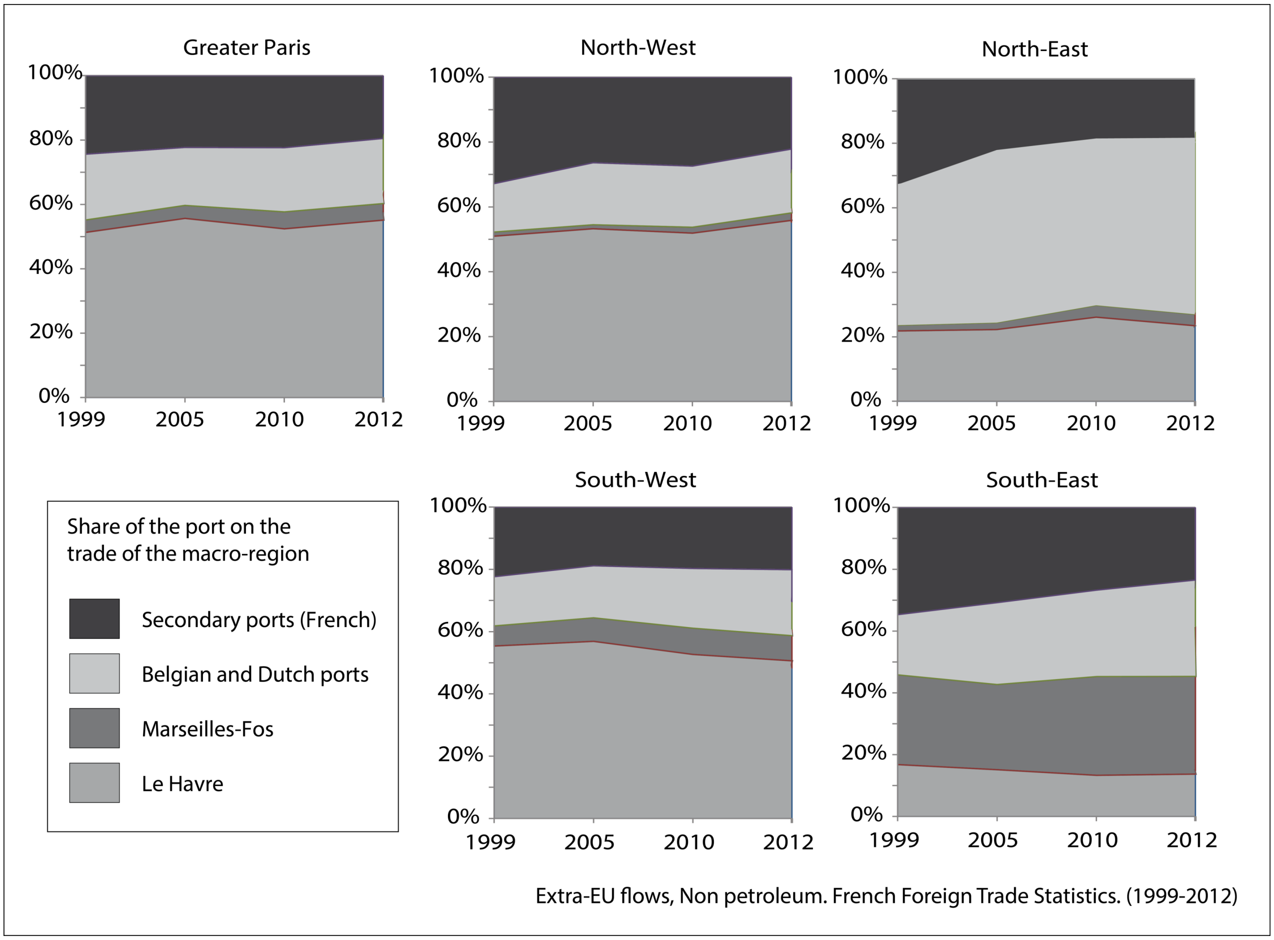

Figure 2. Breakdown of French exports by port (1999-2012)