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Inspire Policy Making with Territorial Evidence

APPLIED RESEARCH PROJECT //

Unveiling the interregional trade between Spain, France and Portugal

Case Study // May 2021

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The information contained herein is subject to change and does not commit the ESPON EGTC and the countries participating in the ESPON 2020 Cooperation Programme.

The final version of the report will be published as soon as approved.

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Abbreviations

C2C	Country to country
EU	European Union
EUROSTAT	European Statistical Office
IRiE	Interregional Relations in Europe
JRC	Joint Research Centre
NUTS	Nomenclature of Territorial Units for Statistics
OD	Origin-Destination
R2R	Region to region

Abstract

The aim of the ESPON IRIE project is to generate new data and find relevant new evidence about interregional economic and social relations in the ESPON space. As a complement to the production and analysis of the interregional trade flows of goods provided in the Task 1.2.a. of this project, this case study analyses, with a detail that has never been done before, the interregional-international trade of Spain with France and Portugal. The core data used here corresponds to the C-intereg project (www.c-intereg.es), which provides a long series of interregional flows in Spain and the whole EU, covering data at the NUTS 3 level. This unique dataset in the EU context serves as a good example for other EU countries, both in the generation of data and the continual updating of structural and current linkages between regions in the EU. It combines interregional freight flows by road and international customs data, covering 2004-2018 and different sectoral disaggregation. In this case study, by means of GIS network analysis, each interregional flow is allocated to an optimal route considering the actual transport infrastructure by road. Then, the intra-national flows within Spain, and their equivalent inter-national flows with France and Portugal at the NUTS 3 level are modelled using different specifications of the gravity equation. The results are very powerful and new, identifying different patterns of trade between these three countries, and finding geographical and economic drivers explaining the intensity and direction of the bilateral flows. Our findings are in line with previous analysis conducted in Europe and other countries such as the United States, Canada or China, although the finer grid of the data used also helped to add new light in some specific respects. For example, the use of NUTS 3 level data, partially qualify the role of being a border-region in the exporting and importing country, as well as the spatial advantages by each region in terms of accessibility to the main gateways in the national border, both with France and Portugal. The results also remark the spatial differences between the flows between Spain and France, crossing the northern border though the natural wall of the Pyrenees, in comparison to the East-West border with Portugal, more porous and with larger numbers of gateways. The study also includes an exercise of computation of the national and regional border effect in Spain, which helps to illustrate how different is the level of regional integration of trade within a country, and with the two neighbouring economies.

Keywords

Interregional trade of goods, European integration, gravity equation, home bias; border effect

Highlights

IN the context of the ESPON IRIE project, which adopts an holistic and pan-European approach to interregional economic relations, the aim of this case study is to analyse, with a detail that has never been done before, the interregional-international trade of Spain with France and Portugal.

- The core data used here corresponds to the C-intereg project (www.c-intereg.es), which provides a long series of interregional flows in Spain and the whole EU, covering data at the NUTS 3 level. This unique dataset in the EU context serves as a good example for other EU countries, both in the generation of data and the continual updating of structural and current linkages between regions in the EU. It combines interregional freight flows by road and international customs data, covering 2004-2018 and a wide sectoral dis-aggregation
- By means of GIS network analysis, each interregional flow is allocated to an optimal route considering the actual transport infrastructure by road. Then, the intra-national flows within Spain, and their equivalent inter-national flows with France and Portugal at the NUTS 3 level are modelled using different specifications of the gravity equation.
- The results are very powerful and new. Although the flows perform following the classical gravity equation, we can obtain new insights thanks to the use of NUTS 3 level data. The detailed consideration of two very different borders, and the right control of variables related to accessibility, contiguity, and geography, also help to exploit the spatial heterogeneity of the data.
- The French border is of particular interest, because of its geographic specificities, given the fact that the Pyrenees behave as a natural wall for the economic interaction between Spain and the European core, with two main gateways (“Biriatou/Irun” and “Le Perthus/La Jonquera”) located considerable far away one from each other (more than 600 km).
- The Spanish-Portuguese border is longer and more porous, with a larger number of crossing points and border regions. However, the population and the economic activity is more concentrated around Lisbon and Oporto, both located in the coast, something that clearly shapes the spatial pattern of the trade relations reported here.
- In the NUTS 3 level, it is not clear that being a border-region is always positive for trade. The Spanish border-regions at the NUTS 3 level do not coincide with the leading provinces within the corresponding NUTS 2 region. This is especially true for the Basque Country and Catalonia, for which Gipuzkoa and Girona, the true border-provinces with France, are less powerful in terms of production and exportation than Vizcaya or Alava and Barcelona. The case of Navarre is also of particular interest to us since it is the only single-province NUTS 2-Spanish border region with France. The Spanish border provinces with Portugal are in the group of peripheral provinces. Something similar happens from the perspective of Portugal. At the NUTS 2 level, most of the Portuguese regions

are coastal and border regions at the same time. However, at the NUTS 3, the coastal and border spatial units are put apart, revealing a core-periphery structure following a coastal-landlocked duality.

- By computing the optimal route for each delivery, we connect the phenomenon of trade and freight, and find core nodes in the transport network, offering a more realistic view of the true accessibility of each location. This exercise, also helps to derive additional consequences for the regions that are crossed in each delivery, in terms of positive spillovers and negative externalities. Moreover, in the context of COVID19 pandemic, routing the trade flows also helps to anticipate to possible disruptions in the supply chain due to restrictions to mobility affecting passengers and freight.
- Through this long case study, the main bilateral flows are identified and visualized. Some of such flows were predictable given the typical variables in the gravity equation, that connects big regions (capital cities) located at a reasonable distance (contiguous and border regions). But in addition, our analysis has identified very singular flows such as the ones that connect Valladolid with some specific French regions, with a clear linkage to the automotive sector. This specific example helps to illustrate how macro-economic figures such as bilateral trade can finally relate to firm-specific flows, with a critical role in the economic activity and the employment generated in an entire region.
- The home bias analysis confirms how regions are more integrated with other regions of the same country, despite the strong linkages that some of them have with foreign regions, in this case, in France and Portugal. Creating a European Single Market can be associated with promoting the inter-national cooperation to the level that this national border-effect will converge to a factor of one, that is, expecting that the regions of different countries will trade one each other with the same intensity than equivalent regions within own territory. As our figures reveal, national borders still matter, even when considering countries with a great level of integration.

1 Introduction

Recent papers have investigated the relationship between international trade performance, firm location and the geographical advantages of internal distance within an exporting country and accessibility to coastlines, trade gateways or certain transport infrastructures (Bleakley & Lin 2012, Duranton, Morrow & Turner, 2014, Atkin & Donaldson, 2015; Coşar & Fajgelbaum, 2016; Gallego & Zofío, 2018, Crozet & Koenig, 2004). In a related literature, various authors have considered how accessibility to international borders affects the international concentration of economic activity within a country (Brülhart, 2011; Redding & Sturm, 2008; Behrens, Gaigné, Ottaviano & Thisse, 2007; Baldwin & Wyplosz, 2006; Rodriguez-Pose & Gill, 2006; Brülhart & Traeger, 2005; Mansori, 2003; Ottaviano, Tabuchi & Thisse, 2002; Hanson, 2001).

The aim of the ESPON IRIE project is to generate new data and find relevant new evidence about interregional economic and social relations in the ESPON space. More specifically, in the Task 1.2.a. a great effort is done generating homogenous and solid estimates of the intra and interregional trade flows, in Euros and Tons, aggregate and split by products and transport modes, covering the whole EU27 plus the UK, Switzerland, Liechtenstein and Iceland. The key virtue of this analysis is the Pan-European coverage, and the coherence of the figures with the national main figures. However, these two virtues necessarily restrict the spatial scope of such analysis, which must focus on the NUTS 2 level, at which the main territorialized data is available for all these countries.

As a complement to the production and analysis of the interregional trade flows of goods provided in that Task, this case study analyses, with a detail that has never been done before, the interregional-international trade between three EU countries with special features, in terms of geography, economy and historical ties. Our analysis centres on actual interregional trade flows by road between Spain and the regions of France and Portugal, with a focus in the cross-border flows and the gateways used for the deliveries. Such analysis is also complemented with the analysis of the intra-national (within Spain) and the inter-national flows (with France and Portugal) by road, in a way that we can compute the border effect faced by the Spanish provinces when trading with the other Spanish regions and the most natural markets at hand, offering an important benchmark to evaluate the trade integration of these three countries at the sub-national level.

The core data used here corresponds to the C-intereg project (www.c-intereg.es), which provides the longest series of interregional flows in Spain and the whole EU, covering data at the NUTS 2, NUTS 3 level. This unique dataset in the EU context could serve as a good example for other EU countries in the next years, both in the generation of data and the continual updating of structural and current linkages between regions in the EU, with a focus on goods and services. To this regard, the dataset used is a reference for the IRIE project, which is much more powerful in terms of the spatial dimension and the typologies of flows analysed.

The dataset used here covers the interregional flows of goods between the Spanish regions (NUTS 3) and the equivalent regions of France and Portugal, combining interregional freight flows and international customs data, covering the period 2004-2018. Thanks to this singular dataset, which covers interregional flows from Spanish provinces to the provinces of these two neighbouring countries, we obtain new evidence that complement previous analysis conducted at a higher spatial level (Gallego & Llano 2014, 2015; Gallego, Llano & Pérez-Balsalobre, 2018).

The French border is of particular interest, because of its geographic specificities, given the fact that the Pyrenees behave as a natural wall for the economic interaction between Spain and the European core, finding two main gateways (“Biriatou/Irun” and “Le Perthus/La Jonquera”) located considerable far away one from each other (more than 600 km). The Spanish-Portuguese border is longer and more porous, with a larger number of crossing points and border regions, which in principle might tent to produce a lower level of spatial concentration of the interactions in a reduced number of gateways. However, once crossed the border, the population and the economic activity is more concentrated around Lisbon and Oporto, both located in the coast, something that clearly shapes the spatial pattern of the trade relations reported here.

In addition, our analysis faces a new dimension not covered by previous research: in several cases, we find that the border-regions at the NUTS 3 level, which enjoy geographical advantage for the exportation to the neighbouring countries, do not coincide with the ones that accumulate the largest share of economic activity (leading city) within the corresponding NUTS 2 region. This is especially true for the Basque Country and Catalonia, for which Gipuzkoa and Girona, the true border-provinces with France, are less powerful in terms of production and exportation than Vizcaya or Alava (which are not border-provinces within the Basque Country, a border NUTS 2 region) and Barcelona (which is not a border-province but is the core of a border NUTS 2 region such as Catalonia). The case of Navarre is also of particular interest to us, since it is the only single-province NUTS 2-Spanish border region with France, with a great historical tradition of connectivity through Roncesvalles (i.e. the roman road “Vía XXXIV” and the “Camino de Santiago”), although the actual main connection for road heavy vehicles usually implies using the “Biriatou/Irun” gateway.

Equivalently, with respect to the trade relationships with Portugal, the border provinces with Portugal (Pontevedra, Orense, Zamora, Salamanca, Badajoz, Cáceres, Huelva) are in the group of Spanish peripheral provinces in terms of income per capita and exporting capacity, while they belong to NUTS 2 regions (Galicia, Castilla León, Extremadura or Andalucía), which are border to Portugal, and are very relevant suppliers, as a whole, to Portugal. Something similar happens from the perspective of the Portuguese border regions. At the NUTS 2 level, most of the Portuguese regions (Norte, Centro, Alentejo, Algarve) look like horizontal stripes connecting the border with the coast. Just Lisbon Metropolitan Area appears as a core coastal non-border region with Spain. However, when considering the NUTS 3 Portuguese regions, the coastal and border spatial units are put apart, revealing a clear core-periphery structure, which, instead of defining a north-south divide as in the archetype NEG model, follows a West-East, or Coastal-Landlocked alternative scheme.

Another innovation of this analysis is the attempt to predict the optimal route for each delivery, adding a very relevant layer to the standard international trade analysis. Why this exercise is so interesting? i) first, the connection between trade and freight helps to understand the inner decisions of exporters and importers, related to the actual effect exerted by the heterogeneous transport costs that really apply in each delivery; ii) second, helps to evaluate the actual use of transport infrastructures as well as a more realistic view of the level of accessibility faced by each location when willing to reach (or to be reached by) other markets in exchange of goods and services; iii) to be able to derive additional consequences for the regions that are crossed in each delivery, with all the positive (transport services) and negative (GHG emissions) spillovers associated with a specific route; iv) last, but not least, the current COVID19 pandemic, and the way in which countries and regions are reacting, teach us how important is to understand that the logistics associated with the exporting/importing activity is exposed to a number of unpredictable changes and constrains, which might overlap to the already uneven reductions in demand and production capacity. Since the first wave of contagious hit Italy in February 2020, and the first confinement measured started to be applied in the EU, intermittent and unpredicted new borders and restrictions to the economic activity and the basic mobility of people and goods have taken place: borders closed, huge waiting times for trucks, Eurotunnel lockdowns, COVID-free passports and PCR for drivers and employees crossing borders, additional paperwork, and red tape for delivering or receiving certain types of products considered as “of national security” (COVID19 related products).

Regarding this network analysis, the results presented in this document corresponds to a first insight in the aggregated results, leaving a more profound and visual approach to a subsequent delivery, using a GIS-platform tool for online interactive analysis.

The rest of the paper is structured as follows: Section 2 revise the background of the topic in the academic literature. Section 3 describes the methodology used regarding the econometric analysis. Section 4 describes the data used, with a focus on the region-to-region trade dataset for the Spanish case, and the definition of the main explanatory variables to identify drivers and barriers. Section 5 comments the main results obtained, starting with a descriptive and visual analysis, and continuing with the econometric results obtained by means of alternative specifications of the gravity equation. Finally, the case study includes a section of policy implications and recommendations to data providers, and a concluding section.

2 Background

To date, there is no official data on region-to-region trade flows between different countries within the European Union (EU). Due to this limitation, several important questions regarding the dynamics of EU integration remain unsolved, both for scholars and policy makers. Thus, researchers are incapable of addressing relevant issues already tested in other countries like the United States (McCallum, 1995; Hillberry & Hummels, 2008) or China (Poncet, 2003).

For example, the analysis of business cycles co-movement for the EU regions suffers from a lack of information on the trading flows connecting each pair of regions. Consequently, those papers that are willing to analyse to what extent the EU integration process is causing an increase in the synchronization of the European economies, and therefore, to a decrease in the asymmetric-shock risk of a non-optimal monetary union, have had to substitute the actual bilateral flows connecting each pair of regions, with physical distance or trade potentials estimated by gravity equations (Fatás, 1997; Barrios & de Lucio, 2003).

Another example can be found in the field of the border effect literature. Conversely to what happens in the U.S. and Canada (McCallum, 1995; Helliwell, 1996; Anderson and van Wincoop, 2003; Feenstra, 2002, 2004), the estimation of the international border effect in Europe has been restricted to the analysis of country-to-country (Chen, 2004; Minondo, 2007) or region-to-country data (Gil-Pareja et al., 2005; Requena & Llano, 2010; Ghemawat et al., 2010; Llano-Verduras et al., 2011). However, research on the internal border effect (home bias) using region-to-region has been confined to those countries where interregional trade datasets are available (Wolf, 2000; Hillberry and Hummels, 2003, 2008; Combes et al., 2005; Requena and Llano, 2010; Garmendia et. al, 2012), but without considering the international cross-border relations. Very few analyses exist covering interregional flows between countries

There are very few exceptions. First, Nijkamp et al., (1997) analysed inter-regional freight flows between EU regions using alternative modelling strategies such as logit models and neuronal networks. Lafourcade & Paluzie (2011), using region-to-country flows with focus in France, found that that countries contiguous with the national border (France) show a higher concentration of inflows in regions bordering the exporting country (Spain). More related with our work, Gallego and Llano (2014, 2015) used a similar dataset to the one considered here for analysing the non-linear relationship between trade and distance, and considering two alternative border effects, the regional one within the country, and the national border with respect to the EU countries. Finally, an interesting paper has been recently published (Chen et al, 2018 where an EU interregional trade dataset has been combined with the World Input Output tables to address the asymmetric impacts of BREXIT on the regional economies of Europe.

3 Methodology

The methodology applied in this study implies four dimensions: i) the estimation and use of a new database containing intra and interregional flows between Spain and Portugal and France, using aggregate and sector specific flows from 2004 to 2018 at the NUTS3 level. ii) an effort on generating the corresponding visualizations and descriptive analysis of the main flows, and the development of different econometric specifications based on the state of the art of the gravity equation, used as the workhorse to identify the role of different geographic and economic variables explaining the intensity of the flows. iii) the preparation and application of different explanatory variables related to the geographical (first nature) and economic (second nature) drivers of the flows, with a special focus on the locational advantages of the border regions and the ESPON typologies. iv) Moreover, by means of a GIS network analysis, each origin-destination flow is “routed”, by computing the optimal routes for every pair of NUTS 3 provinces in the three countries considered. Such effort will allow guessing the most likely “gateway” used to cross the Spanish border with France and Portugal and compute the optimal distance for each route.

3.1 Modelling intra and inter-national trade flows

In this section we revisit the literature on empirical trade analysis and the use of the gravity equation (Head & Mayer, 2014), which is the most used framework for identifying the main drivers and obstacles for the bilateral trade between countries and regions. Following this literature, we start using what has been label as a naïve specification of the gravity equation, which is a benchmark for several classical analysis such as the one developed by McCallum (1995) in his pristine estimation of the border effect between Canada and the United States (US). Then, we enrich that approach defining a micro-founded gravity equation as it is presented by Anderson & van Wincoop (2003) and several subsequent articles. Initially, these two equations are defined with the aim of just modelling the inter-national flows between the Spanish regions and the ones in France and Portugal. Then, in a subsequent step, we enrich these specifications mixing the intra-national flows within Spain, to compute the intra-national and intra-regional border effect.

The virtue of combining all these specifications is the possibility of offering interesting results for policy makers, as well as to offer results that are robust and comparable with the state of the art in trade modelling. The naïve gravity will leave room to the introduction of origin and destination regressors, while the micro-founded gravity version, which implies the inclusion of the corresponding fixed-effects, which might absorb part of the unobservable factors driving the intensity of trade, while offer the more rigorous (not bias) estimation, comparable with the most recent scientific contributions.

In addition to this technical effort, the basic gravity model is augmented by incorporating variables related to the geographic and economic features of the countries and regions considered, taking into account recent theoretical frameworks related with the New Economic Geography and New Trade Theory (Gallego & Zofio, 2018), that explicitly considers the spatial advantage and the transport configuration of the network, as a pre-condition for the historical accumulation of the economic activity in certain locations, and the corresponding pattern of trade derived from such agglomeration.

While the first group of variables are dummy variables to distinguish the case of French regions versus Portuguese regions, the second group are variables that capture the advantages of being a *border region*, a *coastal region* (first-nature variables), or having the country's *capital* (man-made infrastructures, second nature variable).

We first consider the classical and basic gravity equation, also labelled as naïve by certain authors. There, the GPDs for the partner regions, which proxies the capacity of emission and absorption of the exporting and importing regions; and the distance variable, which captures all the elements that hamper the intensity of trade flows, and proxy all trading costs, such as transportation and information costs or any other non-tariff barrier to trade that can be at work. This benchmark specification is defined in equation (1):

$$\mathrm{T}_{ijt} = \beta_0 + \beta_1 \log(GDP_{it}) + \beta_2 \log(GDP_{jt}) + \beta_3 \log(D_{ij}) + \mu_t + \varepsilon_{ijt} \quad (1)$$

T_{ijt} gathers the good flows by road in thousands of euros from a NUTS3 region "i" to a NUTS3 region "j" in the year "t". The variable $\log(GDP_{it})$ is the logaritm transformation of GDP for the origin "i", while $\log(GDP_{jt})$ is for the destination "j". The variable $\log(D_{ij})$ corresponds to the log of the optimal distance between the trading locations, measured in thousands of kilometres. More detail about the computation of such distance is given below. However, in other to consider an additional way of capturing the non-linear relation between trade and distance (Hilberry and Hummels, 2008; Gallego and Llano, 2015, 2016; Gallego et al., 2021), we also consider a complementary treatment for this variable, which will be introduced as $\beta_3 D_{ij} + \beta_4 D_{ij}^2$. Similarly, this strategy has been applied for the micro-founded gravity equation. Then, the term μ_t is the time fixed effect, to control for unobserved time-varying effects affecting all observations in the sample. Finally, ε_{ijt} is the origin-destination and time specific error term.

Such equation is defined in the most general case so it can be applied to the Spanish exports to France and Portugal or to the Spanish imports from any of these countries, in all cases, at the region to region level (NUTS 3). It is important to remark that the dataset used in this paper do not include the flows between Portugal and France, so in a way, it is always pivoting around Spain[1].

Now, equation (2) defines an augmented micro-founded gravity equation, which will be slightly modified in further modifications, with the aim adding new elements able to capture the peculiarities that are just applicable to the flows with Portugal versus France.

$$\mathrm{T}_{ijt} = \beta_0 + \beta_1 \mathrm{Capital}_i + \beta_2 \mathrm{Capital}_j + \beta_3 \log(D_{ij}) + \beta_4 \text{intern-contig}_{ij} + \beta_5 \mathrm{border}_i + \beta_6 \mathrm{border}_j + \beta_7 \mathrm{mountain}_i + \beta_8 \mathrm{mountain}_j + \beta_9 \mathrm{coastal}_i + \beta_{10} \mathrm{coastal}_j + \mu_{it} + \mu_{jt} + \mu_t + \varepsilon_{ijt} \quad (2)$$

The main difference between this new equation and the previous specification comes from the terms μ_{it}, μ_{jt}, which represent the multilateral resistance terms. Such terms are expected to capture the general relation of each trading region "i" and "j" with respect to the rest of possible partners, and how this relation can hamper (resistance) each specific bilateral flow. In accordance with the literature (Head and Mayer, 2014), these variables are proxied by origin-time fixed effects and destination-time fixed effects.

Other innovations of this specification are the introduction of the following variables:

$Capital_i$ is a dummy variable that takes the value 1 when the origin "i" has the capital of the country and the variable $Capital_j$ is the same variable, but for the destination "j".

Then, with the aim of capturing the spatial advantage faced by the border regions, equation (2) includes a variable $\text{intern-contig}_{ij}$, which is a dyadic dummy variable, that takes the value 1 when the origin (i) and the destination (j) are border regions and contiguous but do not belong to the same country. In the case of the Spanish exports, it will take a value 1 when the exporting region is border to France and Portugal, and the importing region is also a French or Portuguese region, border and contiguous to the Spanish exporter.

Then, we decompose this effect, with the aim of controlling independently by the border under consideration, namely, the one on the north with France, or the one on the west with Portugal:

[1] Note that the current case study is based on the c-intereg dataset (www.c-intereg.es), which started in 2004 thanks to the initiative of several Spanish regional governments. Lucky, this data is ready to use in IRIE project, which offers a much wider perspective. Although our dataset offers NUTS 3 level, is based just on the Spanish Survey on Road freight Transportation (EPTMC), which just focusses on the Spanish trucks. Thus, this dataset is not able to cover the flows between France and Portugal. Having said that, in parallel to the development of this case study, with focus in Spain-France-Portugal, the ESPON IRIE project (Task 1.2.a) includes the estimation of all the trade flows between all the regions of the EU27 countries, plus the EES countries. Thus, once that the IRIE project is finished, a similar analysis to the one conducted here, centered in Spain, could be easily extended to all regions in Europe. The limitation of that analysis will be the lack of information at the NUTS 3 level, since the NUTS 2 is the highest common spatial level of disaggregation for the ERFT flows provided by Eurostat. However, it will have the virtue of including all flows by road, reported by trucks from all possible nationalities with representation in Eurostat.

- $\text{intern-contig-es-pt}_{ij}$: It stands for international contiguity between a Spanish region and a Portuguese region. It takes the value 1 when the trade is between two contiguous regions, and one is Spanish whilst the other is Portuguese.
- $\text{intern-contig-es-fr}_{ij}$: It stands for international contiguity between a Spanish region and a French region. It takes the value 1 when the trade is between two contiguous regions, and one is Spanish whilst the other is French, and zero otherwise.

Such variables are included explicitly in the next equation (3)

Digging deeper in this potential locational advantage of the border regions, we now define some new variables, aiming to control for the general advantage of being a border region, independently of the specific bilateral advantage of trading with the contagious international region at the other side of the border. As in the previous case, we start defining the following variable, which is included in equation (2):

border_i / border_j: They are dummy variables that take the value 1 when the origin "i"/destination "j" is a border region to a foreign economy, and zero otherwise.

Then, we divide this variable in two, which will be included in equation (3). The aim of splitting these variables is differentiating the effect depending on the destination of the Spanish export or the origin of the Spanish imports. More specifically, here we define all the possible characterization of this variable depending on the kind of flow (exports versus imports) or partner (Portuguese versus French regions). For a synthetic summarize of this and the rest variables, see Table 8-3.

For the Spanish exports to France and Portugal

$\text{border-es-pt}_\text{i}$ / $\text{border-es-fr}_\text{i}$: These are monadic dummy variables that capture the effect of being a Spanish border region when the economy is exporting. The first variable is for the case of the border regions with Portugal and takes value 1 when the origin region "i" is a border region to Portugal, and zero otherwise; the second is for the case of the border regions to France and takes value 1 when the exporting unit is a Spanish border region with France.

$\text{border-pt}_\text{j}$ / $\text{border-fr}_\text{j}$: These dummy variables attempt to assess whether exists a higher agglomeration of incoming trade in those foreign regions that are on the border. The first one takes the values 1 when the destination region "j" is a Portuguese border region and zero otherwise. Whilst the second takes the value 1 when the destination region "j" is a French border region.

For the Spanish imports from France and Portugal

$\text{border-pt}_\text{i}$ / $\text{border-fr}_\text{i}$: These dummy variables attempt to assets whether exists a higher concentration of outflows in the French and Portuguese border regions to Spain. The first one, takes the values 1 when the origin region "i" is a Portuguese border region, and zero otherwise. Whilst the second, takes the value 1 when the origin region "i" is a French border region, and zero otherwise.

border-es-pt_j / border-es-fr_j: These are dummy variables that capture the concentration of imports arriving to the Spanish border regions. The first variable is for the case of the Spanish border regions to Portugal, while the second is for the case of the Spanish border region to France.

Then, we define two additional variables with the aim of correctly characterize the geographical features of the trading regions:

mountain_i : It takes the value 1 when the origin "i" is a mountainous region, and zero otherwise. Section 3.2 describes in more detail what is considered "a mountainous region" here. mountain_j is defined in the same terms, but for the "j" destination.

coastal_i : It takes the value 1 when the origin "i" is a coastal region, and zero otherwise. Once again, section 3.2 describes what is considered "a coastal region". coastal_j is defined in the same terms, but for the "j" destination.

3.1.1.1 Modelling intra-national and inter-national trade flows: The home bias effect

We now turn to define a complementary equation (3), which combines the intra-national flows within Spain, and the inter-national inter-regional flows considered before. By doing so, we follow McCallum (1995) and Anderson and van Wincoop (2003) in the estimation of the border effect, but also allowing for the estimation of the intra-regional home bias, as Hillberry and Hummels (2008), Poncet (2003) or Wolf (2000).

$$\begin{aligned}\text{T}_{ijt} = {} & \beta_0 + \beta_1\text{Capital}_i + \beta_2\text{Capital}_j \\ & + \beta_3\log(D_{ij}) + \beta_4\text{Home Bias-es-pt}_{ij} + \beta_5\text{Home Bias-es-fr}_{ij} + \beta_6\text{contig}_{ij} \\ & + \beta_7\text{mountain}_i + \beta_8\text{mountain}_j + \beta_9\text{coastal}_i + \beta_{10}\text{coastal}_j + \mu_i + \mu_j + \mu_t + \varepsilon_{ijt}\end{aligned} \quad (3)$$

In this equation, in addition to the variables commented before, two critical new elements are added:

$\text{Home Bias-es-pt}_{ij}$ is a dummy variable that takes the value one when a Spanish region is "exporting to" (or "importing from") a Portuguese region. A negative coefficient for this variable should be interpreted as the presence of a home-bias effect, which indicates that, once we have controlled for the rest of the explanatory variable, a Spanish region tends to trade less with a Portuguese region than with a Spanish region of the same size located at an equivalent distance.

$\text{Home Bias-es-fr}_{ij}$ is a dummy variable that takes the value one when a Spanish region is "exporting to" or "importing from" a French region. Therefore, this variable has the same interpretation than the previous one, but respect to France.

In addition, when introducing the intra-national flows, it is necessary to include a new set of variables capturing the contiguity effect, that is, the usually higher intensity of trade that a Spanish region will have when trading with an adjacent Spanish region:

$\text{intran-contig}_{ij}$: It stands for intranational contiguity. It takes the values one when the origin and the destination are contiguous and belong to the same country, in our case, to Spain.

It is convenient to remark once again, that the border effect computed is always from the perspective of the Spanish economy, since at this point, there are no equivalent data about intranational inter-regional flows at the NUTS3 level for Portugal or France.

3.1.2 Method of estimation

The dataset used for the estimations considers a balanced pool of data for each possible pair of origin-destination partner and for each year. This means that all the origins are faced to all the destinations all over the period, does not matter if the trade value is zero. As a matter of fact, when we consider the international dataset, the percentage of zero values is 57%, and when we also include intranational trade it is 50%. Given the big volume of zeros, we follow Santos Silva & Tenreyro (2006) whose Poisson Pseudo-maximum likelihood estimator (PPML), implemented in STATA, also controls for the Jensen's inequality, which biases the estimation in a heteroskedasticity scenario. As the authors state, for the use of the PPML estimator, the endogenous variable always enters in levels, but its interpretation is in logarithms, that is, they are interpretate as elasticities when an exogenous variable is in logarithm.

3.2 GIS network analysis

In addition to the above-described methodology, this case study brings in a GIS – based network analysis. This exploration allows us to calculate and visualize the optimum real routes by road (understood as the shortest paths) to drive from a specific origin to a specific destination. Moreover, in this survey, besides the corresponding travel times and travel distances, each route is linked to the corresponding interregional trade flows (aggregated data of exports and imports), allowing innovative visualization and farther spatial analyses. This GIS analysis makes four steps that are detailed below.

3.2.1 Estimate of the optimum travel times and distances: Find routes tool

The calculation of the optimum route for each pair of origin – destination points was performed with the GIS network analysis tool *'Find Routes'*. This tool determines the shortest paths to visit the input stops and returns, among others, information about the travel time and distance.

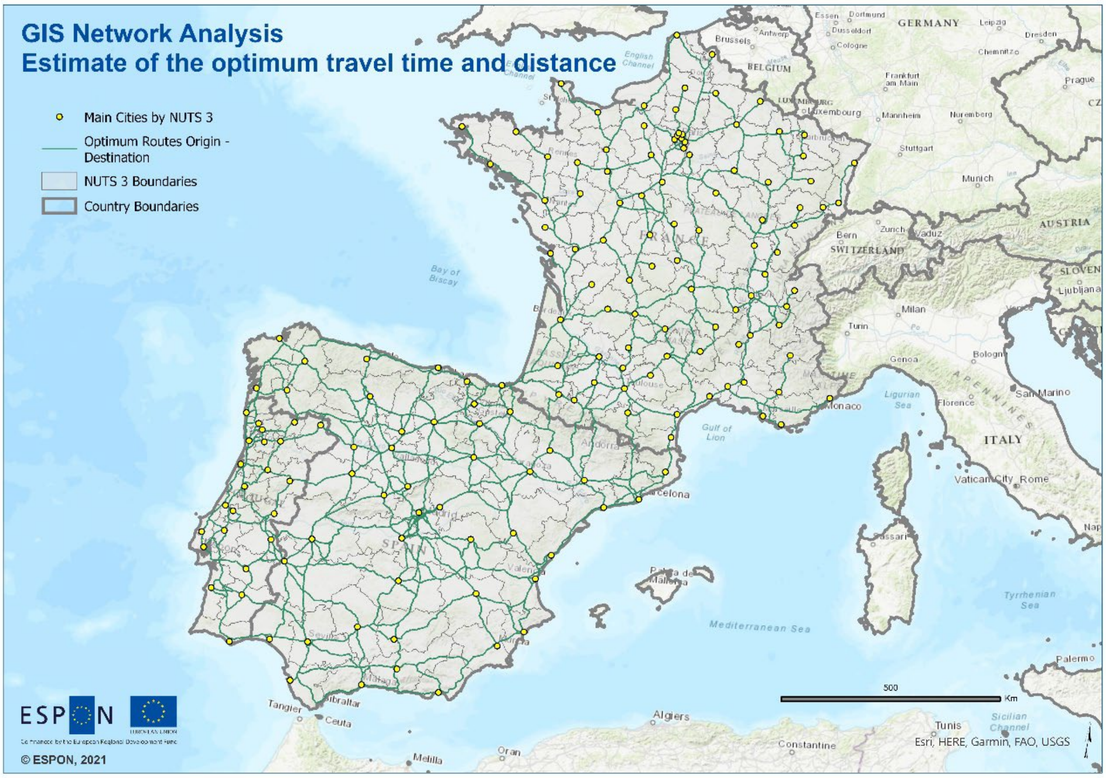
As a first step, we prepared the input layer, a point geometry type layer that should include the main city of each NUTS 3 region considered in the study (164 in total. The islands were disregarded since only interregional flows by road were addressed). Eurostat, through GISCO (geographical information and maps), makes publicly available the download of the administrative/statistical units' datasets (NUTS). However, the points' layer provided is a centroids layer, which is not valid for our analysis of the real routes. To overcome this obstacle, we created an ad-hoc points' layer with the real location of the main cities per NUTS 3 following two criteria. Firstly, we considered the capital regional cities (e.g. for all Spanish NUTS 3 regions). However, this naming is not used officially in several territories of Portugal and France. In those cases, we selected the most populated city in the administrative unit as main city, instead. To get the input layer we count on the support of ESPON EGTC, who provided data on urban centres, towns and metro areas, and IGSO-PAS, our partner in the IRiE project, who provided spatial data on the most populated cities by NUTS 3. This information from IGSO – PAS was obtained during the development of a previous project in 2015, and minor changes were applied to update it. The preparation and combination of both datasets had as a result a NUTS 3 points' feature layer with all the main cities in Spain, France and Portugal. The coordinate reference system used was the EPSG (European Petroleum Survey Group) 3035 - ETRS89/ETRS-LAEA, according to the ESPON EGTC guidelines.

However, because of the technical specifications of the ArcGIS tool 'Find routes', the main cities layer could not be used directly as an input. To calculate the route, the tool needs an input layer with only two points, one indicating the origin and one the destination. Additional points in the layer are consider as mandatory stops in the route. Thus, by using the layer with the 164 cities, the tool would depict a unique route linking all of them, and this is not what we looked for. On the other hand, and considering that there were more than 25.000 one-to-one possible combinations (164 regions –> 164 x 163 = 26.732 routes), we discarded the manual analysis and developed a Python script to create the required, individual origin – destination tables which could go as input into the online tool.

The script creates a dictionary with the geometry of the points and their identifier and for each origin and destination permutation (except when origin and destination coincide or when the route has already been calculated in either direction) it calculates the route with the desired parametrization and stores it in a feature class. Routes are calculated only in one direction (e.g., origin NUTS 3 ES220 to destination NUTS 3 PT170) and then copied, the origin and destination are switched (origin NUTS 3 PT170 to destination NUTS 3 ES220), and the new rows are added to the feature class. Intermediate steps are stored in memory. The outcome is a feature class of lines that gathers all the routes (26.732 routes) with their respective travel times and distances (Figure 4.1).

The parametrization of the tool used for this analysis considered several assumptions in accordance with the context offered by the case study. We considered, for example, the 'Driving a Truck' mode, the options to ‘Avoid Ferries’, ‘Avoid Gates’, ‘Avoid Stairways’, ‘Avoid Unpaved Roads’, etc., and selected the ‘Use Preferred Truck Routes’ method.

Figure 4.1 Road Network used for the GIS Network Analysis.



Regional level: NUTS 3 (2016)
Source: ESPON IRiE, 2021
Origin of data: CEPREDE - C-intereg, 2021
UMS RIATE for administrative boundaries

3.2.2 Maps and visualisations

In any research, when it comes to addressing options for visualization and mapping, the most important factor to focus on is data. In this study, we count on the databases provided by the project C-intereg. As remarked in previous sections, this is a unique dataset that covers long-term series (2004 – 2018) of interregional flows of goods (both export and imports) between the Spanish provinces (NUTS2 and 3) and the equivalent spatial units of France and Portugal. Moreover, the dataset includes the classification of three different sectoral disaggregation.

The visualization and mapping exercise was carried out considering the following data handling:

- Spatial resolution. We worked with the NUTS 3 subset of data.
- Interregional flows of goods. Both exports from Spain to France and Portugal, and imports from those countries to the Spanish provinces were covered (always at NUTS 3 level). Because of the limitations of the used dataset, which is based on the Spanish Survey on

Road freight Transportation (EPTMC), international trade relations between France and Portugal could not be addressed. In addition, although the Spanish intra-national flows were considered for the econometric analyses, they were not included in this part of the case study (although the optimum routes and the respective travel times and distances were calculated).

- Sectoral disaggregation. Despite the C-intereg dataset contains detailed information on sectoral disaggregation according to three different classifications, for this survey we decided to work with the aggregated version of the import/export tables. To that end, we summed up the interregional flows by NUTS 3 and year, for each flow type (import/export). Then, we calculated the average flow for the whole period (2004 – 2018) by NUTS 3 for each flow type. Nevertheless, although sectoral data were disregarded in the current analysis, we have developed a dynamic online tool that allows users to display that data in a friendly environment, with several options to visualise the fluxes and make the analysis attractive and easily understandable.
- Data curation. Once we had the subset of data, we checked it and made the corresponding corrections: fill in empty cells, substitute wrong names, add missing years, incorporate labels in English, check the correct classification of NUTS (2016 version), look for odd symbols in names because of original punctuation marks, remove columns with data not necessary for the analysis, etc.
- Join field. With the aim of linking each interregional flow to an optimal route, we created a new column in the dataset to embed the code that would be used for that purpose. This code was formed by the Origin NUTS 3 Id plus the Destination NUTS 3 Id. E.g., Interregional flow from Madrid to Lisbon (export). The join code would be ES300PT170.
- Allocation of interregional data to the corresponding optimal route (lines feature layer) and the corresponding NUTS 3 (polygon feature layer). As the last step, to map the trade flows we linked the curated C-intereg dataset to 1) the NUTS 3 polygon layer, both by origin and by destination. As we handled flow-related information, each data can be assigned to an origin or to a destination. The linkage of the data to the origin region or to the destination region offers several options for visualization; 2) the optimal routes layer generated with the network analysis 'Find routes'. In this case, the feature layer also had a join field with the respective join code (Origin NUTS 3 Id plus Destination NUTS 3 Id).

As a result of this process, we generated two types of visualisations. On the one hand, we created choropleth maps, both for imports and exports and both by origin and destination. Moreover, to get additional information, we also created separated maps for the Spanish – Portuguese flows and the Spanish – French flows, respectively. To visualize the flows of goods in € we applied a symbolization method by quantity and used a graduated colour scheme: the darker the NUTS 3 polygon, the bigger the flow associated to that region. For exports, we followed a palette of green (5 classes), whereas for imports we selected an orange-red rank (also 5 classes). These colour schemes were also applied in the visualization of the flows by route: green code for exports and orange-red code for imports. In this case, we used a symbolization method by quantity and used proportional symbols. In other words, the thicker the line of the route, the bigger the flow in € associated with that route. Here it is important to note that, because of the huge number of routes considered in this study, we made a selection of the Top 12 routes by country (Spain-Portugal, Spain-France) to map them in an understandable way, and also as an example of what can be obtained with this GIS network analysis. However, to extract all the potentiality of the dataset, we will use the GIS online solution.

4 Data

4.1 Trade flow between regions at the NUTS3 level

Trade and freight flows are different concepts that should be treated carefully. In general terms, the concept of 'international trade of goods' denotes a commercial transaction between two agents (exporter - importer), which, usually, implies the shipment of that good, from the exporting country to the importing one, crossing the national border. In despite of economic and logistic complexity, it is assumed that this operation is registered similarly by the corresponding trade and transport surveys.

In most of the EU countries, there are two main sources for the analysis of bilateral flows:

i. Trade statistics on intra-EU trade, which register bilateral flows between pairs of countries within the EU, both in volume and monetary units. In some countries like Spain, official trade statistics are available at the region-to-country level (NUTS 3 versus NUTS 0), both for exports and imports.

ii. Transport statistics (freight) on intra-national and inter-national freight flows, which -in some cases (road freight)- contain information on the type of product transported (just in volume), as well as on the specific regional origin and destination of the flows. In the case of the Spanish road survey (EPTMC), we have been working with the microdata at the maximum level of disaggregation, namely, the NUTS 5 level for the intra-national flows. Regarding the inter-national flows, the microdata offers information about the municipality (NUTS 5) exporting or importing in Spain, while the information about the foreign destination of the Spanish exports (and the foreign origin of Spanish imports) are available at the NUTS 3 level. Regarding the information available for the whole EU based on the European Freight Survey by Road (ERFS), the highest geographical grid is at the NUTS 2 level.

In this paper, we explore a novel dataset that bridge the gap between trade and freight statistics with the aim of obtaining inter-regional-inter-national flows between the Spanish regions and the ones of seven EU countries. Then we focus on the flows between Spain and France, and between Spain and Portugal. Equivalent inter-regional flows between France and Portugal are not available, but we hope to (partially) close this gap at the end of the IRIE project.

The specific methodology is explained in the Annex. In summary, it relies on the combination of two sources: one for estimating the region-to-region flows in volume (road freight statistics measured in Tons), and the other for estimating region-to-country specific trade prices (official trade statistics in Euros and Tons).

The outcome of this procedure is a unique dataset on region-to-region flows for international shipments departing from/arriving to the 52nd Spanish provinces (NUTS 3). Due to the characteristic of our road flow dataset, we exclude flows where the two Spanish island-region as well as Ceuta and Melilla are involved. After the final screening, the region-to-region dataset includes bilateral exports and imports of the Spanish provinces with respect to the regions (NUTS 3) for a group of selected European countries, disaggregated by K=29 manufacturing products (the list of Spanish regions, European countries and products is reported in the Appendix). Although the original dataset on region-to-region freight flows includes data on the Spanish flows with the regions of 15 countries (for imports) and 12 countries (for exports) in Europe, we limit our sample to the countries where shipments by Spanish trucks are more representative. Finally, the selected sample includes 8 European countries, and their corresponding NUTS 2 regions: Belgium, France, Portugal, Germany, Italy, The Netherlands and United Kingdom, Andorra. This analysis just centres in Portugal and France, to narrow the scope and to centre in countries with the greatest potential for trade integration, where different Euro-region projects and cross-border cooperation initiatives exists.

One of the great potentials of this dataset is that it can be directly connected with the same type of interregional trade flows within Spain (Llano-Verduras et al., 2011; Ghemawat et al., 2010; Requena and Llano, 2010; Garmendia et al. 2012), which contain not just interregional flows but also intraregional ones. Something similar will happened at the end of the IRIE project, where all countries in the EU27 plus EES countries will have equivalent flows within and between countries, opening new avenues for scientific research and policy analysis.

The characteristics of this unique dataset generated by the C-intereg project is the interregional flows of goods between the Spanish provinces (NUTS 3) and the equivalent spatial units of France and Portugal, covering 2004-2018 and 30 sectors.

4.2 Explanatory factors: drivers and barriers

It is time now to revise in more detail the explanatory variables consider in our gravity equations. Following relevant authors in the field of Trade Theory and New Economic Geography (Fujita, Krugman and Venables, 1999; Combes, Mayer and Thissen, 2009), it is convenient to differentiate between "first nature" and "second nature" factors explaining the economic agglomeration and the capacity of emission and absorption of each region within a country. Regarding the first nature, it is common to suggest factors that are directly associated with the geographical conditions, including aspects such as the access to the sea or navigable rivers, roughness, or the climate. Regarding the "second nature", it is common to focus on other variables related with the historical action, which, in a circular causation process, reinforce or curve the first nature condition. This is the natural space for economic variables (GDP, level of industrialization, human capital accumulation…), and more specifically, to all those related with the endowment of infrastructures that strengthen the capacity of internal and external interaction of each region. Having said that, the standard approach in current gravity equations should combine the smart combination of variables related with such factors, with the use of fixed effects of all kinds, that are able to control for the unobservable effects exerted by all these aspects.

More specifically, our analysis includes the distance and travel time variables provided by the GIS network analysis.

Regarding the distance, we compute the optimal distance travelled by the trucks after developing a network analysis based on ArcGIS using an up-to-date actual infrastructure of roads. The virtue of this analysis is that, in addition to the computation of distance, it is possible to obtain other variables that will be used in further extensions of this analysis. Such new variables are related with the optimal travel times, the identification of the most convenient gateways for border-crossing, the capacity of computing the cumulative use of each transport infrastructure when clustering all optimal routes simultaneously; the possibility of inferring the congestion and environmental effects of transit flows as these cumulative use of certain critical gateways, the relative advantage/disadvantage regarding the accessibility of an alternative route in case the preferred one is closed or subject to delays, etc.

As robustness check, our analysis has been also repeated using alternative distance measures, such as: i) the mean actual distance covered by the Spanish trucks in the operations between each pair of trading regions. These data are also obtained from the Spanish Permanent Survey on Commodity Transport by Road (SPSCTR). This variable has the virtue of capturing the actual distance travelled by trucks between origins and destinations and is superior to the one used by other authors, where the intra-national or the inter-national (or both) distances were built on a priori estimates based on the great circle distance (Head and Mayer, 2002); ii) the distance, travel times and generalized transport cost recently computed by the JRC, (Persyn, Díaz-Lanchas and Barbero, 2019).

Regarding the “first nature” drivers of trade, as described before, we have included the coastal and mountain variables.

The rationale behind the “coastal” variable, is that, in principle, coastal region has in comparison to landlocked regions regarding the attraction of certain economic activities (tourism, refinery-chemical clusters, coal-steel and other heavy industries highly dependent on sea connectivity) and clear advantages to benefit from globalization though better accessibility by ship to the furthest markets. This is true even in an analysis centred in the trade flows using road, with a focus in three countries where ground transportation is prevalent. Thus, it is expected a positive relationship between the fact of being a coastal region, and the intensity of inflows and outflows of that region. To categorize this variable as a dummy variable we have used the definition proposed by ESPON EGTC, where a coastal region has a sea border or has more than half of its population within 50 km from the sea.

Inversely, the “mountain” variables are expected to have a negative effect on the intensity of trade. The rationale is less evident. On the one hand, the location of some natural resources are associated to the presence of mountain and rough soil (mining, heavy industries such as cool or steal, wood and certain auxiliary industries, generation of electricity…). For centuries, such basic activities have determined the accumulation of economic activity around certain locations were mining and other energy resource were available (Glaeser et al., 2015). Conversely, roughness can also restrict the accessibility of the regions, not just as an origin or destination of the flows, but also as a potential transit location for other shipments. This variable is of special interest in this case analysis, since for the northern border with France, all the border regions are, at the same time, mountain regions, facing the additional burden of overcoming the natural wall of the Pyrenees. To elaborate a dummy variable to capture the effect of being a mountain region we have used the indicator “typology_index_mount” by ESPON EGTC. This indicator classifies the regions into 4 categories: 1 is for regions with “> 50 % of population live in mountain areas”, 2 is for regions with “> 50 % of surface are in mountain areas”, 3 is for regions with “> 50 % of population and 50 % of surface are in mountain areas” and 4 is for “non-mountain regions”. For simplicity, our “mountain” indicator takes the value 1 for the regions in the categories 2 and 3, and zero otherwise.

Regarding the “second nature”, we introduce the following variables, all of them quite standard in the literature of border effect and gravity equation.

The *capital* variables are expected to have a positive coefficient, since they want to capture the higher exporting (importing) capacity of regions that account for an augmented cumulation of population and economic activity, more directly related to services and the concentration of the headquarters of public and private institutions. It is also a proxy for all the human-made infrastructure that capitals usually enjoy.

In addition, we include the Gross Domestic Product (GDP) in current market prices in million purchasing power standard (PPS), as published by EUROSTAT.

5 Results

In this section we introduce the main results obtained in our analysis. First, we start with a descriptive analysis of the endogenous variable with a focus on the trade flows of goods between Spain and France, unveiling a lawyer of economic interaction that has been secluded until now, at least at this level, both in terms of time and space. The maps represented here are just the first snapshot, which will be complemented with an online-tool for interactive visualization.

Then, we cover the most technical part, where the results obtained by means of the alternative specifications of the gravity equation are analysed. Given the multi-dimensional approach followed in this case study, our analysis will pay more attention to the export dimension using the aggregated flows, limiting the comments about the import side to a final and briefer section. Other potential dimensions of the analysis are left to further investigations.

5.1 International region-to-region trade flows

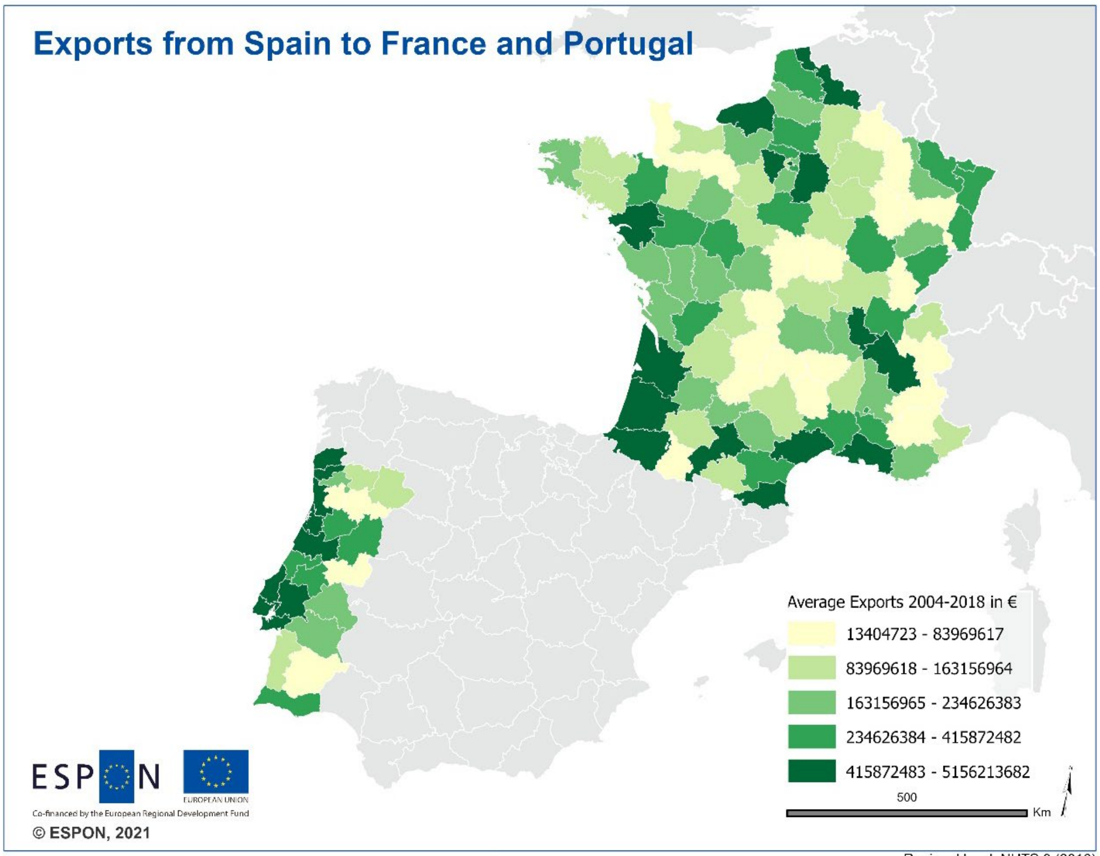
5.1.1 Trade shapes and economic landscapes

In this section we offer a brief descriptive analysis of the international inter-regional flows between Spain and France and Portugal. The analysis is mainly based on maps, covering the origin and destination side of the Spanish exports and imports to these neighbouring countries. For brevity, the analysis focuses on the average flows for the entire period in monetary units, although more detailed analyses in tons for each year are also possible.

We start the analysis with Figure 4.2, which shows the main foreign regions of destination of the Spanish exports in France and Portugal. The green pallet used clearly show a high heterogeneity of the inflows in these countries, with clear patterns of concentration in certain locations. Regarding France, the higher levels of concentration are observed in the regions located close to the two main gateways for crossing the Pyrenees, namely, “Biriatou/Irun” and “Le Perthus/La Jonquera”. These French regions are FRI15 (Pyrénées-Atlantiques), FRI13 (Landes), FRI12 (Gironde) on the west and FRJ15 (Pyrénées-Orientales), FRJ13 (Hérault) and FRL04 (Bouches-du-Rhône) on the East, with the epicentre in Marseille, the Bouches-du-Rhône's largest city. It is also important the concentration of inflows in other French border region, FRJ23, whose capital is Toulouse. In addition, high levels of concentration are found in FRG01 (Loire-Atlantique) and FRE11 (Nord) in the west part of the country; FRD22 (Seine-Maritime), FR101 (París), FR103 (Yvelines) and FR102 (Seine-et-Marne) in the centre of the country, which a specific core around Paris metropolitan area; and FRK26 (Rhône) and FRK24 (Isère) in the east part of the country, with centre in Lyon.

Similarly, Figure 4.2 identifies the most relevant destinations in Portugal. In this case, it is important to remark that all the flows concentrate in the coast and none in the border regions, with only exception of the ones that are also coastal. This spatial pattern is a constant in this analysis and highlights how the spatial configuration of the Portuguese population and economy is conditioned by first nature factors, which have been reinforced through history by the subsequent actions of the public and private sector. In this case, the higher concentrations of inflows appear around the big metropolitan areas of Lisbon (PT170-PT185 and PT16B) and Oporto and the northern corridor in connection to Galicia (PT16E, PT16D, PT11A, PT112, PT111).

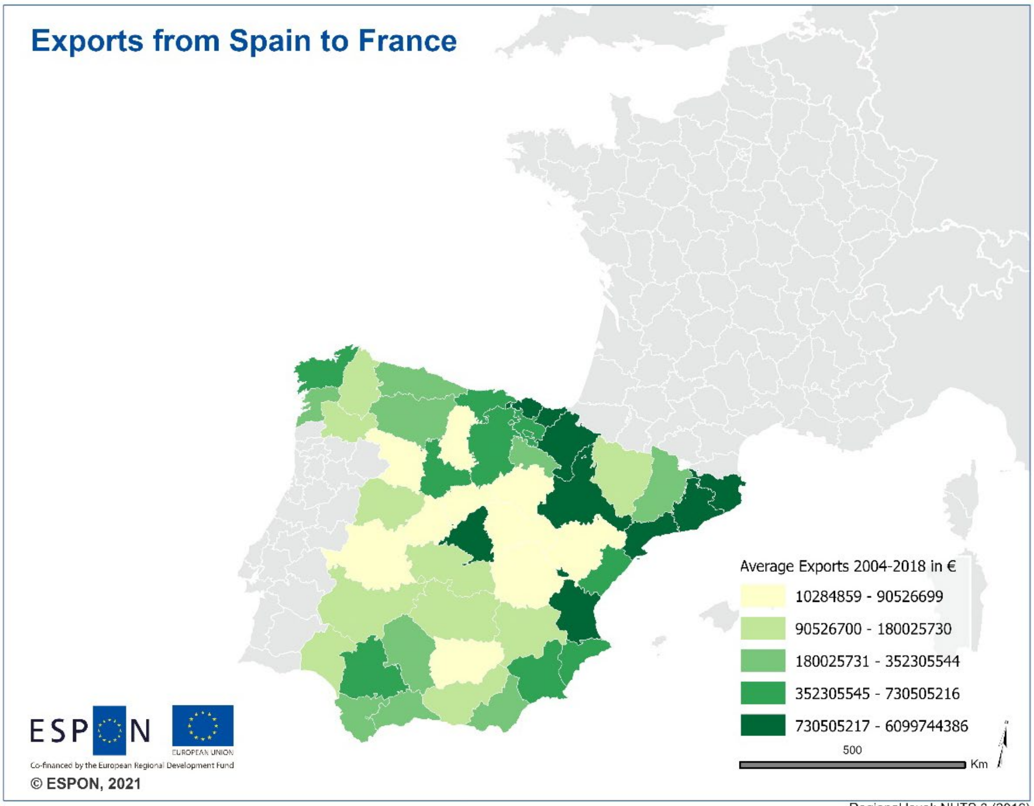
Figure 4.2 Main destinations of the Spanish exports to France and Portugal. NUTS 3 level. Average flows for the period 2004-2018. In Euros.



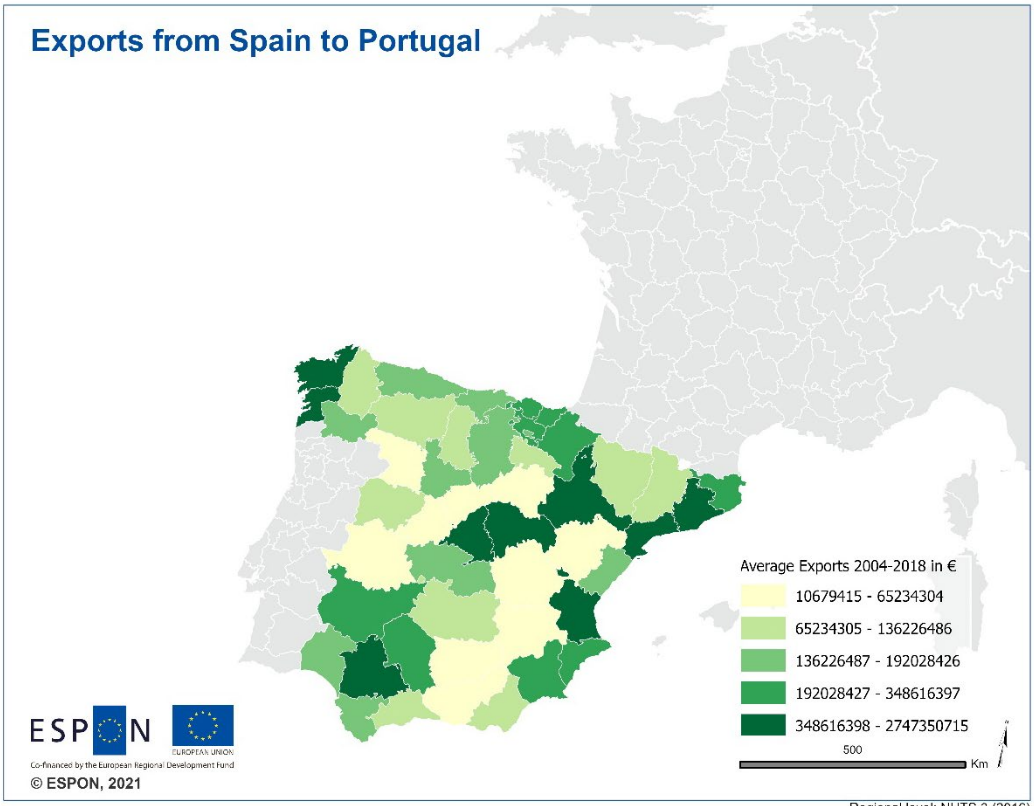
Regional level: NUTS 3 (2016)
Source: ESPON IRiE, 2021
Origin of data: CEPREDE - C-intereg, 2021
UMS RIATE for administrative boundaries

Next, Figure 4.3 plots the most relevant origins of the Spanish exports to these two countries, using two different panels for the flows to France and Portugal. Regarding France (first panel), the main origins concentrate in some of the Spanish border provinces (Gipuzkoa, Navarre, and Girona) but not in all (Huesca and Lerida are colour in pale green). Moreover, the concentration is even higher in Barcelona, Vizcaya (Bilbao) or Madrid, but also in Álava (Vitoria), Navarre, Zaragoza or Valencia. This spatial pattern suggests that the presence of two main drivers of trade, one routed in the geographical advantages of the regions located close to “Biriatou/Irun” and “Le Perthus/La Jonquera” main gateways, and the other, more related with region specific factors such related with the capital of Madrid, and the powerful exporting activity of Valencia, agglomerated around its international port and the presence of important clusters around the automobile sector and the food industry.

Figure 4.3 Main origins of the Spanish exports to France and Portugal. NUTS3-to-NUTS3 disaggregation. Average flows for the period 2004-2018. In Euros.



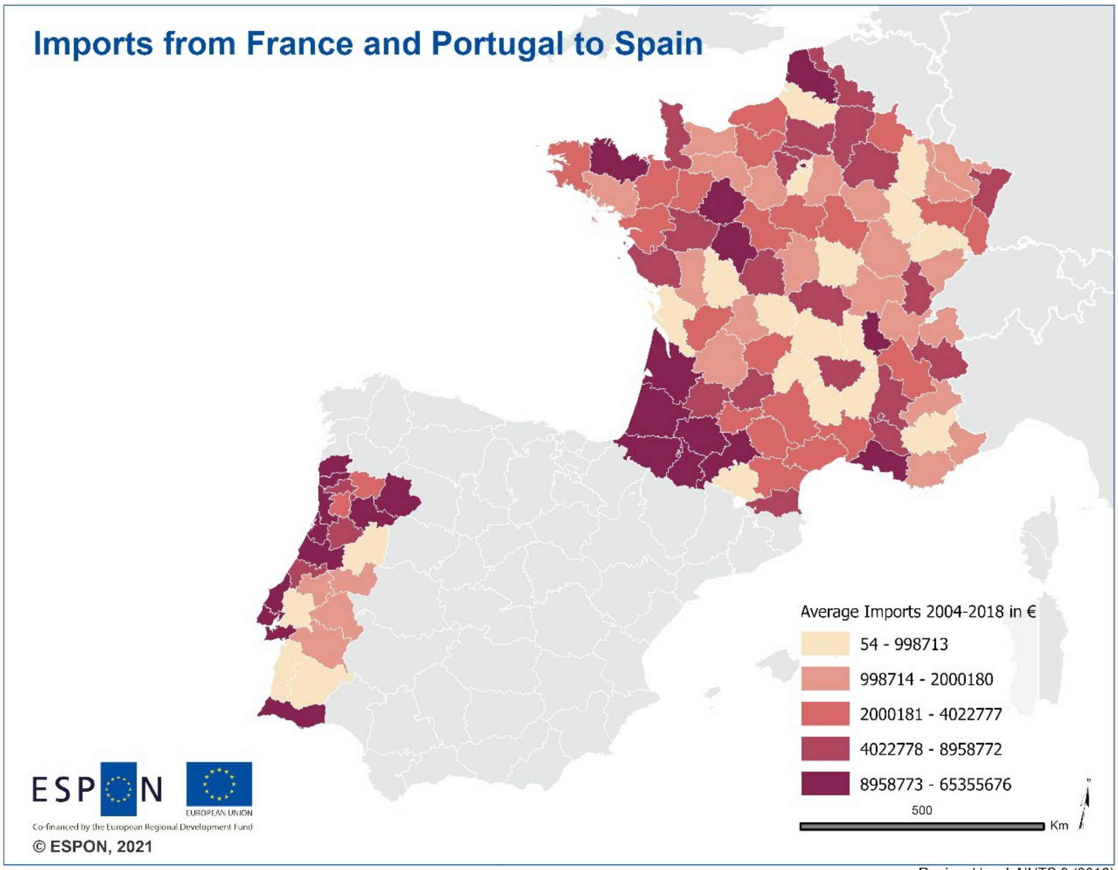
Regional level: NUTS 3 (2016)
Source: ESPON IRiE, 2021
Origin of data: CEPREDE - C-intereg, 2021
UMS RIATE for administrative boundaries



Regional level: NUTS 3 (2016)
Source: ESPON IRiE, 2021
Origin of data: CEPREDE - C-intereg, 2021
UMS RIATE for administrative boundaries

Conversely, the second panel of Figure 4.3, devoted to the concentration of exports to Portugal, is less evident and predictable. In this case, just the one border province (Pontevedra) and its neighbour, La Coruña, both in Galicia, have a strong concentration of exports to Portugal. The rest are concentrated around Seville in the south, Valencia in the east, and more interestingly, in all the provinces along the transport corridor that connects Madrid with Barcelona (Madrid, Guadalajara, Zaragoza, Tarragona and Barcelona). This spatial pattern might also suggest a combination of specific drivers, which of course, requires a more in-depth analysis. On the one hand, the Galician provinces enjoy geographical advantages on the supply of goods to the northern part of Portugal, in an area that currently conform a Euro-region. Something similar happens with Sevilla, which is the largest/closest region to the Algarve, facing a clear advantage with respect to the southern part of Portugal even in comparison to inner suppliers in Lisboan, Oporto or other industrial areas.

Figure 4.4 Main origins of the Spanish imports from France and Portugal. NUTS 3 level. Average flows for the period 2004-2018. In Euros.



Regional level: NUTS 3 (2016)
Source: ESPON IRiE, 2021
Origin of data: CEPREDE - C-intereg, 2021
UMS RIATE for administrative boundaries

Regarding the strong connections between Madrid, Barcelona or Valencia with Portugal, the drivers of trade might be more associated with the strong economic and exporting capacity of these Spanish regions (GDP), but also can mask other more-complex mechanisms, such as: i) the presence of business networks (intra-firm flows between different establishments within a multi-plant company, or the ones of different firms with a relevant capital participation, such as the ones analysed in the Task.1.4. of the IRIE project); ii) the presence of hub-spoke relationships associated with multi-modal flows (connections with ports, train, and airports) or the action of intermediaries such as wholesales and logistic platforms located in these areas. As a consumer and knowing the performance of several multinationals with base in Spain, it is reasonable to think that the supply of certain regions in Spain and Portugal responds to a common problem of optimal supply-chain, assuming an integrated Iberian market, with very little distinctions in terms of tastes, logistic strategies or even product-labelling, knowing that on many occasions, products include texts in both Spanish and Portuguese. Such effect, which might not perform equally for the case of France, could be also associated with the strong concentration of flows observed in Guadalajara or Zaragoza, which are known to be important logistic hubs. Obviously, the empirical verification of this possibility goes beyond the scope of this case study and requires a more detailed information about inter-modal connections and the role played by intermediaries.

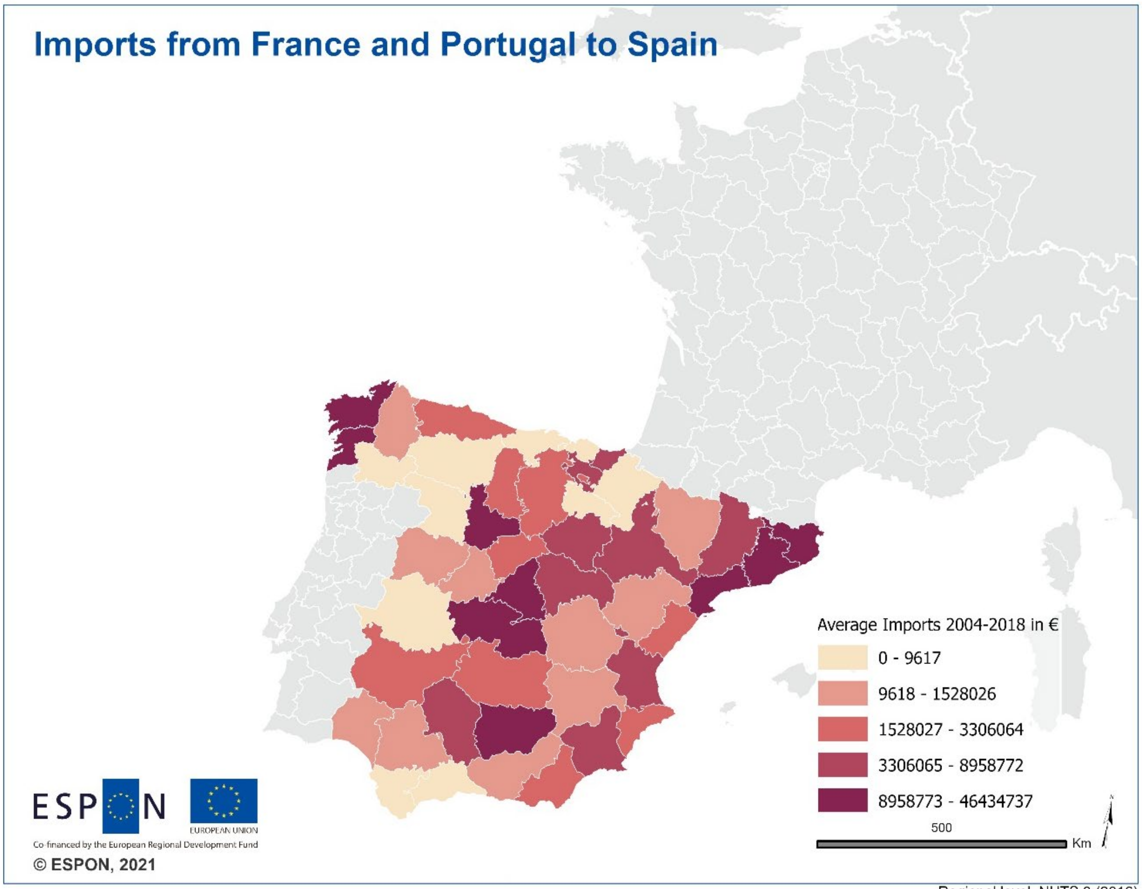
Complementary, Figure 4.4 represents the concentration of the Spanish imports from France and Portugal, highlighting the main exporting regions in these two countries. Again, the map uses average values for the entire period in euros, so reflect a structural pattern of interactions with the country of reference.

Starting with France, it is remarkable the level of concentration of exports with origin in the French regions located close to the French border, skewed towards the western gateway in "Biriatou/Irun". Indeed, the concentration of outflows in the western border regions in France (Aquitania and Midi-Pyrénées) looks stronger than in the case of the concentration of the Spanish exports to France, but revealing a kind of symmetry, which clearly speaks about a great level of integration. The concentration in the eastern part of the border, the one connection Catalonia with the Languedoc-Roussillon is also relevant, but less clear than for the Spanish exports and for the imports entering through the Atlantic corridor. Moreover, the relevance of Marseille, or the regions around Paris are still remarkable, while the concentration around the Rhöne (Lyon) is less intense.

In relation to Portugal, the main origins of the Spanish exports also concentrate in the coastal Portuguese regions, as in the case of the main destinations of the Spanish imports. However, we also find slight differences, with a clearer pattern of concentration in the northern part of Portugal, including landlocked and border-regions such as Terras de Trás-os-Montes, Douro, Visea Dao-Lafoes. Now, the concentration of outflows in Algarve is clearer than for exports, showing a scarce activity of exporting to France in the two NUTS 3 Alentejan regions, Alentejo Litoral and Baixo Alentejo.

Next, Figure 4.5 map the main Spanish regions of destination with respect to the French and Portuguese exports. It is interesting to compare this map with the Figure 4.3 to find similarities and differences. The first thing that stands out is that although the map of the Spanish exports and imports show a similar concentration in the eastern part of the Spanish border regions (Catalonia), the concentration of imports arriving to the north-west border regions (Basque Country, Navarre or Aragon) is less clear than for the exports, and contrasts with the larger concentration of French exporting regions to Spain in Aquitania and Midi-Pyrenees. This strange result might suggest that the French exporting regions close to the Atlantic corridor are not supplying the closest regions in the north, but others with higher levels of concentration such the two Castilla's and Madrid, with special relevance for the capital cities such as Valladolid, Madrid or Toledo. Indeed, the concentration of the main Spanish exporting regions to France and Portugal, and the one for the main Spanish importing regions suggest a more unequal (higher concentration) of the exports than for the imports, and a clearer bias towards the northern-easter regions (Atlantic-Ebro-Mediterranean axis) in the exports, while the imports cover more provinces and reach higher values in centre and southern Spanish regions.

Figure 4.5 Main destinations of the Spanish imports from France or Portugal. NUTS3 level. Average flows for the period 2004-2018. In Euros.



Regional level: NUTS 3 (2016)
Source: ESPON IRiE, 2021
Origin of data: CEPREDE - C-intereg, 2021
UMS RIATE for administrative boundaries

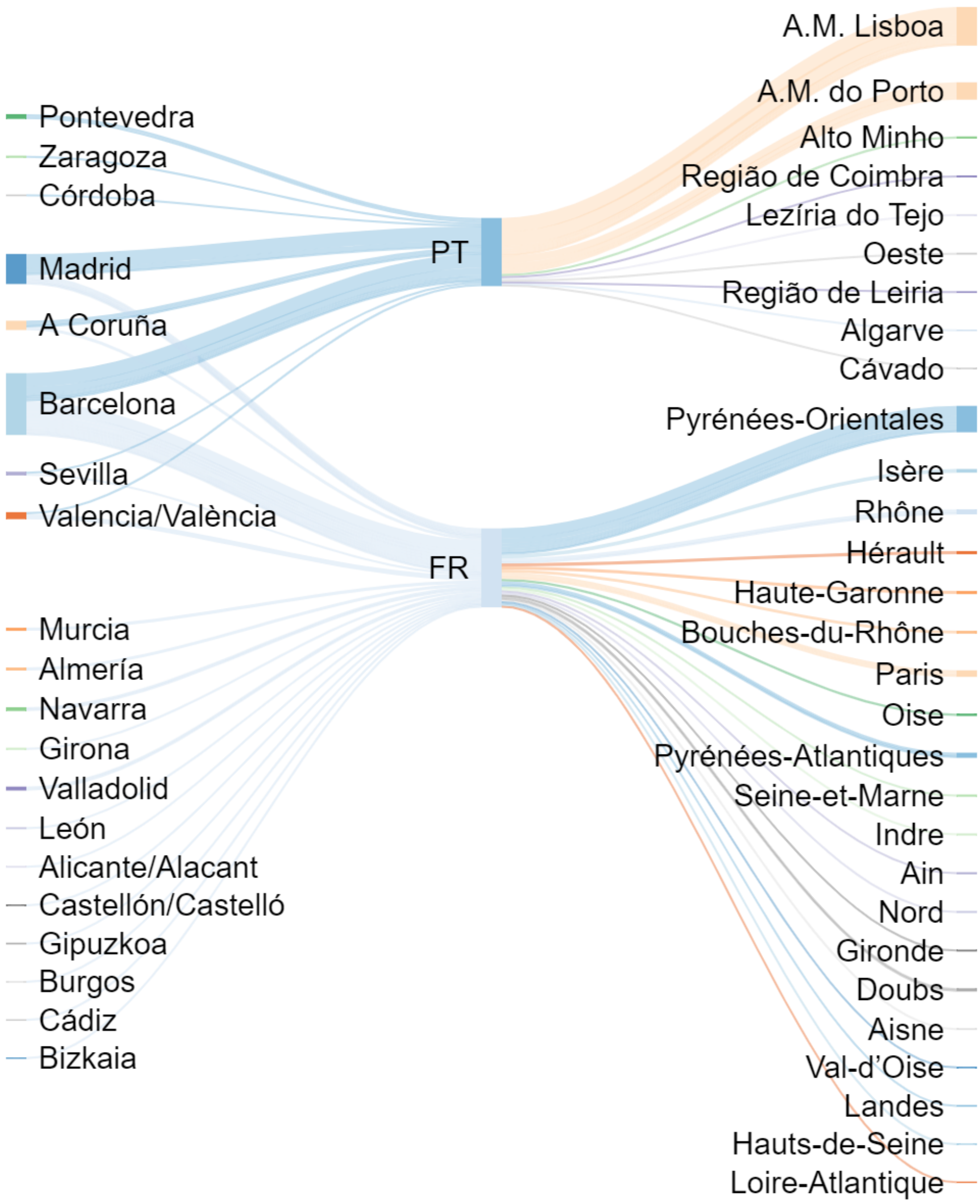
In relation to previous comments about the need to dig deeper on the specific origin-destination flows, Figure 4.6 and Figure 4.7 represents, using a Sankey diagram, the main 50th bilateral Spanish exports to the French and Portuguese NUTS 3 regions, along with the equivalent 50th bilateral Spanish imports. Regarding the Spanish exports, it is interesting to comment that, the most important bilateral flows correspond to:

- Madrid>A.M. Lisboa, which represents a (1.5%) of the total bilateral flows in this sample of average flows across the whole period.

- Barcelona>A.M. Lisboa. Next, and not surprisingly, the largest Flow connects Barcelona with Lisbon, also accounting for a great percentage of 1.4%.
- Barcelona>Pyrénées-Orientales:1.0%. This Flow is also remarkable and perfectly fit with our intuition about how geographical advantages and border and contiguous regions might show levels of integration above the average.
- Barcelona>A.M. do Porto: 0.7%. This relevant Flow also shows that Barcelona, which is very far away from Oporto, has a strong trade connection. This result is not evident and points out to the strong production and exporting activity of Barcelona, and its primal position in certain industries such as the one of Food and Beverage.
- Madrid>A.M. do Porto: 0.5%. This flow is equivalent to the previous one and shows how big producer provinces can easily overcome the trading cost imposed by large distance.
- Valencia/València>Pyrénées-Orientales: 0.5%. Interestingly, this connection introduces a new exporting province in Spain, Valencia, which a strong exporting capacity and a privilege access to France through the east gateway in Catalonia.
- The following main flows have origin in Barcelona and destination in three non-border French regions (Barcelona>Isère: 0.4%; Barcelona>Rhône: 0.4%; Barcelona>Hérault: 0.3%; Barcelona>Haute-Garonne: 0.3%; Barcelona>Bouches-du-Rhône: 0.3%)
- The next flows are originated in two Mediterranean provinces with relatively low industrial activity but a huge export capacity of fruit and vegetables. Interestingly, the flows are bound to the same French border region through the east main gateway (The Murcia>Pyrénées-Orientales: 0.3%; Almería>Pyrénées-Orientales: 0.3%).
- The next flows correspond to provinces in Galicia, and are bound to leading regions in France and Portugal: A Coruña>Paris: 0.3%; A Coruña>A.M. Lisboa: 0.3%; Pontevedra>A.M. do Porto: 0.3%; A Coruña>A.M. do Porto: 0.3%; Pontevedra>Alto Minho: 0.2%)
- Finally, we also want to comment the flows between Valencia/València>A.M. Lisboa: 0.2%; Navarra>Pyrénées-Atlantiques: 0.2% and Zaragoza>A.M. Lisboa: 0.2%. The one from Valencia, because represents an imaginary development axis that connects two strategic enclaves, one of the main Mediterranean ports and the other with the most western European port in the Atlantic. The second, with origin in Navarre and destination in a neighbouring region in France. Finally, the flow with origin in Zaragoza and destination in Lisbon MA.

Then, the import flows represented in Figure 4.7 adds the complementary view, to finally determine the main structural relations observed in this large period. First, it is remarkable how the concentration of the main inflows in Spain seems higher than in the case of the exports, since the number of different Spanish provinces appearing as destinations within the main 50th flows is narrower than the list of the Spanish regions within the list of the main 50th exports. This results contrast with the apparent opposite conclusion drawn from the previous maps, where the Spanish imports look more equally distributed among the Spanish provinces, with better access to the southern part of the country. This paradox is perfectly possible, finding a higher concentration of the imports in the first percentiles of the flows, and a wider range of regions importing in a thicker tail of the distribution.

Figure 4.6 Sankey diagram. 50 main Spanish exports to the French and Portuguese regions (NUTS 3). Average flows for the period 2004-2018. In Euros.



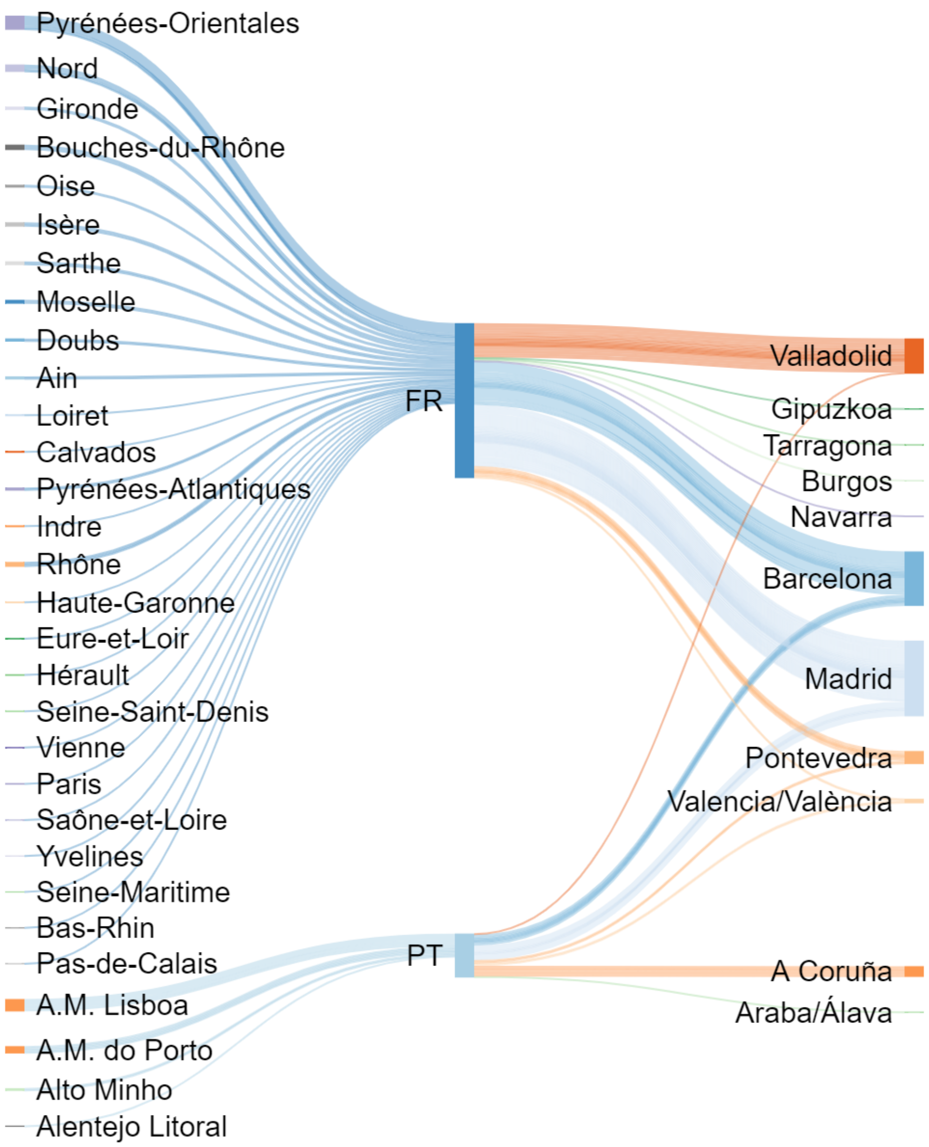
Next, as for the exports, and without being systematic, we want now to comment some of the main Spanish imports represented in that graph:

- The most relevant Flow has the origin in the Pyrénées-Orientales and the destination in Barcelona, representing a huge percentage (1.2%) of the total flows in the sample.
- The next Flow connects A.M. Lisboa with Madrid, and it is also relevant (0.7%), but almost a half of the previous one.
- Nord>Valladolid 0.5%. Interestingly, this flow connects to regions that will have never been predicted by a simple gravity equation. It is the case of two non-very important regions in France and Spain, but that are strongly connected by one single industry (firm):

the presence of Renault! Something similar happens with the strong flows from Gironde to Valladolid (0.4%), from Sarthe to Valladolid (0.3%) or from Indre to Valladolid (0.2%).

- The next more relevant flows are the following: A.M. Lisboa>A Coruña: 0.4%; Bouches-du-Rhône>Barcelona:0.4%; Pyrénées-Orientales>Madrid: 0.4%; Oise>Madrid: 0.3%; A.M. Lisboa>Barcelona: 0.3%; Isère>Barcelona: 0.3%; Bouches-du-Rhône>Madrid: 0.3%; Nord>Madrid: 0.2%; Moselle>Madrid: 0.2%; Doubs>Madrid: 0.2%; Ain>Madrid: 0.2%; Loiret>Madrid: 0.2%; Calvados >Madrid: 0.2%; Moselle>Pontevedra: 0.2%; Pyrénées-Atlantiques>Madrid: 0.2%.

Figure 4.7 Sankey diagram. 75 main Spanish imports form the French and Portuguese regions (NUTS 3). Average flows for the period 2004-2018. In Euros.



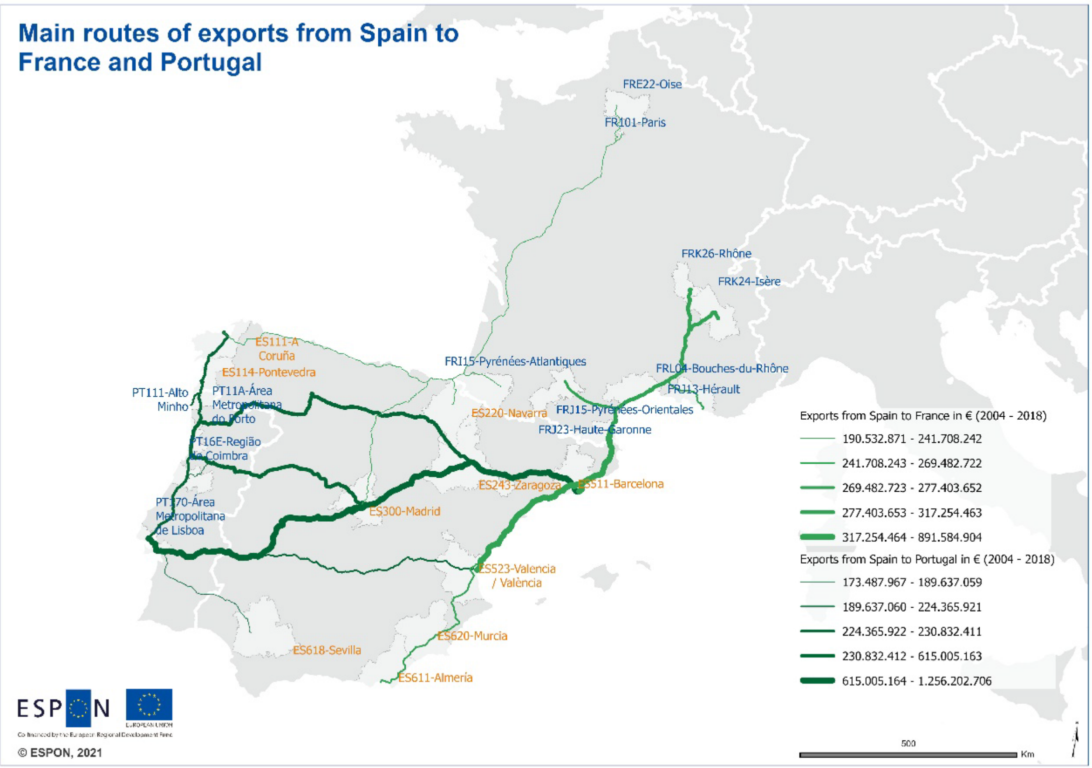
With this short list of flows, represented with the two Sankey diagrams, we have identified the most relevant structural interlinkages between the main partners of these three highly integrated countries. Obviously, such relations can then be decomposed by product and analysed in terms of its temporal evolution, to identify the dynamics behind these structural relations. We will explore part of such relations through our econometric analysis, leaving other to further investigations.

Next, we offer the last layer of our descriptive analysis. In Figure 4.8 we represent the routes that, more likely, the twelve main exports from the Spanish regions (NUTS 3) have followed from the exporting region in Spain to the destination in France and Portugal. This visualization summarize the GIS network analysis described before, where each origin-destination flow has been assigned to the optimal route obtained by minimising the travel time considering the current road network. The map uses the green for exports, with different intensities to distinguish the ones to France (paler green) and Portugal (darker green). The thickness of the lines corresponds to the cumulative use of a given infrastructure when the GIS assigns a common stretch of the network for different origin-destination routes. Obviously, this picture is partial, since just represents the main flows, showing a bias intuition of the real use of networks that would arise from mixing all connections at the same time. In this regard, when focusing on the main flows in absolute terms, the exports from Spain to Portugal generate thicker lines than the ones with France, while we know that the overall intensity of Spanish exports is larger with France than with Portugal. Moreover, when focusing on the routes more likely used for the main exports to France, the map shows a clear concentration in the Mediterranean corridor, while the Atlantic one looks thinner.

Having in mind this partial view, which will be complemented in further analysis, it is now interesting to focus on the flows plotted. Regarding the main exports from Spain to France, it is interesting to remind the ranking commented before, where the main flows had origin mainly in the Mediterranean corridor, with a clear predominancy of Barcelona (Barcelona>Pyrénées-Orientales; Barcelona>Isère; Barcelona>Rhône; Barcelona>Hérault; Barcelona>Haute-Garonne; Barcelona>Bouches-du-Rhône) and just three flows with origin in other Mediterranean provinces (Valencia/València>Pyrénées-Orientales; Murcia>Pyrénées-Orientales; Almería>Pyrénées-Orientales). In contrast, the list of big-specific-flows using the Atlantic corridor were narrower (i.e., Navarra>Pyrénées-Atlantiques).

Regarding the main export flows from Spain to Portugal, the main origin-destination combinations corresponded to the ranking commented before, with a predominancy of Madrid, Barcelona and Galicia (Madrid>A.M. Lisboa; Barcelona>A.M. Lisboa; Barcelona>A.M. do Porto; Madrid>A.M. do Porto; A Coruña>A.M. Lisboa; Pontevedra>A.M. do Porto; A Coruña>A.M. do Porto; Pontevedra>Alto Minho), with just two big flows with origin in Valencia/València and Zaragoza, and destination in Lisboa.

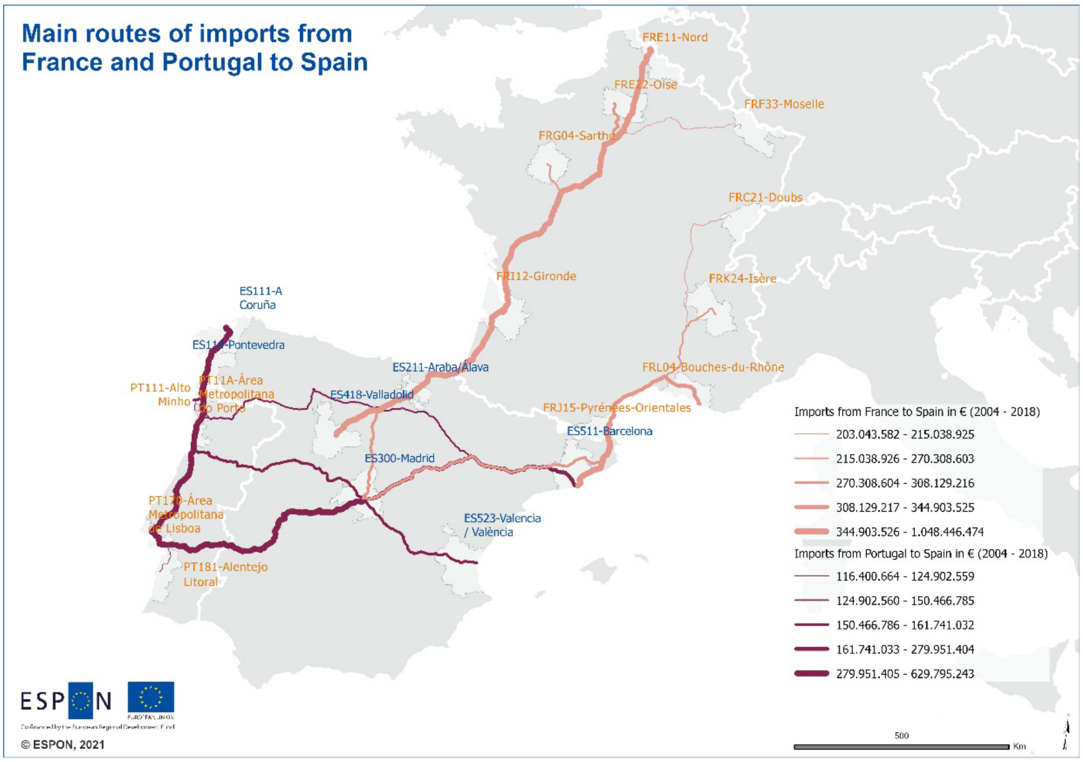
Figure 4.8 Optimal routes for the Spanish main exports to France and Portugal (€). NUTS 3. Average flows for 2004-2018.



Regional level: NUTS 3 (2016)
Source: ESPON IRiE, 2021
Origin of data: CEPREDE - C-intereg, 2021
UMS RIATE for administrative boundaries

Complementary, Figure 4.9 represents the routes that, more likely, have been used by French and Portuguese exporters to reach the Spanish importing regions (NUTS 3). In coherence with the previous visualization, we use red tones for imports, using the most intense for the Portuguese exports and the lighter for the French ones. In this case, although the representation is equally partial, it looks less bias than for the case of the Spanish exports. Now, just focusing on the twelve main flows, the gateways through the two national borders considered look more balanced. The Atlantic and Mediterranean corridor for the French exports appears with similar thicknesses, even with a larger intensity for the Atlantic funnel. It is remarkable the relevance of the route connecting Valladolid with Nord, Indre, Oise, Sarthe and Gironde, with a clear linkage to the automotive sector and Renault. The intense use of the coastal highways in Portugal (E1) connecting Lisboan-Oporto and Galicia is evident, while the connections between Barcelona (crossing Madrid and Valladolid), together with the strong flows with origin in Madrid and destination in Lisbon and Oporto, clearly remark the intense traffic in the E802 crossing through Badajoz, and less clearly, using the E-80 through Ciudad-Rodrigo.

Figure 4.9 Optimal routes for the main Spanish imports from France and Portugal (€). NUTS 3. Average flows for 2004-2018.



Regional level: NUTS 3 (2016)
Source: ESPON IRiE, 2021
Origin of data: CEPREDE - C-intereg, 2021
UMS RIATE for administrative boundaries

5.1.2 Modelling the international exports from Spain to France and Portugal

In this section we revise the main results obtained with the different specifications of the gravity equation described in the previous sections. We start modelling the international Spanish exports to France and Portugal. All the analysis is carried out at the NUTS 3 level, covering the period 2004-2018, with a panel data approach based on the PPML estimator, that is, the most appropriate for a sample that includes a considerable zero flows.

First, Table 3.5-1 provides the results of the classic gravity equation specification (equation 1), offering a benchmark that can be compared with other previous analysis at different spatial scales. In this specification, we applied a pooled regression to the entire sample, including just a time fixed effect. For comparison, the distance variable has been treated in two alternative ways, always with the idea of measuring the non-linear negative effect on trade (Gallego and Llano, 2004, 2015; Hillberry and Hummels, 2008; Diaz-Lanchas et al., 2019). The two first columns correspond to specifications where the distance is introduced in logarithms, while the two last columns opt for introducing a square transformation. With regards to the later, it is expected that, due to the accumulation of trade in the shortest distance, the first distance term will have a negative coefficient, while the one for the quadratic term, which captures the concavity, will be positive.

In general, the results are in line with similar analysis (Garmendia et al., 2012; Llano et al, 2010; Requena and Llano, 2010). The effect of GDP, both for the origin and the destination regions, is positive, significant, and close to 1, suggesting that, in average, an increase of 1% of the GDP of the exporter/importer region will increase its international exports/imports around a 1%, *caeteris paribus*.

The distance coefficients show the expective signs, values, and significance. For the case of the log transformation, its value is negative, significant, and close to -1 (-1.12 in column (1) and -0.96 in column 2 once the contiguity effect is controlled for). For the case of the quadratic transformation, the coefficient of D_{ij} is negative and significant (-2.92 in column (3) and -1.95 in column (4), once the contiguity effect is controlled for), while the one for the quadratic term D_{ij}^2 is positive (0.857 in column (3) and 0.418 in column (4)), indicating the more than expected accumulation of trade in the shortest distance, a common place in the gravity literature. Note that, since in this specification we just consider international Spanish exports to France and Portugal, finding a strong accumulation of trade in the shortest distance will be related with the higher propensity of the border regions to trade with the nearest regions at the other side of the border, something that, as we have seen in the descriptive analysis, is more found of happening in the Spanish-French border, and just in the very northern part of the Spanish-Portuguese one.

To dig deeper in this intuition, it is interesting now to focus on the international contiguity effect captured by the dummy $intern\text{-}contig_{ij}$, whose coefficient is positive and significant, both for the log of distance (1.315 in column (2)) and the quadratic transformation (1.921 in column (4)). So, being contiguous regions increases the intensity of trade from Spain to abroad (here, France or Portugal) between 1.315*100% or 1.921*100%.

For the rest of the estimations, we use different extensions of the micro-founded gravity equation, where the origin-time fixed effects and destination-time fixed effects control for the multilateral resistance terms. Table 5-2 considers all the exporting flows from the Spanish regions to the French and Portuguese counterparts. With respect to the classic gravity equation, besides the origin-time and destination-time fixed effects, these specifications control for the variables: Capital, border, mountain, and coast; all of them for the origin and the destination regions. Regarding the distance, the first 4 columns correspond to its logarithm transformation, while the remaining column (5) corresponds to its square transformation. Although the log transformation provides better R^2, although the results are very similar for both treatments of the distance.

Again, the results obtained for the distance confirm the expectations and the previous results, finding a negative coefficient for $log(D_{ij})$ close to -1, and the two expected signs for the quadratic transformation (-2.731 versus 0.879).

Table 3.5-1: Classic gravity equation for inter-national exports from Spain to France and Portugal. NUTS 3 level. PPML. Period: 2004 – 2018.

	International export from Spain to Portugal and France			
	(1)	(2)	(3)	(4)
VARIABLES	Tijt	Tijt	Tijt	Tijt
$\log(gdp_{it})$	0.996***	1.003***	0.991***	0.997***
	(0.0533)	(0.0521)	(0.0575)	(0.0550)
$\log(gdp_{jt})$	0.973***	0.983***	0.958***	0.974***
	(0.0488)	(0.0480)	(0.0497)	(0.0482)
$\log(D_{ij})$	-1.127***	-0.961***		
	(0.139)	(0.144)		
D_{ij}			-2.925***	-1.957***
			(0.598)	(0.547)
D_{ij}^2			0.857***	0.418*
			(0.265)	(0.238)
intern-contig$_{ij}$		1.315***		1.921***
		(0.337)		(0.318)
Constant	-9.740***	-9.852***	-7.504***	-8.163***
	(0.756)	(0.745)	(0.960)	(0.944)
Observations	23,970	23,970	23,970	23,970
R-squared	0.512	0.542	0.497	0.532

Source: Own elaboration.
Note: PPML estimator. Robust standard errors in parentheses (*** p<0.01, ** p<0.05, * p<0.1). Error term cluster by pairs. All regressions contain a time fixed effect.

With respect to the capital dummies, we obtain a positive and significant coefficient for all the specifications, indicating, for the most complete model (column 4), that, on average, Madrid (capital city of Spain) trades 20.5 times (exp(3.023)) more than any other non-capital non-border non-contiguous Spanish exportin region, caeteris paribus the rest of factors; while the capital regions of destination, Paris and Lisbon, tend to import 11 times (exp(2.399)) more than any other non-capital non-border non-contiguous non-Spanish region in the sample.

Surprisingly, the contiguity effect, is only significant for the cases of the contiguous NUTS 3 regions between Spain and Portugal, which reach the highest coefficient (1.907 in column (4)), when all the geographic drivers (border, coastal, and/or mountainous region) are included. By contrast, the case for the coefficient for the contiguous regions for the Spanish-French frontier is close to zero, negative, and non-significant. This unexpected result should be considered cautiously. Although all previous analysis at the NUTS 2 level (Paluzie and Lafourcade, 2011; Gallego and Llano, 2015, 2016; Gallego et al., 2021) indicate that international contiguous regions trade more that the rest of regions in the country, this effect vanishes when the spatial grid increases to the NUTS 3 level. The reason is clear: Girona, Lérida, Huesca and Gipuzkoa, are the true border provinces with France, but are not the core exporting provinces within their corresponding NUTS 2 border regions, namely, Catalonia, Aragón and the Basque Country. The case of Navarre is singular, since it is the only single province NUTS 2 region border to France, but its direct access to France is less relevant than the more convenient gateway through Irun in the Basque Country. Once again, it is necessary to remark that this *intern-contig*$_{ij}$ variable is dyadic, and just capture if there is a special trade relation between pairs of border-contiguous-regions, which in the case of the northern border of Spain, coincide with the most mountainous and less economic industrialized regions of their corresponding nuts 2 regions.

To dig deeper in this non-obvious result, it is helpful to use the alternative dummy variables, defined as monadic variables (they just refer to exporting or importing regions, but not to pair of trading regions), and controlling for the different effects in these two very different borders, the one with France in the north, and the one with Portugal on the west. Regarding to the effect of being an origin border region for international exports, we have found asymmetric effects depending on the national frontiers. The Spanish border regions to France (*border-es-fr*$_i$) tend to export more (1.158 for column 4), while the coefficient for the Spanish border regions to Portugal is negative (-0.502, in column 3) and even lower and non-significant when we control for all the geographical variables (-0.293, in column 4). With respect to the destination border region effect, the coefficient for the case of Portugal is negative and significant, and persistent along different specifications (-1.287 in column 3; -1.094 in column 4). So, these regions tend to import less than others foreign non-border regions or French border regions. Conversely, this coefficient for the case of the French border regions is positive and significant (0.728 in column 3 and 0.752 in column 4), suggesting that these regions tend to import more from Spain than other non-border regions or the Portuguese border regions.

With respect to the geographical features considered, it is proven that being a coastal region has a positive effect for the case of the Spanish exporting provinces (1.075 in column 4), but as well for the foreign destination regions (0.688 in column 4) in France and Portugal. In relation to the “mountain” effect, the effect is weak and non-significant (0.240 in column 4) for the origin regions, and negative and non-significant for the destination regions (-0.298 in column 4).

Summing up, these first estimations confirm that the intensity of the Spanish exports increases when the flow “comes from” or is “bound for” capital and coastal regions, as well as when it implies Spanish and Portuguese contiguous regions, or when the flow is originated in a Spanish-border region with France (despite the destination in France) or has a destination in the French-border regions (despite the origin in Spain).

Table 5-2 Augmented gravity equation for inter-national exports from Spain to France and Portugal. NUTS 3 level. PPML. Period: 2004 – 2018.

	International Spanish export (flow from Spain to Portugal and France)				
	(1)	(2)	(3)	(4)	(5)
VARIABLES	Tijt	Tijt	Tijt	Tijt	Tijt
$Capital_i$	1.938***	1.964***	2.266***	3.023***	3.096***
	(0.308)	(0.307)	(0.293)	(0.318)	(0.324)
$Capital_j$	2.544***	2.573***	2.617***	2.399***	2.382***
	(0.284)	(0.284)	(0.280)	(0.253)	(0.261)
$log(D_{ij})$	-0.997***	-0.980***	-0.976***	-0.960***	
	(0.0953)	(0.0934)	(0.0966)	(0.0958)	
D_{ij}					-2.731***
					(0.368)
D_{ij}^2					0.879***
					(0.184)
$intern\text{-}contig_{ij}$	-0.0349				
	(0.344)				
$intern\text{-}contig\text{-}es\text{-}pt_{ij}$		1.035***	1.317***	1.336***	1.907***
		(0.208)	(0.217)	(0.216)	(0.208)
$intern\text{-}contig\text{-}es\text{-}fr_{ij}$		-0.314	-0.358	-0.352	-0.0797
		(0.357)	(0.345)	(0.343)	(0.329)
$border\text{-}es\text{-}pt_i$			-0.502**	-0.293	-0.256
			(0.200)	(0.211)	(0.214)
$border\text{-}es\text{-}fr_i$			1.298***	1.158***	1.215***
			(0.203)	(0.204)	(0.212)
$border\text{-}pt_j$			-1.287***	-1.094***	-1.077***
			(0.208)	(0.205)	(0.210)
$border\text{-}fr_j$			0.728***	0.752***	0.753***
			(0.272)	(0.274)	(0.275)
$mountain_i$				0.240	0.292
				(0.198)	(0.198)
$mountain_j$				-0.298	-0.277
				(0.203)	(0.201)
$coastal_i$				1.075***	1.075***
				(0.147)	(0.144)
$coastal_j$				0.688***	0.730***
				(0.163)	(0.162)
Constant	8.213***	8.185***	7.929***	6.929***	8.642***
	(0.0979)	(0.0975)	(0.0963)	(0.231)	(0.330)
Observations	82,391	82,391	82,391	82,391	82,391
R-squared	0.597	0.615	0.621	0.625	0.616

Procedure method of estimation: PPML
Robust standard errors in parentheses (*** p<0.01, ** p<0.05, * p<0.1)
The estimations are cluster under the distance variable of partners.
All regressions contain the multilateral terms (fixed effects by origin and destination interacted with time), and a time fixed effect.

Table 5-3 reports results for the same specifications than in the previous analysis but splitting the sample in two sub-samples. From column A1 to A4, we only consider the Spanish exports to Portugal, whilst from column B1 to B4, we focus on the ones to France. For brevity, we focus on specification 3 (A3 and B3) which is comparable to the column 4 of the previous table.

In terms of the “Capital”-effect and the effect of distance, the signs and the significance are coherent with the previous findings. Though, for the case of international exports to Portugal, the Capital dummies have got higher coefficients, both for the origin and the destination of the flow, while the distance effect decreases.

Regarding to the contiguity effect, for the Portuguese subsample its value remains positive and significant (1.259 in column A3; 1.336 in column 4), while for the French subsample is negative, though weaker, and statistical significance in some cases (-0.613 in column B3, -0.352 and non-significant in column 4).

With respect to the monadic dummies capturing the effect of being a border region, the results slightly diverge from the ones using the whole sample. For the Spanish exports to Portugal, the negative effect of being a Spanish contiguous region obtained in the whole sample (-1.094 in column 4), now turns to positive and significant when the geographic characteristics (0.769 in column A3) are included. Nevertheless, the negative effect of being a Portuguese contiguous destination region remains negative (-1.094 in column 4; -1.34 in column A3). For the French case, being at the border still has a positive and significant effect on both two sides of the frontier, but now the coefficients are lower, especially for the Spanish origin region (1.158 in column 4 and 0.658 in column B3). When we just consider international exports to Portugal, being at the border has now a positive effect, which vanishes when the whole sample was consider. However, when we just consider international exports to France, we have the opposite result. Being at the border, though provides a positive advantage, its estimation is lower than when we consider the full sample.

According to the geographical variables, we have found new results. When we only consider the international exports to Portugal, the effect of being an exporting-mountain-region is positive and significant (1.173 in column A3, while it was not significant in column 4). This effect, which was tapered off in the whole sample, is probably capturing the higher intensity of trade, observed in the descriptive analysis, with origin in Pontevedra and La Coruña, and destination in Oporto and Lisbon M.A. For the case of the destination, now we observe a negative and significant effect (-0.996), so the Portuguese mountainous regions tend to import less, something that is coherent with all our previous reflections about the peripheral inner regions in Portugal, which are the most wrinkled and rural ones.

Table 5-3 Augmented gravity equation for inter-national exports from Spain to Portugal (Panel A) and from Spain to France (Panel B). PPML. Period: 2004 – 2018.

	A: Only international exports to Portugal				B: Only international exports to France			
	A(1)	A(2)	A(3)	A(4)	B(1)	B(2)	B(3)	B(4)
VARIABLES	Tijt	Tijt	Tijt	Tijt	Tijt	Tijt	Tijt	Tijt
$Capital_i$	2.191***	2.370***	3.858***	3.759***	1.921***	2.219***	3.168***	2.977***
	(0.392)	(0.379)	(0.556)	(0.514)	(0.363)	(0.370)	(0.430)	(0.441)
$Capital_j$	3.152***	2.475***	2.212***	2.153***	1.780***	1.860***	1.923***	2.104***
	(0.359)	(0.381)	(0.385)	(0.362)	(0.364)	(0.363)	(0.355)	(0.377)
$\log(D_{ij})$	-0.977***	-0.964***	-1.106***		-1.560***	-1.477***	-1.401***	
	(0.187)	(0.222)	(0.171)		(0.128)	(0.128)	(0.128)	
D_{ij}				-6.697***				-3.243***
				(0.889)				(0.447)
D_{ij}^2				4.080***				0.432*
				(0.653)				(0.230)
intern-$contig_{ij}$	1.192***	1.379***	1.259***	1.427***	-0.717**	-0.670*	-0.613*	0.00538
	(0.229)	(0.261)	(0.221)	(0.199)	(0.361)	(0.348)	(0.343)	(0.286)
border-es_i		0.540	0.769*	0.509		0.718***	0.658***	0.552***
		(0.472)	(0.464)	(0.373)		(0.159)	(0.159)	(0.163)
$border_j$		-1.993***	-1.340***	-1.300***		0.612**	0.662**	0.399
		(0.331)	(0.270)	(0.265)		(0.266)	(0.277)	(0.268)
$mountain_i$			1.173***	0.948***			0.471**	0.139
			(0.311)	(0.273)			(0.232)	(0.245)
$mountain_j$			-0.996***	-0.890***			-0.238	-0.246
			(0.295)	(0.290)			(0.243)	(0.237)
$coastal_i$			1.030***	0.874***			1.058***	1.200***
			(0.296)	(0.264)			(0.164)	(0.173)
$coastal_j$			0.648**	0.645**			0.315	0.364*
			(0.288)	(0.297)			(0.194)	(0.187)
Constant	7.840***	8.311***	6.399***	9.625***	8.242***	7.861***	6.852***	9.885***
	(0.324)	(0.250)	(0.515)	(0.626)	(0.0843)	(0.0999)	(0.256)	(0.384)
Observations	16,215	16,215	16,215	16,215	66,176	66,176	66,176	66,176
R-squared	0.816	0.816	0.820	0.814	0.500	0.501	0.502	0.505

Procedure method of estimation: PPML
Robust standard errors in parentheses (*** p<0.01, ** p<0.05, * p<0.1)
The estimations are cluster under the distance variable.
All regressions contain the multilateral terms (fixed effects by origin and destination interacted with time), and a time fixed effect.

When we analyse the Spanish exports to France, being a mountain region, once again, has a positive effect, but is not as strong and statistically significant (0.471 in column B3) as for the exports to Portugal. This can be explained by the fact that, although the Spanish northern regions are great exporters even being mountainous regions, they compete with other very relevant Spanish exporting regions such as Madrid, Valencia, Valladolid, Murcia or Almería, which are flatter. For the case of the destination, being a French mountainous region has no significant effect.

Regarding the coast variables, we do not have relevant changes for the origin, suggesting that the Spanish coastal regions tend to export more to both markets. However, being a coastal destination region just reach positive and significant coefficients for Portugal (0.648 in column A3, which is very similar to 0.688 for the full sample in column 4).

5.1.3 Modelling the international imports from France and Portugal to Spain

We now turn to analyse the results obtained for the Spanish imports, so now the origins are the French and Portuguese regions. For brevity, this analysis will just focus on the preferred specifications of the previous analysis. Table 5-4, in column 1, reports the coefficients for the full sample and for the augmented gravity equation that includes the geographical features, in column 2, this specification is only fed by the imports from Portugal, while in column 3, it is only fed by the imports from France. Complementary results are reported in the Appendix (Table 8-3, Table 8-4, and Table 8-5).

The coefficients associated to the *distance* and the *capital dummies* are in line with the previous results for the Spanish exports, as in the case of the *intern-contig*$_{ij}$, whose coefficient is only positive and significant for the case of the Portuguese-Spanish, but not for the French-Spanish case.

Regarding to the effect of being a border region, in the case of the Portuguese border, regions on both side of the border show a negative significant coefficient. Focusing on the Portuguese side, the coefficient with the full sample was -1.554 (in column 1), while the one when just Portugal is considered drops to -1.132, (in column2). For the Spanish case, this negative effect melts when we do not include the imports from France, so we can conclude that these border Spanish regions to Portugal tend to import less from France, but not specially from Portugal. For the French border, when the full sample is used, the coefficient is positive but weakly significant for the French border regions as exporters to Spain (0.527, in column 1), but when just the French sub-sample is used, this variable turns to be nonsignificant. Looking no into the Spanish border regions to France, for the full sample, they tend to import more than non-border regions (0.606, in column 1), while for the narrower sub-sample without Portugal, the significance vanishes.

Table 5-4 Augmented gravity equation for inter-national imports from Portugal and France to Spain. NUTS 3 level. PPML. Period: 2004 – 2018.

Origin of the flows:	PT and FR (1) (4 in the Ap-pendix)	PT (2) (3 in the Ap-pendix)	FR (3) (3 in the Ap-pendix)
VARIABLES	Tijt	Tijt	Tijt
$Capital_i$	1.562***	1.762***	1.843**
	(0.297)	(0.305)	(0.735)
$Capital_j$	2.770***	3.387***	2.898***
	(0.350)	(0.398)	(0.489)
$log(D_{ij})$	-0.926***	-1.012***	-2.002***
	(0.163)	(0.205)	(0.141)
intern-contig-es-pt_{ij}	1.075***	0.896***	
	(0.362)	(0.282)	
intern-contig-es-fr_{ij}	0.498		-0.112
	(0.611)		(0.243)
border-pt_i	-1.554***	-1.132***	
	(0.284)	(0.258)	
border-fr_i	0.527*		-0.0747
	(0.300)		(0.346)
border-es-pt_j	-0.514**	0.441	
	(0.230)	(0.348)	
border-es-fr_j	0.606***		0.221
	(0.112)		(0.207)
$mountain_i$	-0.0502	0.0997	-0.00190
	(0.268)	(0.234)	(0.316)
$mountain_j$	-0.719***	0.787***	-0.998***
	(0.182)	(0.280)	(0.258)
$coastal_i$	0.444*	1.172***	0.220
	(0.228)	(0.257)	(0.261)
$coastal_j$	0.954***	0.765***	0.908***
	(0.131)	(0.268)	(0.149)
Constant	7.909***	5.926***	8.101***
	(0.273)	(0.372)	(0.382)
Observations	82,250	16,168	66,082
R-squared	0.274	0.678	0.500

Procedure method of estimation: PPML
Robust standard errors in parentheses (*** p<0.01, ** p<0.05, * p<0.1)
The estimations are cluster under the distance variable.
All regressions contain the multilateral terms (fixed effects by origin and destination interacted with time), and a time fixed effect.

According to the geography features, it is statistically significant the effect of being a mountainous destination region. Besides, we found different signs for the origins mountainous regions, being positive when the origin is Portuguese and negative when is French. Therefore, once we have controlled for the distance, contiguity, border regions, coastal regions and the fixed effects, the

Portuguese regions tend to export more, i.e., over the average, to Spanish mountainous regions. Whilst French regions tend to export less to these rougher regions, and maybe more to the ones in the plane and the Mediterranean Corridor. With respect to the coastal variable, the effect is less ambiguous: it is positive for the origin and the destination in all the cases. And when we split the sample into the Portuguese (column 2) versus French (column 3) origin, this feature is more relevant for the origin when this is Portuguese (1.172 in column 2), but it is more relevant for the destination when the origin is French (0.908 in column 3). Once again, the production activity in Portugal seems to be more concentrated in the coast, while the main Spanish importing regions from France are concentrated in the coast.

5.2 International and intranational region-to-region trade flows

5.2.1 The Spanish Home Biased Effect from the export perspective

In this section we include a critical innovation with respect to most of the analysis done till now, which consist of including the intra-national Spanish flows (by road), as a new benchmark for comparing the level of trade integration with these two main neighbour economies. The results are reported in Table 5-5, where the variables are like the previous specification, but introducing some innovations to control for the potential different nature of the intra-national and inter-national flows. More specifically, we estimate the Home bias effect, here measured as how many times a Spanish region (NUTS 3) exports less to a French or Portuguese region than to another Spanish region once we have controlled for the main drivers of trade. Note that the use of the term Home Bias is sometimes associated with a positive sign of a dummy variable capturing the higher trade within own boundaries. In our case, to avoid confusion with the already proliferous different variables related with the “border regions”, we prefer to keep the label of “home bias”, although in another context it will be more appropriate to talk about “external and internal border effect” (Requena and Llano, 2010; Poncet, 2003; Gallego and Llano, 2014, 2015). We want to remark that in this new set of specifications the intra-provincial Spanish trade is not included.

Since here we are incorporating the intra-national flows, i.e., trade in short distances, the quadratic transformation of the distance suits the best to this expanded dataset. Nevertheless, the column 5 provides the results for the log transformation. In both cases, the estimations are robust to these two kinds of non-linear treatments of distance.

The intra-national trade also allows to decompose the contiguity effect. While in column 1 we just control for the average effect of contiguity, column 2 provides the contiguity effect at two levels: inside of the economy (intranational contiguity effect, i.e., intran-$contig_{ij}$) and between countries (international contiguity effect, i.e., intern-$contig_{ij}$). In columns 3 and 4 the international contiguity effect is specific for the French and the Portuguese case.

Regarding the main results, we observe that the Capital variables are positive and significant for the origin and the destination regions. Distance is also significant and has the expected signs: a sheer and negative coefficient for the distance variable, and feebler and positive for the square of the distance. For the log transformation (column 5) its coefficient is negative, significant, and in line with the expectations (-1.078).

The Home Bias effect with Portugal is significant for all the specifications. When we consider the maximum disaggregation of the contiguity effect, but not the geographic typologies (column 3), its value is -2.67, which means that, on average, a Spanish region tends to export (exp(2.67)=14.4) 14 times less to a Portuguese region than to another Spanish region, ceteris paribus. For the French case, the Home Bias effect is slightly lower (-2.532, in column 3), which suggests that a Spanish region exports, 13 times less (exp=(2.532)=12.57) to a French region than to a Spanish region of equivalent size at a comparable distance. When the geographical characteristics are included, the Home Bias effect increases until 18 times (exp(2.879, in column 4). This result is similar when the distance enters in logs. For the French Home Bias estimation, it decreases until 12 (exp(2.515), in column 4), but if the distance is in log its value is 14 (exp(2.661) in column 5). In general, we can conclude that the first destination of the Spanish exports is Spain, followed at a great distance by France, and finally Portugal.

According to the contiguity effect, this is positive and significant (0.563, in column 1). When this variable is decomposed in *intranational* vs *international*, prevails the positive and significant effect for the intranational contiguity dummy (0.577, in column 2), but it is not significant for the international. And when the international contiguity effect is split by the country of destination it emerges a positive and significant effect for the case of international contiguity with Portugal (0.848, in column 3). For the rest of the estimations, this contiguity effect remains positive and higher than the intranational contiguity effect. For the French trade is negative and nonsignificant.

With respect to the geographical features, prevails the positive and significant effect of being a coastal region, both for the origin and the destination. And for the *mountain* variable, this has a positive and significant effect for the origin of the exports, though its value is always lower (0.358, in column 4) than the effect of the *coastal* variable (0.860 for the origin and 0.779 for the destination, in column 4).

Table 5-5 Augmented gravity equation for inter and intra-national exports from Spain to France and Portugal. NUTS 3 level. PPML. 2004 – 2018.

	Intra-national trade for Spain & exports from Spain to Portugal & France				
	(1)	(2)	(3)	(4)	(5)
VARIABLES	Tijt	Tijt	Tijt	Tijt	Tijt
$Capital_i$	1.187***	1.185***	1.187***	1.953***	1.973***
	(0.230)	(0.231)	(0.231)	(0.217)	(0.219)
$Capital_j$	1.752***	1.750***	1.753***	2.294***	2.313***
	(0.200)	(0.201)	(0.201)	(0.173)	(0.172)
$log(D_{ij})$					-1.078***
					(0.0410)
D_{ij}	-3.863***	-3.864***	-3.863***	-3.947***	
	(0.196)	(0.197)	(0.197)	(0.197)	
D_{ij}^2	1.244***	1.240***	1.240***	1.268***	
	(0.129)	(0.129)	(0.129)	(0.129)	
Home Bias-es-pt_{ij}	-2.653***	-2.618***	-2.671***	-2.879***	-2.904***
	(0.205)	(0.206)	(0.209)	(0.192)	(0.190)
Home Bias-es-fr_{ij}	-2.553***	-2.535***	-2.532***	-2.515***	-2.661***
	(0.121)	(0.123)	(0.123)	(0.123)	(0.111)
$contig_{ij}$	0.563***				
	(0.0567)				
intran-$contig_{ij}$		0.577***	0.578***	0.560***	0.251***
		(0.0571)	(0.0571)	(0.0568)	(0.0731)
intern-$contig_{ij}$		0.0595			
		(0.296)			
intern-contig-es-pt_{ij}			0.848***	0.900***	0.576***
			(0.246)	(0.235)	(0.203)
intern-contig-es-fr_{ij}			-0.172	-0.208	-0.231
			(0.313)	(0.312)	(0.312)
$mountain_i$				0.358***	0.332***
				(0.117)	(0.116)
$mountain_j$				0.0781	0.0549
				(0.121)	(0.121)
$coastal_i$				0.860***	0.811***
				(0.113)	(0.112)
$coastal_j$				0.779***	0.703***
				(0.125)	(0.125)
Constant	13.41***	13.41***	13.41***	12.38***	10.04***
	(0.108)	(0.108)	(0.108)	(0.143)	(0.118)
Home bias ES-PT = exp(β)	14	14	14	18	18
Home bias ES-FR = exp(β)	13	13	13	12	14
Observations	98,730	98,730	98,730	98,730	98,730
R-squared	0.794	0.794	0.794	0.806	0.798

Procedure method of estimation: PPML
Robust standard errors in parentheses (*** p<0.01, ** p<0.05, * p<0.1)
The estimations are cluster under the distance variable.
All regressions contain the multilateral terms (fixed effects by origin and destination interacted with time), and a time fixed effect.

Table 5-6 splits the sample in two: columns A1-A4 for the Spanish export to Spain and Portugal, and columns B1-B4 for the Spanish export to Spain and France. By doing this, the estimation of all the coefficients can have a better adjustment to each specific case. Focusing on the most extensive specification of the gravity equation (column A3 and B3), we observe that the Home

Bias effect prevails more intensive for the Portuguese case (exp(2.910) = 18, in column A3) than for the French case (exp(2.360)=11, in column B3). However, the international contiguity effect is only positive and significant for the Portuguese frontier. Regarding the geographic variables, the results are very similar to the ones reported for the full sample.

Table 5-6 Augmented gravity equation for intra-national Spanish trade and the Spanish exports to Portugal (Panel A) and to France (Panel B). NUTS 3 level. PPML. 2004 – 2018.

	A: Intra-national Spanish trade & Spanish exports to Portugal				B: Intra-national Spanish trade & Spanish exports to France			
	(A1)	(A2)	(A3)	(A4)	(B1)	(B2)	(B3)	(B4)
VARIABLES	Tijt	Tijt	Tijt	Tijt	Tijt	Tijt	Tijt	Tijt
$Capital_i$	1.124***	1.125***	1.893***	1.911***	1.110***	1.109***	1.846***	1.881***
	(0.249)	(0.249)	(0.233)	(0.235)	(0.235)	(0.236)	(0.225)	(0.228)
$Capital_j$	1.728***	1.729***	2.297***	2.326***	1.614***	1.614***	2.225***	2.250***
	(0.207)	(0.207)	(0.177)	(0.180)	(0.210)	(0.211)	(0.187)	(0.187)
$\log(D_{ij})$				-1.064***				-1.131***
				(0.0431)				(0.0420)
D_{ij}	-5.528***	-5.530***	-5.581***		-3.885***	-3.887***	-3.965***	
	(0.427)	(0.427)	(0.432)		(0.194)	(0.194)	(0.194)	
D_{ij}^2	2.734***	2.737***	2.720***		1.081***	1.077***	1.102***	
	(0.365)	(0.365)	(0.369)		(0.104)	(0.105)	(0.105)	
Home $Bias_{ij}$	-2.655***	-2.681***	-2.910***	-2.914***	-2.416***	-2.394***	-2.360***	-2.609***
	(0.206)	(0.210)	(0.192)	(0.192)	(0.113)	(0.115)	(0.116)	(0.112)
$contig_{ij}$	0.385***				0.503***			
	(0.0700)				(0.0560)			
intran-$contig_{ij}$		0.383***	0.364***	0.268***		0.519***	0.502***	0.177**
		(0.0701)	(0.0705)	(0.0752)		(0.0563)	(0.0563)	(0.0731)
intern-$contig_{ij}$		0.681***	0.730***	0.577***		-0.200	-0.234	-0.255
		(0.245)	(0.232)	(0.207)		(0.308)	(0.307)	(0.312)
$mountain_i$			0.347***	0.321***			0.304**	0.293**
			(0.121)	(0.122)			(0.120)	(0.119)
$mountain_j$			0.0701	0.0532			0.135	0.113
			(0.137)	(0.138)			(0.126)	(0.126)
$coastal_i$			0.838***	0.791***			0.873***	0.810***
			(0.121)	(0.121)			(0.118)	(0.116)
$coastal_j$			0.790***	0.719***			0.726***	0.641***
			(0.143)	(0.142)			(0.133)	(0.133)
Constant	13.81***	13.81***	12.79***	10.07***	13.49***	13.49***	12.47***	10.04***
	(0.140)	(0.140)	(0.172)	(0.122)	(0.106)	(0.106)	(0.141)	(0.119)
Home bias ES = exp(β)	14	15	18	18	11	11	11	14
Observations	32,554	32,554	32,554	32,554	82,515	82,515	82,515	82,515
R-squared	0.790	0.791	0.803	0.794	0.801	0.802	0.812	0.804

Procedure method of estimation: PPML
Robust standard errors in parentheses (*** p<0.01, ** p<0.05, * p<0.1)
The estimations are cluster under the distance variable

5.2.2 The Spanish Home Biased Effect from the import perspective

Table 5-7 reports the result of our most extensive specification of the gravity equation for the international imports and the Spanish intranational trade. In column 1 the specification is fed by the full sample, in column 2 it is fed only by the import from Spain and Portugal, and in column 3 it is from Spain and France.

When all the international imports are considered, the Home bias effect with Portugal (exp(3.323)=28, in column 1) is even higher than for the international exports (exp(2.879)=18 in column 4,Table 4-5), whilst for the French estimation is lower (exp(2.164)=9, in column 1). The estimation of the Home bias for the sub-sample provides more extreme values: the Home bias effect with respect to Portugal increases (exp(3.514)=34, in column 2), while respect to France slightly decreases (exp(2.097)=8, in column 3).

According to the contiguity effect, for the intranational case, this always displays a positive and significant value. For the international contiguity, its effect is positive and significant for the two foreign contiguities (0.764 for the Portuguese case and 0.640 for the French, in column 1). However, when the sample is divided, only the French contiguity effect remains similar. The positive and significant contiguity effect with Portugal vanishes.

And once again, regarding the topology of the surface, being a coastal location has a positive effect on export and import trade flows, for any specification and sub-sample.

Table 5-7 Augmented gravity equation for the Spanish intra-national trade and the Spanish imports from France and Portugal. NUTS 3 level. PPML. 2004 – 2018.

Origin of the flows:	ES, PT and FR	ES and PT	ES and FR
	(1) (4 in the Appendix)	(2) (3 in the Appendix)	(3) (3 in the Appendix)
VARIABLES	Tijt	Tijt	Tijt
$Capital_i$	2.097***	1.434***	2.080***
	(0.173)	(0.186)	(0.187)
$Capital_j$	2.258***	1.838***	2.223***
	(0.316)	(0.381)	(0.327)
D_{ij}	-3.844***	-5.097***	-3.848***
	(0.196)	(0.647)	(0.204)
D_{ij}^2	1.140***	2.290***	1.063***
	(0.120)	(0.509)	(0.123)
Home Bias-es-pt_{ij}	-3.323***	-3.514***	
	(0.156)	(0.160)	
Home Bias-es-fr_{ij}	-2.164***		-2.097***
	(0.146)		(0.145)
intran-$contig_{ij}$	0.536***	0.265**	0.511***
	(0.0589)	(0.129)	(0.0595)
intern-contig-es-pt_{ij}	0.764***	0.341	
	(0.230)	(0.415)	
intern-contig-es-fr_{ij}	0.640**		0.627**
	(0.252)		(0.255)
$mountain_i$	0.342***	-0.368***	0.370***
	(0.107)	(0.0884)	(0.110)
$mountain_j$	0.417***	0.0837	0.398***
	(0.113)	(0.0866)	(0.116)
$coastal_i$	0.869***	0.673***	0.847***
	(0.126)	(0.0954)	(0.131)
$coastal_j$	0.483***	0.529***	0.484***
	(0.111)	(0.0881)	(0.113)
Constant	12.16***	13.35***	12.19***
	(0.140)	(0.209)	(0.144)
Home bias PT-ES	28	34	
Home bias FR-ES	9		8
Observations	98,341	32,306	82,173
R-squared	0.792	0.529	0.794

Procedure method of estimation: PPML
Robust standard errors in parentheses (*** p<0.01, ** p<0.05, * p<0.1)
The estimations are cluster under the distance variable.
All regressions contain the multilateral terms (fixed effects by origin and destination interacted with time), and a time fixed effect.

6 Policy implications

The final aim of this case study is to convince policy makers, managers, and researchers that what we knew about international trade between three neighbours' countries, sharing the same currency and belonging to the European Union, was just the pick of the iceberg.

Having just country-to-country statistics for the trade between Spain-France and Portugal, is like assuming that all the GDP and population of these three countries concentrates in three points in the space, with the reductionist temptation of identifying them with Madrid, Paris, and Lisbon.

Even for the lucky countries that periodically publish trade flows at the region to country level, the possibilities of really measure the level of integration and the exact allocation of the economic interactions in the space remain partially secluded.

Moreover, the analysis conducted here suggest that it is not enough with having a static view of such relations, or just to focus on one spatial grid such as the NUTS 2 level, for example, arguing that this is the scale at which the decentralized countries adopt most of the decisions (i.e., Autonomous Communities for the case of Spain). Many economic phenomena are sensitive to the "modifiable area unit problem" (MAUP), and trade is one clear example.

In this analysis we have seen, with very simple visualizations and robust econometric approaches, that what we might expect at one spatial scale is not necessarily true for another, or at least, requires a more carefully consideration. This is so because of the great heterogeneity of the economic relations in the space, as well as the clear persistence of certain dynamics, where the current spatial interactions between different regions are clearly conditioned by stubborn geographical and historical factors. On the contrary, a single start shining (leading firm) in a peripheral territory can produce strong international connections. Without having considered firm-specific information, some non-predictable flows analysed here are driven by a short list of big firms (some of which are multinationals) operating in very few locations, i.e., performing in the automobile sector, the food and beverage industry or the chemical-pharmaceutical cluster.

This analysis has shown that trade between Spain-France and Portugal performs, in general, following the rules of the gravity equation, where two big economies that are close together have more probability of interacting. But we have also learned that this relation is not linear, and that many other factors can be also at work. First, economic geography, and all factors linked to the first nature (geography) and the second nature (human action) are relevant. In principle, being a border region to the foreign market will increase your trade with that partner, but this positive effect can be moderated if one must overpass a natural wall such as the Pyrenees, or if, through centuries, the border regions have been living in isolation or turning their backs to their neighbours, maybe in prevention of their hostility or expansionist impulses of any kind. Cross-border cooperation and building common infrastructure is all about bridging these inertial forces.

Before this analysis, we knew that a border Spanish NUTS 2 regions with France and Portugal increases one's intensity of trade with these two countries. The typical example was the Basque

Country and Catalonia are two main Spanish exporters and have geographical advantages through the two main gateways in the northern border. However, at the NUTS 3 level, the predominant provinces within these NUTS 2 regions are Vizcaya and Barcelona, which are not border provinces. Our analysis has sown similar effects for the case of Portugal, where the results at the NUTS 2 and NUTS 3 level are sensitive to the administrative units used, given the strong concentration of the population and the economic activity in the coast, and the flatter economic landscape in the inner-border regions with Spain.

Our analysis has also shown that, once that the strong and growing trade relationships between these three countries are identified, they are much smaller than the ones that take place within the national borders. For a region, everything that is out of its border is "the rest of the world". They are truly open economies, and disconnection is a synonym of economic calamity. By contrast, though openness, competition and increasing efforts of integration, small spatial units can benefit from the winds of globalization and the growing integration in the European Single Market. Having said that, it is quite necessary to remember that the economic relations have inertia, and the most important markets corresponds to the own region and the neighbours in the same country. Thus, in general, finding positive *home bias effect* should be interpreted as a sign of internal integration, and not necessarily as an indication of disconnection with other countries. However, without being naive, there are also evident and no so evident barriers to trade with the foreign neighbour. This was tested for countries such as Canada and United States, and now is revisited for three European countries.

Every region faces a tension between intra-national and inter-national integration. Similarly, there are trade-offs between internal and external inequality or trilemmas between economic growth, equal distribution of income and the protection of the environment.

What seems critical is to find the correct path for each spatial unit, with a diversified range of relations, a vibrant entrepreneurial and work force, able to take advantage, or simply overpass the geography and historical burdens. A good mix of human capital, good institutions and a permanent effort of innovation are critical. Resilience and smart specialization are key concepts here, which unfortunately, in many cases, are not well routed in a detailed knowledge of the true territorial relations affecting each region. This case study wants to remark that "smartness" requires "good data", and in the 21st century, this is synonym of geo-referenced data.

Far from being conclusive, our analysis also suggests that, once that we have unveil the spatial dimension of the bilateral flows within and between countries, interesting new questions arise, such as, for example, guessing the most optimal route followed by each delivery. By doing so, it is possible to better understand how the production, transportation and consumption decisions are taken, and how the policy intervention can help to compensate the geographical and historical obstacles that leaves some regions behind. Our effort of "routing" the origin-destination flows open new avenues for the policy actions in terms of creating the required infrastructure for facilitating the interaction for the leading and the lagging regions. The current COVI19 shock is telling us how relevant the exact knowledge of the routes followed by every input and every output of one`s economy is for the current and future performance.

In the case of the relations between Spain, France and Portugal, several policy options pop-ups:

- The Pyrenees impose a clear barrier for economic and human interaction. The high cost of developing fast infrastructures have polarized the traffic and the economic interaction around the two main gateways: "Biriatou/Irun" and "Le Perthus/La Jonquera". A strong effort of cross-border cooperation between the regions directly implied in the Atlantic and Mediterranean corridors (Ten-T) seems to be critical. But, furthermore, the dynamization of the economic activity in the other less-favoured-border-regions also suggest the need for amplifying the transport infrastructures connecting the north-centre of Spain (Aragón-Middy-Pyrenees) in line with some current projects such as the development of the high-way of the Pyrenees, connecting the Atlantic and Mediterranean corridor, or further strengthening of North-South less developed gateways. The relations between the Spanish border regions and those of the south of France, and the improvement of the connections with the nodes of the Bordeaux-Toulouse-Montpelier axis, can consolidate a cross-border Macro-region and another decentralized European area, around the Pyrenees, of intense activity and economic flows of all type. An extra effort in this dimension is needed.
- Part of the trade flows observed are likely to be associated with the role played by multi-country-multi-region firms, whose efficient contribution to the economy requires enjoying economic of scales. All efforts towards a friendly and stable legal framework at different spatial levels will help to reduce the transaction costs that remain after the elimination of tariffs and the introduction of the euro. Technical barriers, overlapping regulations, taxes and legal differences between regions within and between countries also hamper an efficient deployment of the production and exchange of goods and services within territories. Greater harmonization and cooperation between all levels of government are desirable. All the efforts conducted in favour of the European Single Market at the country level, should be also followed by an equivalent effort at the sub-national level, considering not just the governance at the NUTS 2 level, but also at lower scales such as provinces or municipalities.
- This analysis has centred in the flows by road, given the lack of equivalent information for the other modes. An important implication of the intra-national and inter-national trade is the environmental impact that generates, which do not affect just the exporting and importing regions, but also the transit locations. Our contribution to the "optimal routing" of trade helps to illustrate how certain locations perform as gateways to flows generated elsewhere, enjoying positive spillovers linked to the traffic of people and vehicles, but also suffering the bad externalities of congestion and pollution. Thus, improving the quality of the information for all modes and their combination seems critical to have the whole picture of the production-trade-environment linkage of the current growth model of each country and region. But it is also needed to formulate precise policy actions to promote

the de-carbonization of the current trade-transport mix, by easing the transport-mode shifts from air and road to train and ship and promote the introduction of less polluting technologies in each mode.

- The results suggest that an extra effort is needed to compensate the burdens imposed to some geographical and historical factors, improving the quality of the transport infrastructure connecting these three countries and promoting the social and economic cooperation in all dimensions. In this regard, reinforcing the cooperation between the border-regions seems to be critical, strengthening the links within the existing Euro-regions where regions of Spain, France and Portugal are involved.

7 Recommendations for data providers

Several recommendations for data providers are drawn from this case study:

- The fastest way to improve the information about interregional economic relations between the EU countries is to publish the data that is already available but, for different reasons, it is not usually disclosed. Our analysis proves that a layer of truly valuable information, such as the region of origin and destination of the international freight flows by road can be of great interest when it is combined with other information, such as the official trade flows. All EU countries produce equivalent datasets in the field of the road freight survey, under the coordination of Eurostat, but most of them do not publish any information about the intra-national or the inter-national deliveries with the equivalent spatial grid that we have used in this case study.
- In many EU countries, and in Eurostat as a whole, trade statistics do not offer any information about the region of origin or destination. Instead, country-to-country flows are published with detail at the product level by months. In some other countries, such as Spain, these official statistics are published at the NUTS 3 level every month. Furthermore, there are even large samples with international exports at the firm-level, which can be geo-localized at the zip code level. This is a clear paradox, knowing that in the whole EU27 trade statistics share the same Intrastat / DUA information system, so the data collected might be really the same in all countries. Thus, the harmonization and publication of these data that is already there will be a great improvement for researchers and the development of evidence-based policy.
- It is highly appreciated the effort done by Eurostat in the harmonization and publication of the European Road Freight Survey in the microdata format. However, any attempt to use this relevant source for extending this analysis to the whole Europe, as we do in the IRIE project (Task.1.2.), face clear limitations. On the one hand, the spatial level offered is restricted to the NUTS 2 level, impeding analysis like the one conducted here. Moreover, the time window covered is limited to 2011-2019, losing the long run perspective or even the pre-crisis situation.
- In line with the previous comment, we want to highlight that, as we have shown in this analysis, many economic phenomena are sensitive to the spatial administrative unit used, in line with the literature on the modifiable areal unit. It is important to remark that the NUTS 3 level is probably the most homogeneous spatial unit in Europe, and it is the one that better represents the economy of cities, the main protagonist on a knowledge-based economy. Thus, although the most powerful sub-national institutions correspond to the NUTS 2 level, and, therefore, this is the common denominator for most part of the European regional statistics, an extra effort on downscaling covering NUTS 3 level is also desirable.

- Another paradox is that the data regarding the transport mode that are more concentrated in very few actors (train and ship) and are supposed to be the mode of the future in a European Green Economy, are the ones with the worst statistical information, and with the less transparent policy for publication and use. To this regard, there are no sectoral information about the region-to-region freight flows between the regions, train stations or ports of any country in the EU, something that diverge from the information available for road mode, where, in principle, the higher level of atomization raise the cost of data collection.
- All in all, the collection of data about trade and freight flows in each country, and for the whole Europe, can be clearly improved if each statistical exercise is defined with a spatial perspective and a holistic approach. For example, it will be reasonable that transport and trade statistics will be, somehow, more comparable, both in terms of the product classifications and their correspondence, the coverage of the spatial unit of reference, or the units of measurement used. Moreover, with focus in the transport statistics, it will be desirable that each transport mode will not be considered in isolation, including fields related with multimodality and intermediation. This aspect is critical in the context of “the last mile revolution”, the political interest on tracking the environmental footprint of the flows generated, and the additional difficulties introduced by the parallel development of the e-commerce, where transactions are arranged over non-located digital platforms, and the complex logistic network that serves the deliveries, which multiplies the number of transit locations from the producer to the final destination.
- Finally, the true statistical revolution regarding the spatial tracking of economic flows will come from unveiling the fiscal information, always with full respect of firms and individual information rights. Assuming that the VAT is the most homogeneous and European tax of all, wouldn´t be possible that its information will be also used for the public good of knowing the origin-destination of the flows in Europe. Some exploratory analyses are being conducted in certain countries, but they are completely disconnected to the rest of the statistical system.

8 Conclusions

Researchers in empirical trade do not live in a world with perfect traceability, where products can be followed from the exact point of production to the exact final point of consumption. Instead, they usually confront the frustrating reality of a world of incomplete information, full of statistical gaps, disconnections, and data constraints. This is clear for the EU, where the information with respect to the economic flows (goods, services, people, capital, and knowledge) between regions in different countries is almost inexistent. Consequently, the spatial pattern of the EU single market at the sub-national level, and several important questions regarding the dynamics of its level of integration, are simply unknown.

The main goal of the ESPON IRIE Project is to alleviate this burden, making an extraordinary effort, never accomplished before in this scale in Europe and elsewhere, to estimate, analyse and combine all types of flows at the regional level (NUTS 2) covering the whole ESPON space, that is, the EU27 plus the UK, Switzerland, Iceland and Liechtenstein.

In this context, the IRIE Project includes several case studies, aimed to offer a reinforced analysis, with focus in certain flows or territories, for which better data is available or specific conclusions can be drawn as a complement to the ones to be taken in the general analysis.

In this case study we explore the information already developed by the c-intereg project (www.c-intereg.es), funded by many regional governments in Spain, which offers, to the best of our knowledge, the largest and more detailed dataset on the intra-national and inter-national region-to-region flows for a European. The project also serves as a living example on how some regional governments can mix efforts, going beyond the guidance of the national institutions, which sometimes goes one step behind the needs of the sub-national units.

The dataset combines the official trade and transport statistics available in Spain. The process followed during several years for estimating such flows for Spain is basically the one that we follow using equivalent data for the whole Europe in the Task 1.2. of the IRIE project. Indeed, this case study wants to illustrate the contribution that the ESPON IRIE project is expected to make for all regions in the ESPON space once that data equivalent to the one used here will be available for all countries and regions. This is the appetizer of what the IRIE project will serve once it is finished.

Our datasets capture the intra-national flows within Spain as well as the inter-national flows between Spain and the main partners in Europe, with a specific focus in the flows traveling by trucks. Our analysis centres in the period 2004-2018, covering volumes and monetary units, and specifically wants to unveil the bilateral trade relations between Spain, France and Portugal, using the Spanish data as pivot.

Based on this singular dataset obtained for Spain, several analyses are developed with the aim of testing the robustness and coherence of the figures, as well as for the identification of the main trading patterns with a region-to-region specific breakdown, working always at the NUTS 3 level, a spatial grid that is the most homogeneous within Europe, and that better represents the economy of cities, the main protagonist on a knowledge-based economy.

Our analysis starts with a descriptive section, where several visualizations based on maps, Sankey diagrams and tables, allow identifying the main structural relations between these three highly integrated economies. Then, by means of several specifications of the gravity equation, we model econometrically the relations between the bilateral trade and several variables, selected among the most common factors performing as drivers and barriers of the interregional trade of goods. Such variables correspond to geographical and economic factors and wants to consider with more detail the accessibility of each region when engaging in trade with the closest and furthest regions in the sample.

As always, the analysis is partial, and allows several extensions and improvements, that we expect to cover in the other parts of the IRIE project, as well as in future academic papers to be publish in this regard.

9 Appendix


ESPAÑA - NUTS level 3
ES111
ES112
ES114
ES113
ES120
ES130
ES213
ES212
ES211
ES220
ES230
ES241
ES243
ES242
ES413
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ES422
ES431
ES421
ES513
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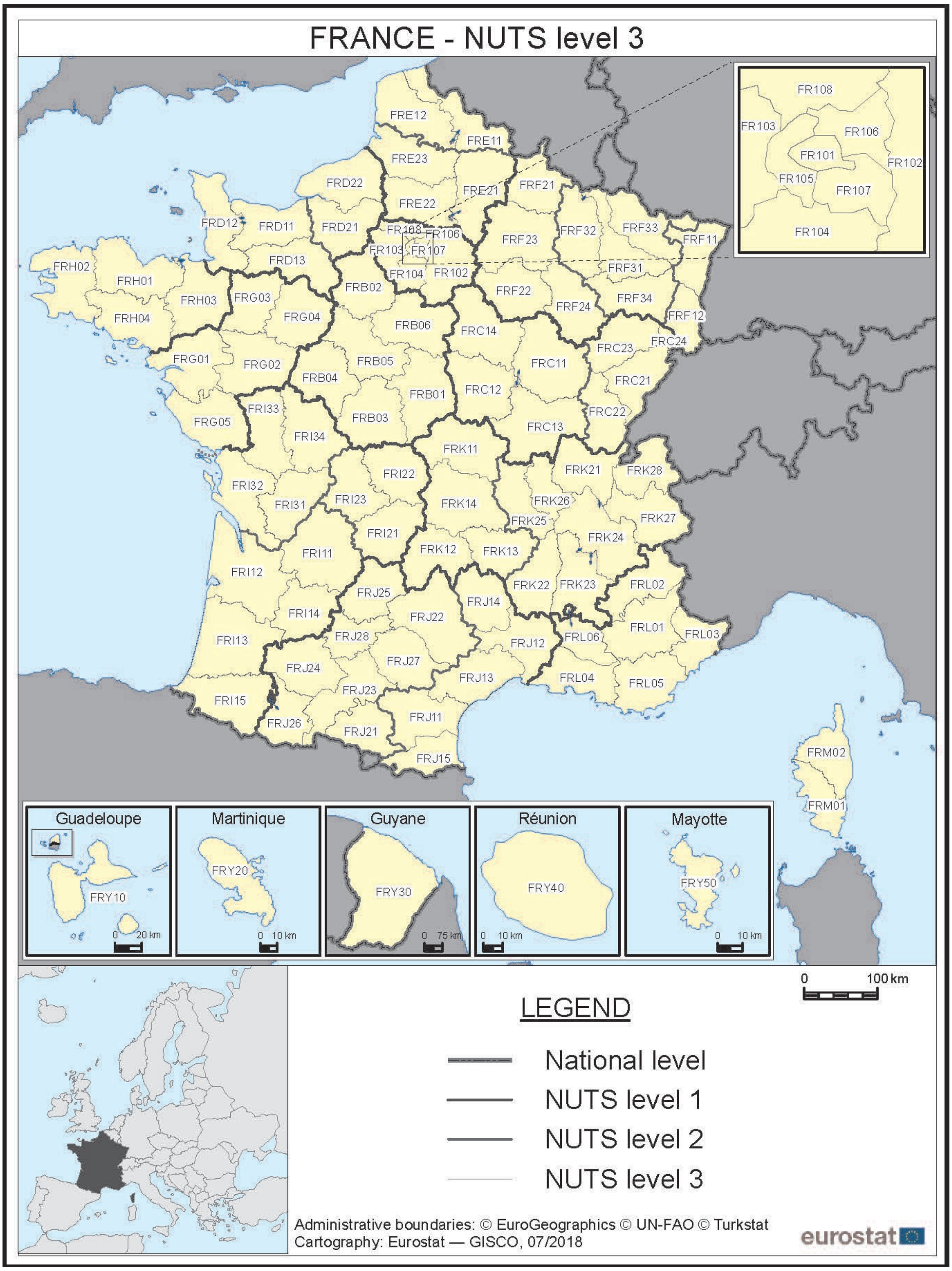
ES522
ES523
ES521
ES533
ES532
ES531
ES613
ES616
ES620
ES615
ES618
ES614
ES611
ES617
ES612
ES630
ES640
Canarias
ES708
ES707
ES709
ES704
ES706
ES705
ES703
0
120 km
0
100 km
LEGEND
National level
NUTS level 1
NUTS level 2
NUTS level 3
Administrative boundaries: © EuroGeographics © UN-FAO © Turkstat
Cartography: Eurostat — GISCO, 07/2018
eurostat


FRANCE - NUTS level 3
FRE12
FRE11
FRE23
FRD22
FRE21
FRF21
FRE22
FRD12
FRD11
FRD21
FR108
FR106
FR103
FR107
FRF23
FRF32
FRF33
FRF11
FRD13
FR104
FR102
FRF31
FRH02
FRH01
FRH03
FRG03
FRB02
FRF22
FRF34
FRH04
FRG04
FRB06
FRC14
FRF24
FRF12
FRC24
FRC23
FRG01
FRG02
FRB05
FRC11
FRB04
FRC21
FRB01
FRC12
FRI33
FRC22
FRG05
FRB03
FRI34
FRC13
FRK11
FRK21
FRK28
FRI22
FRI32
FRI23
FRK26
FRI31
FRK14
FRK27
FRK25
FRI21
FRK24
FRK12
FRK13
FRI11
FRI12
FRK22
FRK23
FRL02
FRJ25
FRJ14
FRI14
FRJ22
FRL01
FRL06
FRL03
FRJ12
FRI13
FRJ28
FRJ27
FRJ24
FRJ13
FRL04
FRL05
FRJ23
FRI15
FRJ11
FRJ26
FRJ21
FRJ15
FRM02
FRM01
FR101
FR105
FR102
Guadeloupe
FRY10
0 20 km
Martinique
FRY20
0 10 km
Guyane
FRY30
0 75 km
Réunion
FRY40
0 10 km
Mayotte
FRY50
0 10 km
0 100 km
LEGEND
National level
NUTS level 1
NUTS level 2
NUTS level 3
Administrative boundaries: © EuroGeographics © UN-FAO © Turkstat
Cartography: Eurostat — GISCO, 07/2018
eurostat


PORTUGAL - NUTS level 3
PT111
PT112
PT119
PT11B
PT11E
PT11A
PT11C
PT11D
PT16G
PT16D
PT16J
PT16E
PT16F
PT16H
PT16I
PT16B
PT185
PT186
PT170
PT187
PT181
PT184
PT150
Açores
PT200
0 150 km
Madeira
PT300
0 30 km
0 50km
LEGEND
National level
NUTS level 1
NUTS level 2
NUTS level 3
Administrative boundaries: © EuroGeographics © UN-FAO © Turkstat
Cartography: Eurostat — GISCO, 07/2018
eurostat

Table 9-1 List of NUTS3 regions included and *excluded* (in bold and italic font) in the analysis

NUTS3	NUTS2	Name NUTS2	Name NUTS3
FR101	FR10	Ile-de-France	Paris
FR102	FR10	Ile-de-France	Seine-et-Marne
FR103	FR10	Ile-de-France	Yvelines
FR104	FR10	Ile-de-France	Essonne
FR105	FR10	Ile-de-France	Hauts-de-Seine
FR106	FR10	Ile-de-France	Seine-Saint-Denis
FR107	FR10	Ile-de-France	Val-de-Marne
FR108	FR10	Ile-de-France	Val-d'Oise
FRB01	FRB0	Centre — Val de Loire	Cher
FRB02	FRB0	Centre — Val de Loire	Eure-et-Loir
FRB03	FRB0	Centre — Val de Loire	Indre
FRB04	FRB0	Centre — Val de Loire	Indre-et-Loire
FRB05	FRB0	Centre — Val de Loire	Loir-et-Cher
FRB06	FRB0	Centre — Val de Loire	Loiret
FRC11	FRC1	Bourgogne	Côte-d'Or
FRC12	FRC1	Bourgogne	Nièvre
FRC13	FRC1	Bourgogne	Saône-et-Loire
FRC14	FRC1	Bourgogne	Yonne
FRC21	FRC2	Franche-Comté	Doubs
FRC22	FRC2	Franche-Comté	Jura
FRC23	FRC2	Franche-Comté	Haute-Saône
FRC24	FRC2	Franche-Comté	Territoire de Belfort
FRD11	FRD1	Basse-Normandie	Calvados
FRD12	FRD1	Basse-Normandie	Manche
FRD13	FRD1	Basse-Normandie	Orne
FRD21	FRD2	Haute-Normandie	Eure
FRD22	FRD2	Haute-Normandie	Seine-Maritime
FRE11	FRE1	Nord-Pas de Calais	Nord
FRE12	FRE1	Nord-Pas de Calais	Pas-de-Calais
FRE21	FRE2	Picardie	Aisne
FRE22	FRE2	Picardie	Oise
FRE23	FRE2	Picardie	Somme
FRF11	FRF1	Alsace	Bas-Rhin
FRF12	FRF1	Alsace	Haut-Rhin
FRF21	FRF2	Champagne-Ardenne	Ardennes
FRF22	FRF2	Champagne-Ardenne	Aube
FRF23	FRF2	Champagne-Ardenne	Marne
FRF24	FRF2	Champagne-Ardenne	Haute-Marne
FRF31	FRF3	Lorraine	Meurthe-et-Moselle
FRF32	FRF3	Lorraine	Meuse
FRF33	FRF3	Lorraine	Moselle
FRF34	FRF3	Lorraine	Vosges
FRG01	FRG0	Pays de la Loire	Loire-Atlantique
FRG02	FRG0	Pays de la Loire	Maine-et-Loire
FRG03	FRG0	Pays de la Loire	Mayenne

FRG04	FRG0	Pays de la Loire	Sarthe
FRG05	FRG0	Pays de la Loire	Vendée
FRH01	FRH0	Bretagne	Côtes-d'Armor
FRH02	FRH0	Bretagne	Finistère
FRH03	FRH0	Bretagne	Ille-et-Vilaine
FRH04	FRH0	Bretagne	Morbihan
FRI11	FRI1	Aquitaine	Dordogne
FRI12	FRI1	Aquitaine	Gironde
FRI13	FRI1	Aquitaine	Landes
FRI14	FRI1	Aquitaine	Lot-et-Garonne
FRI15	FRI1	Aquitaine	Pyrénées-Atlantiques
FRI21	FRI2	Limousin	Corrèze
FRI22	FRI2	Limousin	Creuse
FRI23	FRI2	Limousin	Haute-Vienne
FRI31	FRI3	Poitou-Charentes	Charente
FRI32	FRI3	Poitou-Charentes	Charente-Maritime
FRI33	FRI3	Poitou-Charentes	Deux-Sèvres
FRI34	FRI3	Poitou-Charentes	Vienne
FRJ11	FRJ1	Languedoc-Roussillon	Aude
FRJ12	FRJ1	Languedoc-Roussillon	Gard
FRJ13	FRJ1	Languedoc-Roussillon	Hérault
FRJ14	FRJ1	Languedoc-Roussillon	Lozère
FRJ15	FRJ1	Languedoc-Roussillon	Pyrénées-Orientales
FRJ21	FRJ2	Midi-Pyrénées	Ariège
FRJ22	FRJ2	Midi-Pyrénées	Aveyron
FRJ23	FRJ2	Midi-Pyrénées	Haute-Garonne
FRJ24	FRJ2	Midi-Pyrénées	Gers
FRJ25	FRJ2	Midi-Pyrénées	Lot
FRJ26	FRJ2	Midi-Pyrénées	Hautes-Pyrénées
FRJ27	FRJ2	Midi-Pyrénées	Tarn
FRJ28	FRJ2	Midi-Pyrénées	Tarn-et-Garonne
FRK11	FRK1	Auvergne	Allier
FRK12	FRK1	Auvergne	Cantal
FRK13	FRK1	Auvergne	Haute-Loire
FRK14	FRK1	Auvergne	Puy-de-Dôme
FRK21	FRK2	Rhône-Alpes	Ain
FRK22	FRK2	Rhône-Alpes	Ardèche
FRK23	FRK2	Rhône-Alpes	Drôme
FRK24	FRK2	Rhône-Alpes	Isère
FRK25	FRK2	Rhône-Alpes	Loire
FRK26	FRK2	Rhône-Alpes	Rhône
FRK27	FRK2	Rhône-Alpes	Savoie
FRK28	FRK2	Rhône-Alpes	Haute-Savoie
FRL01	FRL0	Provence-Alpes-Côte d'Azur	Alpes-de-Haute-Provence
FRL02	FRL0	Provence-Alpes-Côte d'Azur	Hautes-Alpes
FRL03	FRL0	Provence-Alpes-Côte d'Azur	Alpes-Maritimes
FRL04	FRL0	Provence-Alpes-Côte d'Azur	Bouches-du-Rhône
FRL05	FRL0	Provence-Alpes-Côte d'Azur	Var
FRL06	FRL0	Provence-Alpes-Côte d'Azur	Vaucluse
FRM01	***FRM0***	***Corse***	***Corse-du-Sud***

FRM02	***FRM0***	***Corse***	***Haute-Corse***
FRY10	***FRY1***	***Guadeloupe***	***Guadeloupe***
FRY20	***FRY2***	***Martinique***	***Martinique***
FRY30	***FRY3***	***Guyane***	***Guyane***
FRY40	***FRY4***	***La Réunion***	***La Réunion***
FRY50	***FRY5***	***Mayotte***	***Mayotte***
PT111	PT11	Norte	Alto Minho
PT112	PT11	Norte	Cávado
PT119	PT11	Norte	Ave
PT11A	PT11	Norte	Área Metropolitana do Porto
PT11B	PT11	Norte	Alto Tâmega
PT11C	PT11	Norte	Tâmega e Sousa
PT11D	PT11	Norte	Douro
PT11E	PT11	Norte	Terras de Trás-os-Montes
PT150	PT15	Algarve	Algarve
PT16B	PT16	Centro (PT)	Oeste
PT16D	PT16	Centro (PT)	Região de Aveiro
PT16E	PT16	Centro (PT)	Região de Coimbra
PT16F	PT16	Centro (PT)	Região de Leiria
PT16G	PT16	Centro (PT)	Viseu Dão Lafões
PT16H	PT16	Centro (PT)	Beira Baixa
PT16I	PT16	Centro (PT)	Médio Tejo
PT16J	PT16	Centro (PT)	Beiras e Serra da Estrela
PT170	PT17	Área Metropolitana de Lisboa	Área Metropolitana de Lisboa
PT181	PT18	Alentejo	Alentejo Litoral
PT184	PT18	Alentejo	Baixo Alentejo
PT185	PT18	Alentejo	Lezíria do Tejo
PT186	PT18	Alentejo	Alto Alentejo
PT187	PT18	Alentejo	Alentejo Central
PT200	***PT20***	***Região Autónoma dos Açores***	***Região Autónoma dos Açores***
PT300	***PT30***	***Região Autónoma da Madeira***	***Região Autónoma da Madeira***
ES111	ES11	Galicia	A Coruña
ES112	ES11	Galicia	Lugo
ES113	ES11	Galicia	Ourense
ES114	ES11	Galicia	Pontevedra
ES120	ES12	Principado de Asturias	Asturias
ES130	ES13	Cantabria	Cantabria
ES211	ES21	País Vasco	Araba/Álava
ES212	ES21	País Vasco	Gipuzkoa
ES213	ES21	País Vasco	Bizkaia
ES220	ES22	Comunidad Foral de Navarra	Navarra
ES230	ES23	La Rioja	La Rioja
ES241	ES24	Aragón	Huesca
ES242	ES24	Aragón	Teruel
ES243	ES24	Aragón	Zaragoza
ES300	ES30	Comunidad de Madrid	Madrid
ES411	ES41	Castilla y León	Ávila
ES412	ES41	Castilla y León	Burgos
ES413	ES41	Castilla y León	León
ES414	ES41	Castilla y León	Palencia

ES415	ES41	Castilla y León	Salamanca
ES416	ES41	Castilla y León	Segovia
ES417	ES41	Castilla y León	Soria
ES418	ES41	Castilla y León	Valladolid
ES419	ES41	Castilla y León	Zamora
ES421	ES42	Castilla-La Mancha	Albacete
ES422	ES42	Castilla-La Mancha	Ciudad Real
ES423	ES42	Castilla-La Mancha	Cuenca
ES424	ES42	Castilla-La Mancha	Guadalajara
ES425	ES42	Castilla-La Mancha	Toledo
ES431	ES43	Extremadura	Badajoz
ES432	ES43	Extremadura	Cáceres
ES511	ES51	Cataluña	Barcelona
ES512	ES51	Cataluña	Girona
ES513	ES51	Cataluña	Lleida
ES514	ES51	Cataluña	Tarragona
ES521	ES52	Comunidad Valenciana	Alicante/Alacant
ES522	ES52	Comunidad Valenciana	Castellón/Castelló
ES523	ES52	Comunidad Valenciana	Valencia/València
ES531	***ES53***	***Illes Balears***	***Eivissa y Formentera***
ES532	***ES53***	***Illes Balears***	***Mallorca***
ES533	***ES53***	***Illes Balears***	***Menorca***
ES611	ES61	Andalucía	Almería
ES612	ES61	Andalucía	Cádiz
ES613	ES61	Andalucía	Córdoba
ES614	ES61	Andalucía	Granada
ES615	ES61	Andalucía	Huelva
ES616	ES61	Andalucía	Jaén
ES617	ES61	Andalucía	Málaga
ES618	ES61	Andalucía	Sevilla
ES620	ES62	Región de Murcia	Murcia
ES630	***ES63***	***Ciudad Autónoma de Ceuta***	***Ceuta***
ES640	***ES64***	***Ciudad Autónoma de Melilla***	***Melilla***
ES703	***ES70***	***Canarias***	***El Hierro***
ES704	***ES70***	***Canarias***	***Fuerteventura***
ES705	***ES70***	***Canarias***	***Gran Canaria***
ES706	***ES70***	***Canarias***	***La Gomera***
ES707	***ES70***	***Canarias***	***La Palma***
ES708	***ES70***	***Canarias***	***Lanzarote***
ES709	***ES70***	***Canarias***	***Tenerife***

NUTS3 region excluded

Table 9-2 Product classification

Code	R30 - Product
1	Live animals
2	Cereals
3	Unprocessed food
4	Wood
5	Processed food products
6	Oil (food)
7	Tobacco
8	Drinks
9	Coal
10	Minerals (not ECSC)
11	Liquid fuels
12	Minerals (ECSC)
13	Steel products (ECSC)
14	Steel products (not ECSC)
15	Rocks, sand, and salt
16	Cement and limestone
17	Glass
18	Construction materials
19	Fertilizers
20	Chemical products
21	Plastics and rubber
22	Machinery (non-electric)
23	Machinery (electric)
24	Transport equipment
25	Textile and clothing
26	Leather and footwear
27	Paper
28	Products of wood and cork
29	Furniture, other goods

Note: this classification was developed within the C-intereg project in search for the widest product classification coherent with the one for with the main transport mode statistics are published (NSTR), and with the best match with the CNAE-93, the one that was applicable when the project started.

Table 8-3 List of variables: Label, definition, units and source. Period 2004-2018.

Variable	Label	Definition	Units	Source
Trade flows of goods	T_{ijt}	Exporting (/ importing) NUTS3-to-NUTS3 trade flows from(/to) Spain to(/from) Portugal and France (when only international trade is considered) and within Spain (whin intranational trade is also considered. It is not included international trade between Portugal and France nor intranational trade of these two countries.	Thousand euros	C-intereg (www.c-intereg.es)
Distance	D_{ij}	Road distance computing using the optimal route for each origin-destination pair.	Thousand kilometers	Own elaboration
	D^2_{ij}	Square transformation of the distance variable		
	$Log(D_{ij})$	This is the log transformation of the distance variable		
Gross Domestic Product	gdp_i / gdp_j	Gross domestic product (GDP) at current market prices by the origin "i" / destination "j" NUTS3 region.	Million purchasing power standards (PPS)	Eurostat
International contiguity	$intern\text{-}contig_{ij}$	It takes the value 1 when two regions are contiguous but do not belong to the same country.	Dummy variable (0, 1)	Own elaboration
	$intern\text{-}contig\text{-}es\text{-}pt_{ij}$	It takes the value 1 when two regions are contiguous, and one is Spanish and the other Portuguese.	Dummy variable (0, 1)	
	$intern\text{-}contig\text{-}es\text{-}fr_{ij}$	It takes the value 1 when two regions are contiguous, and one is Spanish and the other French.	Dummy variable (0, 1)	
Intranational contiguity	$intran\text{-}contig_{ij}$	It takes the value 1 when two regions inside of Spain are contiguous.	Dummy variable (0, 1)	
Contiguity	$contig_{ij}$	It takes the value 1 when two regions are contiguous, no matter the country they belong.	Dummy variable (0, 1)	
Capital effect	$Capital_i$ / $Capital_j$	It takes the value 1 when the NUTS3 region origin "*i*" / destination "*j*" region includes the capital of the country.	Dummy variable (0, 1)	Own elaboration
Border regions	$border\text{-}es\text{-}pt_i$ / $border\text{-}es\text{-}pt_j$	It takes the value 1 when the origin "*i*" / destination "*j*" is a Spanish border region with Portugal.	Dummy variable (0, 1)	Own elaboration
	$border\text{-}es\text{-}fr_i$ / $border\text{-}es\text{-}fr_j$	It takes the value 1 when the origin "*i*" / destination "*j*" is a Spanish border region with France.	Dummy variable (0, 1)	
	$border\text{-}es_i$ / $border\text{-}es_j$	It takes the value 1 when the origin "*i*" / destination "*j*" is a Spanish region.	Dummy variable (0, 1)	
	$border\text{-}pt_i$ / $border\text{-}pt_j$	It takes the value 1 when the origin "*i*" / destination "*j*" is a Portugues border region with Spain.	Dummy variable (0, 1)	
	$border\text{-}fr_i$ / $border\text{-}fr_j$	It takes the value 1 when the origin "*i*" / destination "*j*" is a French border region with Spain.	Dummy variable (0, 1)	

Home Bias effect	Home Bias-es-pt_{ij}	It takes the value 1 when the trade flow is between a Spanish region and a Portugues region, and zero otherwise.	Dummy variable (0, 1)	Own elaboration.
	Home Bias-es-fr_{ij}	It takes the value 1 when the trade flow is between a Spanish region and a French region, and zero otherwise.	Dummy variable (0, 1)	
	Home $Bias_{ij}$	It takes the value 1 when the trade flow is between a Spanish region and a non-Spanish region, and zero otherwise.	Dummy variable (0, 1)	
Mountain	$mountain_i$ / $mountain_j$	It takes the value 1 when the origin "*i*" / destination "*j*" has more of the 50% of the surface in mountain areas. More specifically, this variable considers as mountain the categories 2 (> 50 % of surface are in mountain areas) and 3 (> 50 % of population and 50 % of surface are in mountain areas) of the variable "mountain_typology" elaborated by Eurostat.	Dummy variable	ESPON EGTC Own elaboration from the variable "mountain_typology" from © ESPON and published by the Eurostat. The original classification was at NUTS3 2013, but we transformed it into NUTS3 2016.
Coastal	$coastal_i$ /$coastal_j$	It takes the value 1 when the origin "i" / destination "j" NUTS3 region "has a sea border " or "has more than half of its population within 50 km from the sea", and zero otherwise. This dummy variable follows the Eurostat criteria used for its "List of Coastal regions".	Dummy variable	ESPON EGTC Own elaboration from the variable "List of Coastal regions" from © ESPON for Eurostat. NUTS3 classification 2016.

Table 8-4 Appendix. International imports from French and Portuguese NUTS3 regions to Spanish NUTS3 regions. Period: 2004 – 2018.

	International import from Portugal and France to Spain			
	(1)	(2)	(3)	(4)
VARIABLES	Tijt	Tijt	Tijt	Tijt
$\log(gdp_{it})$	0.833***	0.842***	0.829***	0.841***
	(0.0530)	(0.0531)	(0.0544)	(0.0539)
$\log(gdp_{jt})$	1.023***	1.030***	1.031***	1.037***
	(0.0448)	(0.0432)	(0.0472)	(0.0438)
$\log(D_{ij})$	-1.284***	-1.107***		
	(0.127)	(0.104)		
D_{ij}			-4.506***	-3.606***
			(0.631)	(0.501)
D_{ij}^2			1.608***	1.218***
			(0.282)	(0.232)
intern-contig$_{ij}$		1.210***		1.588***
		(0.331)		(0.312)
Constant	-9.470***	-9.572***	-6.736***	-7.328***
	(0.668)	(0.651)	(0.669)	(0.627)
FE by year	YES	YES	YES	YES
FE orig. x year	NO	NO	NO	NO
FE dest. x year	NO	NO	NO	NO
Observations	23,970	23,970	23,970	23,970
R-squared	0.319	0.364	0.307	0.368

Procedure method of estimation: PPML

Robust standard errors in parentheses (*** p<0.01, ** p<0.05, * p<0.1)

The estimations are cluster under the distance variable.

Table 8-5 Appendix. Gravity equation for international imports from French and Portuguese to Spain. NUTS 3 level. Period: 2004 – 2018.

	International Spanish imports (flow from Portugal and from France to Spain)				
	(1)	(2)	(3)	(4)	(5)
VARIABLES	Tijt	Tijt	Tijt	Tijt	Tijt
$Capital_i$	1.768***	1.764***	1.721***	1.562***	1.572***
	(0.286)	(0.286)	(0.294)	(0.297)	(0.298)
$Capital_j$	2.718***	2.713***	2.797***	2.770***	2.854***
	(0.307)	(0.308)	(0.306)	(0.350)	(0.356)
$log(D_{ij})$	-0.996***	-1.003***	-1.021***	-0.926***	
	(0.153)	(0.153)	(0.166)	(0.163)	
D_{ij}					-3.286***
					(0.503)
D_{ij}^2					1.163***
					(0.239)
$intern\text{-}contig_{ij}$	0.597				
	(0.498)				
$intern\text{-}contig\text{-}es\text{-}pt_{ij}$		0.366	0.742*	1.075***	1.478***
		(0.414)	(0.438)	(0.362)	(0.361)
$intern\text{-}contig\text{-}es\text{-}fr_{ij}$		0.671	0.425	0.498	0.627
		(0.613)	(0.608)	(0.611)	(0.523)
$border\text{-}pt_i$			-1.604***	-1.554***	-1.573***
			(0.284)	(0.284)	(0.287)
$border\text{-}fr_i$			0.508	0.527*	0.518*
			(0.371)	(0.300)	(0.292)
$border\text{-}es\text{-}pt_j$			-0.477**	-0.514**	-0.528**
			(0.210)	(0.230)	(0.214)
$border\text{-}es\text{-}fr_j$			0.551***	0.606***	0.620***
			(0.110)	(0.112)	(0.112)
$mountain_i$				-0.0502	-0.0163
				(0.268)	(0.268)
$mountain_j$				-0.719***	-0.686***
				(0.182)	(0.186)
$coastal_i$				0.444*	0.480**
				(0.228)	(0.225)
$coastal_j$				0.954***	0.987***
				(0.131)	(0.135)
Constant	8.013***	8.017***	8.034***	7.909***	9.843***
	(0.112)	(0.114)	(0.114)	(0.273)	(0.395)
Home bias PT-ES = exp(β)	25	26	26	28	28
Home bias FR-ES = exp(β)	10	10	10	9	11
Observations	82,250	82,250	82,250	82,250	82,250
R-squared	0.255	0.253	0.258	0.274	0.300

Procedure method of estimation: PPML
Robust standard errors in parentheses (*** p<0.01, ** p<0.05, * p<0.1)
The estimations are cluster under the distance variable of partners.
All regressions contain the multilateral terms (fixed effects by origin and destination interacted with time), and a time fixed effect.

Table 8-6 Appendix. Gravity equation for international imports from Portugal to Spain (panel A) and from France to Spain (panel B). Period: 2004 – 2018.

	Only international imports from Portugal				Only international imports from France			
	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
VARIABLES	Tijt	Tijt	Tijt	Tijt	Tijt	Tijt	Tijt	Tijt
$Capital_i$	2.574***	2.019***	1.762***	1.736***	1.782**	1.776**	1.843**	1.906**
	(0.280)	(0.299)	(0.305)	(0.309)	(0.714)	(0.716)	(0.735)	(0.743)
$Capital_j$	2.313***	2.397***	3.387***	3.379***	3.071***	3.172***	2.898***	3.004***
	(0.235)	(0.265)	(0.398)	(0.377)	(0.356)	(0.378)	(0.489)	(0.512)
$log(D_{ij})$	-0.933***	-0.941***	-1.012***		-2.005***	-1.983***	-2.002***	
	(0.209)	(0.215)	(0.205)		(0.131)	(0.131)	(0.141)	
D_{ij}				-5.212***				-6.326***
				(1.491)				(0.484)
D_{ij}^2				2.948***				2.023***
				(1.087)				(0.232)
$intern\text{-}contig_{ij}$	0.885***	0.963***	0.896***	1.158***	-0.102	-0.0915	-0.112	0.251
	(0.285)	(0.287)	(0.282)	(0.279)	(0.237)	(0.238)	(0.243)	(0.205)
$border_i$		-1.483***	-1.132***	-1.130***		-0.0596	-0.0747	-0.159
		(0.328)	(0.258)	(0.252)		(0.417)	(0.346)	(0.340)
$border_j$		0.292	0.441	0.338		0.264	0.221	0.253
		(0.343)	(0.348)	(0.316)		(0.235)	(0.207)	(0.209)
$mountain_i$			0.0997	0.140			-0.00190	0.0665
			(0.234)	(0.231)			(0.316)	(0.313)
$mountain_j$			0.787***	0.682**			-0.998***	-0.895***
			(0.280)	(0.277)			(0.258)	(0.286)
$coastal_i$			1.172***	1.164***			0.220	0.365
			(0.257)	(0.263)			(0.261)	(0.258)
$coastal_j$			0.765***	0.698***			0.908***	0.873***
			(0.268)	(0.263)			(0.149)	(0.166)
Constant	7.386***	7.833***	5.926***	8.516***	7.991***	7.896***	8.101***	12.14***
	(0.252)	(0.244)	(0.372)	(0.654)	(0.130)	(0.178)	(0.382)	(0.530)
Observations	16,168	16,168	16,168	16,168	66,082	66,082	66,082	66,082
R-squared	0.677	0.677	0.678	0.659	0.501	0.501	0.500	0.507

Procedure method of estimation: PPML
Robust standard errors in parentheses (*** p<0.01, ** p<0.05, * p<0.1)
The estimations are cluster under the distance variable.
All regressions contain the multilateral terms (fixed effects by origin and destination interacted with time), and a time fixed effect.

Table 8-7 Appendix. Gravity equation for inter and intra-national imports from Spanish, French and Portuguese regions (NUTS3). Period: 2004 – 2018.

	Import from Spain, from Portugal and from France to Spain				
VARIABLES	(1) Tijt	(2) Tijt	(3) Tijt	(4) Tijt	(5) Tijt
$Capital_i$	1.380***	1.381***	1.381***	2.097***	1.966***
	(0.208)	(0.208)	(0.208)	(0.173)	(0.199)
$Capital_j$	1.639***	1.640***	1.640***	2.258***	2.158***
	(0.343)	(0.342)	(0.342)	(0.316)	(0.334)
$\log(D_{ij})$					-1.053***
					(0.0432)
D_{ij}	-3.737***	-3.736***	-3.736***	-3.844***	
	(0.203)	(0.203)	(0.203)	(0.196)	
D_{ij}^2	1.093***	1.094***	1.094***	1.140***	
	(0.123)	(0.123)	(0.123)	(0.120)	
Home Bias-es-pt_{ij}	-3.225***	-3.239***	-3.243***	-3.323***	-3.344***
	(0.159)	(0.160)	(0.161)	(0.156)	(0.159)
Home Bias-es-fr_{ij}	-2.327***	-2.333***	-2.333***	-2.164***	-2.380***
	(0.149)	(0.148)	(0.148)	(0.146)	(0.146)
$contig_{ij}$	0.561***				
	(0.0602)				
intran-$contig_{ij}$		0.557***	0.557***	0.536***	0.274***
		(0.0605)	(0.0605)	(0.0589)	(0.0754)
intern-$contig_{ij}$		0.715***			
		(0.209)			
intern-contig-es-pt_{ij}			0.756***	0.764***	0.473**
			(0.233)	(0.230)	(0.218)
intern-contig-es-fr_{ij}			0.702***	0.640**	0.700**
			(0.260)	(0.252)	(0.285)
$mountain_i$				0.342***	0.293***
				(0.107)	(0.113)
$mountain_j$				0.417***	0.338***
				(0.113)	(0.115)
$coastal_i$				0.869***	0.868***
				(0.126)	(0.134)
$coastal_j$				0.483***	0.501***
				(0.111)	(0.114)
Constant	13.28***	13.28***	13.28***	12.16***	9.846***
	(0.0971)	(0.0972)	(0.0972)	(0.140)	(0.131)
Home bias PT-ES = exp(β)	25	26	26	28	28
Home bias FR-ES = exp(β)	10	10	10	9	11
Observations	98,341	98,341	98,341	98,341	98,343
R-squared	0.782	0.783	0.783	0.792	0.777

Procedure method of estimation: PPML

Robust standard errors in parentheses (*** p<0.01, ** p<0.05, * p<0.1)

The estimations are cluster under the distance variable

All regressions contain the multilateral terms (fixed effects by origin and destination interacted with time), and a time fixed effect.

Table 8-8 Appendix. Gravity equation for inter and intra-national imports from Spain and Portugal to Spain (panel A) and from Spain to and France to Spain (Panel B). Period: 2004 – 2018.

	Import from Spain and from Portugal to Spain				Import from Spain and from France to Spain			
VARIABLES	(1) Tijt	(2) Tijt	(3) Tijt	(4) Tijt	(1) Tijt	(2) Tijt	(3) Tijt	(4) Tijt
$Capital_i$	1.328***	1.328***	1.434***	1.369***	1.310***	1.310***	2.080***	1.940***
	(0.213)	(0.213)	(0.186)	(0.192)	(0.219)	(0.219)	(0.187)	(0.215)
$Capital_j$	1.490***	1.490***	1.838***	1.796***	1.615***	1.615***	2.223***	2.122***
	(0.393)	(0.393)	(0.381)	(0.387)	(0.352)	(0.352)	(0.327)	(0.346)
$\log(D_{ij})$				-0.986***				-1.074***
				(0.0742)				(0.0452)
D_{ij}	-5.223***	-5.222***	-5.097***		-3.742***	-3.742***	-3.848***	
	(0.681)	(0.681)	(0.647)		(0.211)	(0.211)	(0.204)	
D_{ij}^2	2.550***	2.549***	2.290***		1.017***	1.018***	1.063***	
	(0.537)	(0.537)	(0.509)		(0.126)	(0.126)	(0.123)	
Home $Bias_{ij}$	-3.285***	-3.278***	-3.514***	-3.549***	-2.268***	-2.273***	-2.097***	-2.360***
	(0.161)	(0.162)	(0.160)	(0.161)	(0.148)	(0.147)	(0.145)	(0.147)
$contig_{ij}$	0.268**				0.535***			
	(0.132)				(0.0610)			
intran-$contig_{ij}$		0.268**	0.265**	0.214		0.533***	0.511***	0.244***
		(0.132)	(0.129)	(0.134)		(0.0612)	(0.0595)	(0.0770)
intern-$contig_{ij}$		0.154	0.341	0.337		0.689***	0.627**	0.692**
		(0.519)	(0.415)	(0.394)		(0.262)	(0.255)	(0.291)
$mountain_i$			-0.368***	-0.390***			0.370***	0.317***
			(0.0884)	(0.0965)			(0.110)	(0.117)
$mountain_j$			0.0837	0.0798			0.398***	0.323***
			(0.0866)	(0.0864)			(0.116)	(0.117)
$coastal_i$			0.673***	0.657***			0.847***	0.846***
			(0.0954)	(0.0969)			(0.131)	(0.139)
$coastal_j$			0.529***	0.518***			0.484***	0.500***
			(0.0881)	(0.0854)			(0.113)	(0.117)
Constant	13.67***	13.67***	13.35***	10.76***	13.31***	13.32***	12.19***	9.841***
	(0.200)	(0.200)	(0.209)	(0.124)	(0.0987)	(0.0987)	(0.144)	(0.134)
Home bias ES = exp(β)	27	27	34	35	10	10	8	11
Observations	32,306	32,306	32,306	32,306	82,173	82,173	82,173	82,173
R-squared	0.490	0.490	0.529	0.506	0.785	0.785	0.794	0.779

Procedure method of estimation: PPML
Robust standard errors in parentheses (*** p<0.01, ** p<0.05, * p<0.1)
The estimations are cluster under the distance variable
All regressions contain the multilateral terms (fixed effects by origin and destination interacted with time), and a time fixed effect.

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