Thick and thin borders in the EU: how deep internal integration is within countries, and how shallow between them[1]

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JEL Codes: F14, F15
Keywords: border effect, distance, interregional trade, region-to-region international trade, European integration.

Abstract

The existence of large border effects is one of the main puzzles of international macroeconomics. The seminal paper by McCallum found that trade between any two Canadian provinces was (on average) 22 times greater than trade between any Canadian province and any United State (US). Although various authors have estimated internal and external border effects for the whole EU and some specific European countries, none has done so in the manner that McCallum's seminal paper, stymied by lack of data on region-to-region international trade flows. This paper uses a novel dataset that captures intra- and inter-national truck shipments between Spanish regions and regions in seven European countries during the period 2004-2011. It computes internal and external border effects, offering novel results for aggregate flows and the importing countries, and estimates several specifications of the gravity equation, so as to tackle such issues as the multilateral resistance term, heteroskedasticity, and zero flows and non-linear relation between trade and distance. The paper also adds a detailed analysis on the external border effect for each Spanish exporting region and each of the seven European countries considered. By means of this analysis we shed new light on the *relative integration* between regions of these seven countries and Spanish exporting regions. Finally, we conduct an extrapolation exercise, computing the "trade potentials" that would be expected in a fully integrated Europe, and estimating how long full integration would take to achieve between each Spanish exporting region and each European importing country. To this regard, two alternative scenarios are considered: one using the growth rates of Spanish exports before the crisis (2001-2008) and other considering the post-crisis growth rates (2011-2013).

[1] Acknowledgements: This paper was developed in the context of three research projects: the C-intereg Project (www.c-intereg.es), founded by seven Spanish regional governments; the TransporTrade Program S2007/HUM/497, funded by the Directorate for Education and Universities from the Comunidad Autónoma de Madrid (www.uam.es/transportrade); and (ECO2010-21643) from the Spanish Ministry of Economics and Innovation. Nuria Gallego expresses her gratitude to the UAM for the FPI scholarships. Much-appreciated comments from various colleagues have served to improve the quality and scope of previous versions of this manuscript. However, any errors herein are entirely the responsibility of the authors. Special reference is needed in this case for: Francisco Requena and Asier Minondo during the INTECO workshop 2010; Rosella Nicolini, J.P. Lesage and Roberto Patuelli during the NARSC 2013; Francisco Alcalá and David Wenstein during a seminar at Columbia University in 2012.

But what, in economic terms, is a nation? As we move across geographical space, what is special about crossing a national boundary?

Fujita, Krugman and Venables, 1999, pp. 239.

1. Introduction

As the main economic journals and newspapers have reported, several regions in Europe are demanding greater political autonomy or openly calling for independence. Such is the case with Cataluña and the País Vasco in Spain (*Economist*, 2012a; *New York Times*, 2012), Flanders in Belgium (*Economist*, 2011) and Scotland in the UK (*Economist*, 2012b). What are the costs and benefits for the new economies to come and the countries to which they belong? What would the overall consequence be for citizens and the European project as a whole?

The aim of this paper is not to answer these questions but to add some *stylized facts* for the discussion.

If the EU moves towards a "Europe of regions", or any of the current sub-national units become a new member state, it would be critical to have a better knowledge of the level of integration (expressed in similar spatial units) that each has now—or could have in the future—with every other region of the Single European Market. In addressing the previous questions abstractly, we join other economists in wondering what, in economic terms, a nation actually is, and how national and regional boundaries differ as impediments to economic integration. The border-effect literature offers a valuable basis for discussion, since it allows us to quantify, after controlling for a set of factors, the higher intensity of trade within a certain spatial unit in comparison with the intensity in other markets.

The existence of large border effects is one of the main puzzles of international macroeconomics (Obstfeld and Rogoff, 2000). The seminal paper by McCallum (1995) found that trade between any two Canadian provinces was (on average) 22 times greater than trade between any Canadian province and any US. state. Since then, many authors have repeated the exercise with other countries[2] and other spatial units, whether countries, regions, provinces or even zip codes (see Table 1 for summary).

<< Table 1 about here >>

For the European Union (EU), certain papers have estimated the relevance of international borders by comparing a European country's domestic trade volume with its international trade volume (Head and Mayer, 2000; Minondo, 2007; Chen, 2004). Similar analyses have been produced at the sub-national level so as to compute *external border effects*. These have taken a country's regions (or provinces) as their point of reference and counted how many more times they traded with the rest of the country (as a whole) than with other countries (Gil et al., 2005; Ghemawat et al., 2010).

In parallel, we also find estimates of *internal border effects*, defined as how much more trade some region (province) of a given country conducts with itself than with any other region (province) of the same country. Wolf (1997, 2000), for example, while investigating market fragmentation in the United States (US), found intra-state trade unduly high in relation to inter-state trade. Later, Hillberry and Hummels (2008) analyzed the impact of geographical frictions on trade, using truck deliveries within US at different spatial levels. They found that internal border effects would disappear in the US. as the spatial units became very fine. Similarly, Combes et al. (2005) and Garmendia et al. (2012), taking into account social and business networks, investigated the narrowing of internal border effects at the province level (Nuts 3) for France and Spain, respectively.

To the best of our knowledge, no one has yet produced a pristine estimate of border effects in Europe. No one, that is, has estimated how much more trade a particular region of a

[2] Japan (Okubo, 2004), US(Wolf, 2000; Hillberry, 2002; Hillberry and Hummels, 2003; 2008; Millimet and Osang, 2007), the European Union (Chen, 2004; Nitsch, 2000, 2002; Evans, 2003), Germany (Shultze and Wolf, 2008), Russia (Djankov and Freund, 2000) and Brazil (Daumal and Zignago, 2008), among others.

European country conducts with another region of the same country than with a third region in another European country. The reason is lack of data on region-to-region trade flows between Europe's countries. Thus the most ambitious attempts to measure the effect of international borders on inter-regional trade structures in the European Single Market are either indirect or restricted to border regions with intense bilateral trade relations (Lafourcade and Paluzie, 2011; Helble, 2007).

Moreover, whenever an *external border effect* has been computed—on the basis of flows between sub-national units on both sides of a national border (McCallum, 1995; Anderson and van Wincoop, 2003; Feenstra, 2002, 2004)—only inter-regional flows between contiguous countries (e.g., Canada-US.) have been considered. The actual effects of a national-border crossing have thus been mixed with those of high economic integration and cultural and historical similarities. It would therefore be most interesting to have an alternative estimate of Anderson and van Wincoop's border effect, one between the Canadian provinces and the regions of a non-contiguous country: the Mexican states, for example. Space being non-neutral, we should keep in mind that a Canadian province wishing to deliver a product by truck to regions in another country must either trade with the US. or send the truck across it. The US, on the other hand, can deliver products by truck to two contiguous countries, Canada and Mexico. Similarly, Spain can trade with three contiguous countries (Portugal, France and Andorra), and with many others once its trucks have crossed France. Since competing destinations so thoroughly condition international trade (Anderson and van Wincoop, 2003), and different European countries share such different levels of economic and cultural integration, it would be interesting to compute external border effects *à la* McCallum—but to do so for region-to-region trade between non-contiguous European countries as well. This would give us a first insight into the true roles played by various national borders.

In this paper, using a unique dataset that captures region-to-region intra- and inter-national trade, we estimate *internal* and *external border effects*, contrasting the intra- and inter-regional trade between Spain's regions (Nuts 2) against the inter-regional trade between Spanish regions and those of seven other European countries. To do so, we test several specifications of the gravity model (McCallum 1995; Feenstra 2002, 2004; Anderson and van Wincoop 2003; Gil et al, 2005), producing benchmarks for the results of our novel dataset. Then, in line with some recent papers (Head and Mayer, 2000, 2002; Hillberry and Hummels, 2008; Llano-Verduras et al., 2011; Garmendia et al., 2012) we also consider the non-linear relationship between distance and trade that appears when the analysis is conducted at a low spatial scale. Like in these previous papers, we obtain border effects that shrink along with the size of the exporting unit, simply by dividing up the spatial unit of the importer (from country to regions). This result probably masks the mismeasurement of the *external border effect* in region-to-country data, a mismeasurement due to an inappropriate assumption about the distribution of trade within the importing country's regions.

In sum, we believe this paper contributes to the previous literature in the following ways: (1) It produces the first estimates for the *external border* of European regions by means of region-to-region flows, just as McCallum, Feenstra or Anderson and van Wincoop did for Canada and the US. These estimates confirm that trade integration is even higher between European regions than between North America's equivalent spatial units. (2) It computes *external* and *internal border effects* for inter-regional intra-national and inter-national flows between one country (Spain) and its seven main European partners. Whereas previous papers considered only inter-regional trade between two contiguous countries, this approach sheds new light on the effect of different national borders. (3) The paper then adds a detailed analysis focusing on the external border effect for each Spanish exporting region, as well as for the seven EU countries considered. We thus shed new light on the *relative integration of regions* (corrected by distance and market power) of these seven countries with regards to the Spanish exporting regions. Surprisingly, the analysis points to the Spanish regions' greater integration with the richer, more distant European regions of the so-called *"blue banana"* than with the closer regions of France. We therefore part ways with previous papers (Lafourcade and Paluzie, 2011) and conclude that the intensity of trade in border regions, although clearly above average, is significantly less than what we would expect from their great market potential (per capita income/distance) with respect to the European core. Our analysis concludes, finally, with an interesting extrapolation exercise, where we compute the "trade potentials" that would be expected in a fully integrated Europe—that is, assuming a non-external border effect for the Spanish regions when they export to the regions of these seven countries. We then estimate how long each Spanish exporting region would take to reach full integration, considering two alternative scenarios with regards to the rhythms of penetration in those markets. The first scenario considers the pre-crisis evolution of the Spanish exports to these seven countries, taking into account the growth rates observed in the exports of each region from 2001 (the introduction of the euro until 2008 (the last year before the sharp downturn in trade). The second scenario is based on the evolution of the Spanish exports to these seven countries during the period of recovery (2011-2013). The result shows that, for the two scenarios, it will take from 30 to 1,337 years to achieve the same level of integration with the EU than with the other Spanish region. Moreover, the results suggest that in some cases (Asturias), it will take between 400 and 1,000 years to reach that level of integration assuming the exporting dynamic observed before or after the crisis. In our view such dramatic figures, generated even with prudent hypotheses, clearly illustrate the role of internal and external borders, and provide some insight for the debate on what a nation is in economic terms.

The rest of the paper is organized as follows. . Section 2 describes the alternative specifications of the gravity equation used in our analysis. Section 3 briefly summarizes our method for estimating a region-to-region trade dataset for the Spanish case and offers a descriptive analysis of new trade flows. Section 4 presents the results obtained with different specifications of the gravity equation. Our analysis explores new dimensions of the dataset, offering detailed results by exporting Spanish region and importing EU region. The final section summarises the main conclusions of our paper.

2. The Empirical Model

The backbone of our investigation is the gravity equation, where the intensity of trade between any two locations (regions or countries) is positively related to their economic size and inversely related to the trade cost (proxy by geographical distance) between them. However, we depart from previous literature by redefining specific border effects to be measured. By *internal border effect* we denote the number of times a Spanish region trades more with itself than with any another region in the sample. By *external border effect* we denote the number of times a Spanish region trades more with another Spanish region than with a foreign region elsewhere in Europe, controlling for a set of factors.

First, we define our specifications by taking inspiration from some classic papers on the estimation of border effects with sub-national spatial units in Canada and the US (McCallum, 1995; Anderson and van Wincoop, 2003; Feenstra, 2002, 2004). We will thus for the first time estimate the real flavor of border effects in an EU country as measured with homogeneous spatial units on both sides of the national border (region-to-region, instead of country-to-country or region-to-country). Next, we have our dataset replicate the specifications used to generate previous estimates of region-to-country trade flows in Spain (Gil et al., 2005). We thus highlight for the Spanish case the difference between the benchmark results and the results generated by our new dataset. It is important to note, however, that despite our efforts to keep close to the benchmarks, certain important differences in the datasets will limit the comparability of the results. These differences are laid out in Section 4.

For the sake of brevity, we here define two equations that contain all the models used in this article. They include variables that will be *switched on* or *off* depending on the model in use at a given time. For example, equation [1] formulates a general specification for estimating the external border effect using the inter-regional flows (intra excluded) along with GDPs, distance and other standard control variables:

$$ln\, T_{ijt}^{eu} = \beta_0 + \beta_1 lnY_{it} + \beta_2 lnY_{jt} + \beta_3 External\_Border + \beta_4 lndist_{ij} + \beta_5 External\_Contig + \mu_i + \mu_j + \alpha_{ij} + \gamma_t + \varepsilon_{ijt} \quad [1]$$

where lnT_{ij}^{eu} is the logarithm of the flow from region i in country e to region j in country u in year t. Note that: (a) if $e = u = Spain$ and $i = j$, equation [1] will capture intra-regional trade flows for a Spanish region i; (b) if $e = u = Spain$ and $i \neq j$, equation [1] will capture inter-regional trade flows for a pair of regions within Spain; (c) if $e \neq u$, equation [1] will capture inter-regional flows between Spain and another European country in the sample. Since this paper focuses on flows originating in Spanish regions, $e = Spain$. The variables lnY_{it} and lnY_{jt} are the logarithms of the nominal gross domestic product (GDP) of the exporting and importing region, respectively. The variable $lndist_{ij}$ is the logarithm of the distance between region i and region j.

The variable *External_Border* is a dummy that takes the value one for inter-regional flows within Spain ($e = u = Spain$) and zero otherwise. The anti-log of the parameter associated with this variable measures the size of the *external border effect*.

To capture the positive effect of adjacency, we introduce the dummy variable *Contig*, which takes the value one when trading regions i and j are contiguous and zero otherwise. This variable conveniently controls for higher inter-regional trade flows between contiguous Spanish regions as well as for the higher concentration of trade between border regions of different countries (Spain-Portugal, Spain-France). It is in line with the results of Lafourcade and Paluzie (2011), who have shown that border regions in countries like France and Spain tend on average to capture larger shares of bilateral trade and FDI flows. The terms μ_i and μ_j correspond to multilateral-resistance fixed effects for the origin and the destination region, respectively. Their inclusion follows Anderson and van Wincoop (2003) and Feenstra (2002, 2004) and is meant to control for competitive effects exerted by the non-observable price index of partner regions and by other competitors. They are also meant to capture other particular characteristics of the regions in question. The variable α_{ij} is the region-pair effect and γ_t the time fixed effect.

We next define an additional set of models based on equation [2]:

$$ln\frac{T_{ijt}^{eu}}{Y_{it}Y_{jt}} = \beta_0 + \beta_1 Internal\_Border + \beta_2 External\_Border + \beta_3 dist_{ij} + \ \beta_4 dist_{ij}^2 + \beta_5 Internal\_Contig \quad + \beta_6 External\_Contig + \mu_{it} + \mu_{jt} + \mu^u + \gamma_t + \ \varepsilon_{ijt}$$

[2]

where $\frac{T_{ijt}^{eu}}{Y_{it}Y_{jt}}$ represents bilateral flows originating in Spanish regions and corrected by the GDPs of the trading regions. Anderson and van Wincoop (2003) have shown that the inclusion of bilateral trade as corrected by unitary income elasticity does not greatly affect the other parameters.

This specification includes the variable *Internal_Border*, which takes the value one when the origin and the destination region are the same (intraregional flows $i = j$) and zero otherwise. It also includes certain refinements in the treatment of distance. It thus includes, apart from the traditional variable $dist_{ij}$, a new variable $dist_{ij}^2$. As in Hillberry and Hummels (2008), Llano-Verduras et al. (2011) and Garmendia et al. (2012), the variable $dist_{ij}^2$ is defined as the square of the distance between trading regions and is expected to capture the non-linear relationship between trade and distance that is observed for kernel regressions in Figure 2. Also in line with these papers, we split the interpretation of these two variables (capturing the negative but non-linear effect of distance on trade) into two parts: (i) a negative and direct effect of distance on trade and (ii) a positive effect for the square of the distance, to capture the high concentration of trade over the shortest distance as observed in the kernel regression. Note also that the *Contig* dummy is also split into two variables: *Internal_Contig* and *External_Contig*. This allows us to consider (simultaneously or independently) the different effects that *adjacency* exerts on trade flows between two contiguous regions in Spain or between a Spanish region and a contiguous foreign one. The terms μ_{it} and μ_{jt} correspond to the multilateral-resistance fixed effects for each origin and destination region interacted with time, respectively. It is worth mentioning that, because of their cross-section dataset, the origin and destination fixed effects in Anderson and van Wincoop (2003) and Feenstra (2002) did not consider their interaction with time. To account for the likely heterogeneity between countries and its effect on the estimate of a single border effect, we have also added a fixed-effect term for each destination country (μ^u).

Having defined all the variables and specifications, we now briefly explain the models used for our empirical analysis and the ways they include our variables and specifications. The estimation methods and data types used for the first set of models are as similar as possible to those of the benchmarks. For models 1 and 2 (M1 and M2), the estimation of equation [1]—as in McCallum (1995) and Anderson and van Winkoop (2003)—is based on cross-section datasets (2011) for region-to-region flows and takes into account only non-zero values (zero values represent 44% of our sample; 2004-2011). For comparability with previous authors (Gil et al., 2005), in models M3 and M4 we incorporate the dataset broken down in region-to-country level, we use a specific econometric technique (panel random effects) and we use the same distance measure. This distance is a weighted average of geodesic distance between the main cities within each region. Estimates for the other models are based on equation [2] - (Table 3) and use a pool of data (2004–2011). For models estimating the *external border effect*, intra-regional trade flows are excluded (and *Internal_Border* therefore drops). For models focusing on the *internal border effect*, international flows are excluded (and *External_Border* drops).

Ordinal Least Square (OLS) estimators are used when the gravity equation is applied to a dataset with no zero values. When zeros are included[3], we instead use the Poisson pseudo-maximum likelihood technique (PPML). It was Santos Silva and Tenreyro (2006) who proposed using the PPML approach, which also sorts out Jensen's inequality (note that the endogenous variable is in levels) and produces unbiased estimates of the coefficients by solving the heteroskedasticity problem. For M3 and M4—as in Gil et al. (2005)—we use a panel random effect estimator (REM) with time fixed effects.

3. The Data

[3] The zero values considered in our dataset correspond to region dyads that had non-zero values in at least one year of the period 2004–2011. Zeros corresponding to regions that did not receive any exports from a Spanish region during that period are not considered in our sample.

There is no official data on region-to-region international trade flows for any country in the EU. Gallego and Llano (2012), however, have laid out a method for estimating region-to-region international flows between Spain and seven European countries[4]. It combines region-to-region freight statistics for Spanish trucking with international price indices (deduced from official trade data[5]) for each region-country variety (cf. Appendix for a summary of the method). Then, in order to improve the quality of our international flows, the levels are rescaled in order to match the official information available on international trade by road (customs). This match is set at the lower common level of disaggregation available for both sources annual region-to-country international trade by road for each specific product (NSTR-3 digits). Therefore, the final database keeps the region-to-region dimension and is coherent with the official levels on Spanish exports by road to these countries. This process of harmonization has two main advantages: i) first, it rises the level of representativeness of our dataset in levels, due to the fact that our region-to-region original dataset on freight flows just includes deliveries developed by Spanish trucks, while the official trade levels -used now as constraint- include all deliveries by road (regardless of the nationality of the transporter)[6]. . ii) Second, , having in mind that the purpose of our analysis is the quantification of the border effect, i.e. the measure of differences in levels of trade depending on the final destination, it is crucial to assure the comparability between the levels of the Spanish deliveries within Spain and the ones to the EU countries. After this harmonization with the official flows by road, most of the potential biases are avoided.

[4] Although for the sake simplicity we use the label EU, our sample of countries does not fall under any specific administrative category.

[5] For most of our EU countries, two main sources for the inter-national bilateral flows of goods exists: (1) Trade statistics on intra-EU trade, which register bilateral flows between pairs of countries, both in volume and in monetary units; for certain countries, like Spain, the trade data identify the exporting or the importing region but never both simultaneously. (2) Transport statistics on intra-national and inter-national freight flows, which in some cases (e.g., road freight) provide information on the type of product transported (quantity) as well as on the regional origin and destination of the flows. Our method aims to build up a region-to-region trade dataset by combining these two sources: (1) region-to-region flows in quantities (road-freight statistics) and (2) specific region-to-country trade prices (from the official trade statistics).

[6] It is important to remark that, since Spanish trucks account for the main share in the Spanish exports by road to these seven EU countries, we can assume that the region-to-region structure observed for the Spanish trucks (observable in the freight statistics) is similar to the (non-observable) structure corresponding to the non-Spanish trucks.

This novel dataset for region-to-region international trade flows was connected with equivalent data on (intra- and inter-regional) trade flows within Spain. This second dataset is similar (but not exactly the same) to the ones used in previous analysis (Garmendia et al., 2012; Llano-Verduras et al., 2011; Ghemawhat et al., 2010; Requena and Llano, 2010; Llano et al., 2010). The result is a unique dataset on region-to-region flows for intra-regional, inter-regional and inter-national flows into and out of the regions of Spain (Nuts 2) and the regions of Spain's seven main European partners.

Our distance variable is the *mean actual distance* covered by Spanish trucks between each pair of trading regions, as reported in the survey published by Spain's Ministry of Public Works and Transport (Ministerio de Fomento). This variable has the virtue of capturing the *real distance* travelled by trucks between actual points of departure and destinations. In this sense, it is superior to the variable used by other authors, where intra-national and/or inter-national distance is either an a-priori estimate based on the great circle distance between main cities weighted by population or an ad-hoc estimate by mathematical approximation. By using actual distance, we should, in theory, be able to account for region-to-region inter-country links that are not attributable to the mere allocation of population. There are specific regional endowments or specificities that weighted distance tends to mask. This difference alone should set this paper apart from papers that use region-to-country flows and assume that the distance between the exporting region and the importing country (as a whole) is equivalent to the weighted average of the linear distance between the exporting region and the importing country's main cities (weighted by population). The Ministry's survey also includes the actual distance travelled by trucks for inter- and intra-regional deliveries. Crucially, this allows us to avoid choosing alternative ad-hoc intra-regional distances, which alter results on border effects (Head and Mayer, 2002). Because the actual distance travelled by each truck between each pair of regions can vary in every year, and because with the aim of eliminating the risks of endogeneity, we have arrived at our intra- and inter-regional distances by averaging the distances observed in all deliveries from 2004 to 2011 for each specific dyad *i-j*. Regional GDPs for the EU regions under consideration are published by Eurostat.

3.1. Descriptive Analysis

Before proceeding to the econometric analysis, we will briefly analyze the novel dataset.

<< Figure 1 about here >>

Figure 1 plots the spatial concentration of exports delivered from three important Spanish regions, corrected by the product of the GDPs of the trading partners and expressed in terms of standard deviations. The maps are referred to the average of the largest period available (2004-2011). It is worth mentioning the novelty of these three maps, which reveal the hitherto unknown region-to-region dimension of Spain's trade relations with seven European partners. It is important, also, to highlight that in all three cases intra-national trade flows are clearly greater than inter-national flows. The intensity of the color shows a clear discontinuity in the relevance of trade flows between Spanish and European markets, even when three of the country's main exporting regions are considered. As we will see in the next sections, this result leads to positive and significant *external border effects* for all exporting regions and all importing countries. Note that for all three regions the most intense interregional trade flows within Spain are concentrated in the closest regions. This will be tested by contiguity dummies.

In addition, like some recent papers (Garmendia et al., 2012; Llano-Verduras et al., 2011; Hillberry and Hummels, 2008), we offer here a first view of the distribution of trade (always region-to-region) as it depends on distance travelled by trucks, for both domestic and international deliveries. Like them, we also use a kernel regression to generate a nonparametric estimate of the relationship between distance and the intensity of Spanish regional export flows[7]. One novelty of this approach is that we plot the kernel distribution for consecutive years in the same graph.

<< Figure 2 about here >>

Figure 2 plots the distribution of domestic and international flows (exports) for each region against those for the rest of Spain's regions and the seven European countries. Note that trade flows are corrected by the GDP of each exporting/importing region.

Therefore, the kernel distribution for the *corrected trade* over *the actual distance travelled by the Spanish trucks* is close to plotting the endogenous variable considered in the gravity equation [3] against the distance. It is also worth mentioning that, even when intra-regional trade flows are not included, the highest concentration of trade flows (in current monetary units) for each year occurs over the shortest distance, and follows a decline in intensity for the first 700 km. This result is in line with the results of previous papers (Llano-Verduras et al., 2011), which also analysed all Spanish flows (domestic and international), considering all the flows (and not just the deliveries by Spanish trucks) without the region-to-region breakdown. Before the econometric analysis, it is convenient to remark a slight variation in the shape of the kernel regression during the period. Such variation is clearer in the thicker part of the distribution, that is, the one that corresponds to the largest intensities of trade observed in the shortest distance. To this regard, the volume of trade in the shortest distance is larger at the beginning of the period (2004) than at the end (2011). To make this point clear, the lines corresponding to the pre-crisis / post-crisis are plotted with two different colours. In our view, this result is connected with the two paradigmatic patterns of trade observed in Spain before and after the crisis, something that will be analysed with some detail in section 4.1.

4. Results

[7] We use the Gaussian kernel estimator in STATA, with n = 100 points and the estimator calculating optimal bandwidth.

We begin our empirical analysis by revisiting some classic specifications for the estimation of border effects, so as to test the performance of our new dataset against them. This will afford us some measure of comparability with previous results and thus allow us to determine which of our results derive from new specifications and which from our dataset itself. Table 2 lays out the results for four models.

<< Table 2 about here >>

The first two models (M1 and M2) were inspired by McCallum (1995), Anderson and van Wincoop (2003) and Feenstra (2002, 2004)[8]. As reported in the first column (M1), when fed our dataset the McCallum-like specification generates an external border effect of 24 (vs. McCallum's 22 for Canada-US!). The coefficients and signs for the rest of the variables align with expectations. There is, however, a slightly lower coefficient for GDPs than the normal values in our benchmarks, which use all trade flows and not just truck deliveries. Similarly, the figures for model 2 (M2) were generated by our novel dataset and a specification similar to that defined by Anderson and van Wincoop (2003) and Feenstra (2002, 2004). The results once again align with expectations. As in the benchmark papers, we find a significant decrease in the external border effect (now of factor 14) when multilateral resistance terms are taken into consideration.

In the Table 2 the model 3 (M3) and 4 (M4) report the results generated by a specification similar to the one used by Gil et al. (2005) but with our novel dataset. To reduce differences, we aggregate our region-to-region dataset to the data structure used in their paper—flows between each Spanish region to the rest of Spain (ROS) or to other countries—and use

[8] Before comparing results, we should point out some relevant differences between our dataset and the dataset used by these authors: (i) We must emphasize that figures obtained for external border effects in a country like Spain in its trade with seven European countries can hardly be compared with the figures for Canada and the US. (ii) Our distance variable for intra- and inter-national flows measures the actual distance travelled by trucks delivering commodities, whereas the distance used by McCallum (and in papers published thereafter) was either the linear distance between the main cities in each province and state or the weighted distance. (iii) In our sample we consider seven different "international borders", and two contiguous countries (France and Portugal), whereas McCallum and all the subsequent articles replicating his work with similar datasets considered only one "international border": between Canada and the US.

their distance measure[9]. Like them, we also omit data on intra-regional flows and focus on the estimation of the *external border effect*. According with the distance variable in the model 3 (M3) we find a negative elasticity of –1.626 and an external border effect of 13 [exp(2.594)] for Spanish exports. Similarly, Gil et al. (2005) obtained negative elasticity at a distance of –1.28 when using GDPs and at a distance of –1.26 when using Population and Surface (columns (1) and (3) in Table 1 of their paper). With these two specifications, which do not control for contiguity, they obtained an *external border effect* of 20 [exp(2.99)] for exports and of 24 [exp(3.18)] for imports. With model 4 (M4), where they controlled for contiguity (as we have done), they obtained a lower negative coefficient for distance (–0.88, vs. –1.439 in our estimates). They obtained a similar external border effect than ours (13) for exports to other countries contiguous and member states of the EU and the EFTA, but clearly larger (54) for neither contiguous nor a member of the EU or EFTA[10].

We now revisit more recent specifications that have considered alternative spatial units and discussed the nonlinear relationship between trade and distance (Hillberry and Hummels, 2008; Llano-Verduras et al., 2011; Garmendia et al., 2012). These models use equation [2] and the full dimensions of our novel region-to-region dataset. For comparability with previous papers, external and internal border effects are estimated separately.

<< **Table 3 about here** >>

Table 3 reports results for a first set of models estimating the *external border effect* and the *internal border effect*, considering the full sample (2004-2011). All of these models use the

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[9] Some important differences nevertheless hold. For example: (1) Gil et al. (2005) used a different database on inter-regional trade flows within Spain for 1995–1998, used international flows by all transport modes for twenty-seven OECD countries, and included Spain's two island regions. Our estimate uses data for 2004–2007, considers only inter-regional and inter-national flows by Spanish trucking to seven European countries, and excludes the islands. (2) Gil et al. (2005) used trade flows and GDPs in real terms; we use them in current terms.

[10] In our view, our larger border effect for exports can be explained by the differences between the two datasets. Gil et al. (2005) used total flows (not just truck deliveries) and a wider range of countries. Although the number of deliveries by trucks could be taken as representative of all internal trade flows (trucks accounting for more than 90% of Spain's internal transport flows), the international truck deliveries in our sample fall far short of the total trade considered in their all-modes sample for twenty-seven OECD countries.

corrected trade flows $\frac{T_{ijt}^{eu}}{Y_{it}Y_{jt}}$ as an endogenous variable as well as all the fixed effects described above. However, each uses a different estimation procedures and treatment of the distance variable. M5 include zero flows, use the PPML estimator and the distance in logs. M6 include zero flows and use the PPML estimator including the *distance* and the *square of distance*, both in levels. M7 exclude zero flows, use OLS estimators and include the *distance* and the *square of distance* also in levels. M8 and M9, which are related to the domestic trade (intra-regional and inter-regional) just include one zero value, therefore, use OLS estimator procedure and also include the log-transformation of distance and its quadratic form, respectively.

First, we analyze the results obtained for the *external border* (M5-M7). The first three models generate significant coefficients with the expected signs for all variables except *External_Contig* in M5 and M6. This result suggests that the difference in the intensity of trade between a Spanish region and a foreign border region, on the one hand, and between non-adjacent Spanish regions, on the other, is non-significant, whether the intensity is higher or lower. Note, in fact, that the coefficient for the *Internal_Contig* variable is positive and significant. Moreover, the results for distance variables that control for the non-linear relationship between trade and distance in M6 and M7 suggest that distance acts as a clear impediment to trade (negative coefficient for $dist_{ij}$), but an impediment that tapers off as distance increases (positive coefficient for the square of distance). As for the *external border effect*, the three models reach similar factors: 7 for M5, 8 for M6, and 10 for M7. Thus, seems to be persistent and robust to alternative specifications, subsamples and estimation procedures. This persistent *external border effect* around 8 is slightly larger than that obtained by Llano-Verduras et al. (2011) with region-to-country [3.3 = exp(1.2)] and province-to-country [4.9 = exp(1.6)] data. Note that the papers use different datasets but similar specifications for distance and the same estimation procedures as in M6 and M7[11]. However, the *external border*

[11] In Llano-Verduras et al. (2011), the external border effect was computed with PPML procedures. Simply by disaggregating the spatial unit of the exporting area in Spain, they were able to obtain a significant reduction in the border effect. That said, the squared-distance term was non-significantly different from zero with region-to-country data, but only at the province-to-country level. When our novel dataset is used with full disaggregation (zeros included and region-to-region), the external border effect

effect for Spanish exportsis smaller than the 13 and 16 obtained when the same dataset is applied in a region-to-country aggregated format (M3 and M4), as in Gil et al. (2005).

We now focus on our results for the *internal border effect*, reported in the last two columns of Table 3. Both models are estimated using OLS due to the very few zero flows observed during the period for the intra-national deliveries. Thus, the only difference between the two specifications is the treatment of distance. The most surprising result is the low factor of the *internal border effect* in M-8 (1), whereas in M-9 it reaches a significant factor of 5. The latter *internal border effect* is greater than the one obtained by Garmendia et al. (2012) with province-to-province data, OLS [3.7 = exp(1.31)] and PPML [2.4 = exp(0.88)] procedures and similar specifications for the distance variable (square of distance). Now, as in Llano-Verduras et al. (2011), the contiguity dummy becomes non-significant for the two models, and even and negative for M8.

4.1. The evolution of the external border effect before and after the crisis

In this section we focus on the evolution of the *external border effect* during an eight years period, which includes the largest crisis observed in the Spanish Economy since the Great Depression. This analysis has the additional interest of showing to what extent the evolution of the *external border effect* just reflects a monotonic increase of trade integration of the Spanish regions with the ones of the main European partners, or, as it is the case, if this effect is sensitive to the evolution of the demand of the two main markets under analysis, namely, the rest of the country and the other EU countries considered in the sample. By doing so, we will shed new light on how the *external border effect* is sensitive to the cycle. To this regard, the Spanish case is paradigmatic. Before the crisis, the Spanish economy was fueled by the real state and the service sector, recording huge growth rates in the internal demand, which

slightly decreases (1.869 in M6 versus 1.852 in M7) and the square of the distance has a positive and significant coefficient (0.767 in M7). We believe these results in part from the splitting of importing countries into their corresponding regions as well as for the difference in the datasets used in the two papers.

generated intense levels of intra-national trade (mainly in the short distance). The evolution of international exports during that period of boom was also very intense, and in fact, with a strong concentration in the EU countries. However, after the crisis (2010-2013), the Spanish economy followed a completely different pattern of growth, based on a strong increase in their international exports and a weak evolution of the domestic demand (intra-national trade).

<< **Figure 3 about here** >>

Departing from this context, Figure 3 plots the evolution of the border effect during the whole period. The specific results are described in Table 6 in the Annex. Note that, in order to isolate the effect of the evolution of trade (goods) and the GDPs (goods + construction + services), whose composition was especially different before and after the crisis, for this analysis the product of GDPs are included in the right hand side of the equation rather than as a denominator of the endogenous variable. Regarding the results, as expected, the evolution of the Spanish *external border effect* is far from monotonic, and it is coherent with the evolution of the internal/external demand. Thus, the results point out to a pro-cyclical *external border effect* for the Spanish economy with regards to their seven main European partners, since it expands during the boom previous to 2009 and it contracts during the recovery. However, for several reasons, the pattern observed is not as clean as expected. The external border effect starts with a slight decrease from 2004 to 2005; then, it rises up to a maximum factor of 19 (27 for the specification using the log of distance) in 2008. This is a year in which the international trade contracted, while the Spanish internal demand was fueled by expansive fiscal policies. After this year, the Spanish external border effect decreased continuously until 2011 (with factors of 14 and 11 respectively). In our view, this evolution is more connected with the relative evolution of the internal/European demand, than with the *process of integration* promoted by the EU Commission through the elimination of external barriers to trade. As said before, after 2009 the Spanish international exports experienced an unknown expansion while its internal demand remained extremely weak due to strong cuts in public expenses, a sharp reduction in the loanable funds offered by the commercial Banks (several subject to external intervention) and the largest unemployment rate ever recorded in the Euro Area (26%). All these factors collapsed in a clear reduction of the *external border effect*. Finally, it is worth mentioning that although this effect decreased from 2008 (19) to 2011 (11), it remained higher than in 2005 (5). Although further research is needed, such result can be connected with the fact that the recent expansive period for the Spanish exports (2010-2011) was not specifically oriented towards the European markets (also affected by the strong recession) but to third countries. This fact will be discussed in the last section of this paper.

4.2. Results by exporting region and importing country

Next, we want to dig deeper into the spatial dimension of the *external border effect*, decomposing the overall effect by exporting region and importing country simultaneously. This will shed new light on the heterogeneous level of trade integration between Spanish regions and the regions of Spain's main European partners. Note that with this analysis we examine the thickness of seven heterogeneous national borders— two with contiguous countries (Portugal and France) and five with non-adjacent ones (Belgium, Germany, Italy, the Netherlands and the United Kingdom). We compute equation [2] with a single regression, but controlling, by means of dummies, the exporting region and the importing country. We generate these estimates with the PPML procedure and the pre-crisis sub-sample (2004–2008), with zero flows included. The *external border effect* is now expressed negatively, indicating how many fewer times a Spanish region exports to a non-adjacent foreign region (e.g., in France) than to a non-adjacent Spanish region, ceteris paribus. Note that intra-regional flows and the *Internal_Border* are not included in the analysis. We present our results in two complementary ways: the detailed results obtained from the regressions are reported in Table 5 (Annex), while Figure 4 uses a spider-web graph for a more visual report of the corresponding *external border effects*.

<< **Figure 4 about here** >>

As reported in Table 5 (Annex), the lowest *external border effects* are obtained for Portugal (5.41), Germany (6.81), the UK (7.17), Belgium (7.42), the Netherlands (7.44), Italy (8.31) and France (8.81). If we consider this *external border effect* as a measure of *relative integration* between Spanish regions and the regions of the sevenEuropean partners—with size, bilateral distance and contiguity previously controlled for—it is remarkable that the rankings do not coincide with what one might expect when considering only the absolute intensity of trade (corrected by GDPs), as plotted in Figure 1. It is clear that distance (and the square of distance) is playing an important role, together with other non-observable fixed effects. As our results suggest, the border effect is a *relative measure of integration* between each European region and each exporting Spanish region, with respect to their *market power* (GDP_j) and the distance between them. Therefore, our specification for the *external border effect* by country calls for a higher intensity of exports from a given Spanish region (e.g., Cataluña) to a French border region (e.g., Languedoc-Roussillon) than from the same Spanish region to an Italian region (e.g., Milan) of the similar size and idiosyncratic demand. If this intensity does not reach the level suggested by equivalent "inter-regional" flows from the same exporting region to other Spanish regions (internal trade), then the French region (e.g., Languedoc-Roussillon) is *punished* with a higher *external border effect* than the more distant Italian region (e.g., Milan). If we keep this in mind, the previously described ranking suggests that the highest *external border effects* under these specifications correspond to France, which is contiguous to two strong Spanish regions, with intense interregional flows to the rest of the country., Conversely, the lowest border effects are found in Portugal, which is also contiguous to Spain, but which shares frontier with the poorest Spanish regions (Extremadura, Andalusia, the two Castillas and Galicia). Low border effects are also obtained for rich but more distant countries, such as Germany, the UK, Belgium, and the Netherlands. These non-evident results are in line with those of other papers, which have also found lower external border effects for Germany than for France when using region-to-country flows for specific Spanish regions like Cataluña and the País Vasco (Ghemawat, 2010; Gil-Pareja et al., 2006)[12]. However, our results may differ from

[12] Note that the results are not fully comparable, because of notable differences in the data type and

those papers using alternative specifications and datasets. The smaller border effect obtained for Belgium is striking and requires further research, perhaps into the effect of Belgium's business networks, hub-spoke structure, tax system, or status as the seat (via Brussels) of the EU government. Before entering upon a detailed analysis of the border effect by region and country, we should comment on the other variables reported in Table 5 (Annex). To control for the enhancing effect of border regions (Lafourcade and Paluzie, 2011), we consider two *Contiguity dummies,* finding that just the *Internal_Cont* is positive and significant. f

We focus now on the border effects reported in Figure 4 for each exporting region and each importing country, as obtained with region-to-region trade flows. The overall ranking of the Spanish border effect with respect to the seven EU countries is the same as previously stated. The thick red line tracks the *external border effect* for each Spanish region with respect to the regions of each importing country. It is easy to see that the lowest *external border effects* are obtained for Madrid (4.8 = exp[1.57]), while the largest are obtained for La Rioja (13.8 = exp[2.62]), Asturias (10.6 = exp[2.36]) and Cantabria (8.7 = exp[2.17]). Pais Vasco and Cataluña can be considered as special cases. Both are contiguous to France, and have intense trade with the EU and the internal market. At first blush, when we consider the Cataluña high intensity of trade with the seven EU countries (see Figure 1), one may expect the lowest *border effect*. However, by taking into account its huge intensity of trade with the rest of Spain (Ghemawat et al, 2010), we see that the model demands much higher international trade flow from Cataluña with the nearest French regions than is the actually case. Cataluña's large external border effect is thus induced by its high GDP, its relative orientation towards the Spanish market and its geographical advantage as the main "gateway" to the European core. Something similar may happened with País Vasco. It seems clear from this analysis that the strong intensity of interregional trade over the shortest distance within Spain *calls for* the same

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specifications used in each paper. Thus Ghemawat et al. (2010), using total trade flows (exports + imports by all transport modes), found a low and shrinking external border effect for Cataluña in its trade with France. Another case in point is Gil-Pareja et al. (2006), who also found—using regional balance-of-payment data and region-to-country data—that the external border effect for País Vasco exports was lower for trade with countries such as Portugal, Belgium, Germany, Finland and the Czech Republic than it was for trade with France.

intensity of trade for exports to the bordering regions of France. To the best of our knowledge, this is the first time that this puzzling result is observed in Europe, due to the lack of information on region-to-region international trade flows. One of the goals of our research is precisely to explain this jump in the intensity of trade with the crossing of the national border. To reach this goal, we will need to refine our sectoral, geographical and historical characterization of each region.

4.3. Results by importing region

We now complete the previous analysis with an alternative focus on the external border effect of Spain as a whole with respect to each specific region in the seven EU countries. Note that a complete region-to-region breakdown of the external border is not possible because of a lack of degrees of freedom (a maximum of four observations for each region-to-region dyad is available). For brevity, the results are presented in Figure 5 as a map, which captures the *external border effect* for each EU region along with the *border effect* obtained in the previous analysis for its corresponding country. This breakdown, new to the literature, helps us identify EU regions that are relatively integrated with the Spanish regions (as exporters). It also shows a remarkable variability of the *relative integration* within each country. Note again that, in this map, the intra-country variability of the *border effect* with respect to Spanish exports is driven by: (1) the high intensity of trade within Spain, (2) the size of the importing EU region and (3) the importing region’s accessibility (by road) from Spanish exporting regions.

<< **Figure 5 about here** >>

With this in mind, we identify two great patterns in the variability of the *external border effect* within each importing country in Figure 5: (i) for France, the largest *border effects* are obtained in some of the regions nearest to Spain (some of them border regions), while the lowest *border effects* are obtained in the most distant ones (northeastern France); (ii) for our other countries, the darkest regions within each country (highest *border effects* for importers from Spain) are the furthest regions from Spain (by road) while the palest (lowest *borders effects* for importers from Spain) correspond to the nearest. The pattern is perfectly clear for Italy, the UK and Germany. Belgium and the Netherlands obtain very low border effects in all their regions. To verify this pattern, Figure 6 shows the scatterplot of the *external border effect* against the *market potential* of the destination region (per capita income of the importing region / distance from Spain). For clarity, the observations for each importing country are plotted in different colors, and the market potential of the sub-sample (2004-2008) is standardized to 100%. The sample is then divided into two groups by average market potential with respect to Spain, and two trend lines (both significant) are added for each group. The figure thereby shows clearly that the trend line for regions with the lowest market potential with respect to Spain (the UK, Italy, the Netherlands, Belgium, Germany) has a negative slope. Within these countries, then, the regions with the highest market potential (the richest ones, located near the *"blue banana"*) register the lowest border effects with respect to Spain. Conversely, in the other group—regions with above-average market potential (mainly regions from France)—the trend line has a positive slope, which confirms that the Spanish external border effect is higher for the closest regions in France than it is for the most distant regions within these same countries.

<< **Figure 6 about here** >>

Again, in order to better understand this interesting result, we may wish to think of the border effect as a *relative measure of integration*. If actual trade between Spanish regions (internal trade) is greater than trade over equivalent distances between Spanish and French regions, then the French regions are being *punished* with a large border effect. Why? Because their actual trade with Spanish regions should have a level similar to that of trade observed within Spain. This "border penalty" affects mainly French regions, which should have a much higher level of imports from Spain than is observed, at least if we consider a unified single market. Conversely, the low border effect obtained for Portugal suggests that its actual trade with Spain is similar to than expected, given its *market potential* with respect to Spain. By contrast, when we consider regions of more distant countries (the UK, Italy, Germany), the ratio between actual interregional international flow and Spanish internal trade is smaller (lower border effects). The explanation is that, assuming the *distance decade* of interregional trade within Spain, the expected trade with a further region in Germany is not that far from the actual one, even if that German region is richer –on average- than a Spanish region.

One of the main conclusions of this analysis is that Spanish exports in general seem to have a reasonable penetration in the main EU markets, when we consider the *internal distance decade* and the great distance at which such rich European markets lie. At the same time, although the intensity of Spanish exports is greater over the shortest distance (to border regions in France), it is much smaller than what we should expect if they were as integrated as any other Spanish region.

4.4. How far are we from a full integrated market

To add a more insightful corollary for policymakers, we would like to conclude with a simple extrapolation exercise. We begin with a question: how intense would exports from Spanish regions to their EU counterparts be in a world of perfect integration—that is, in an EU market where the external border effects of the Spanish regions were null? To find out, we estimate previous models using Spanish interregional trade flows alone: i.e., using a perfectly integrated market (trade within a country, without intra-regional flows). Then, with the estimated coefficients for each Spanish region, we predict region-to-region flows with respect to our seven EU countries.

As in previous sections, two alternative specifications are used, both with zero flows and PPML procedures for the period 2004–2008. The first includes the square of distance: the estimation is described by equation [3], the prediction by equation [4].

$$T_{ijt}^{ee} = \beta_0 + \beta_1 ln(Y_{it} * Y_{jt}) + \beta_2 dist_{ij}^2 + \beta_3 dist_{ij} + \beta_4 Contig + \mu_{it} + \varepsilon_{ij} \qquad [3]$$

$$\hat{T}_{ijt}^{eu} = \hat{\beta}_0 + \hat{\beta}_1 ln(Y_{it} * Y_{jt}) + \hat{\beta}_2 dist_{ij}^2 + \hat{\beta}_3 dist + \hat{\beta}_4 Contig + \mu_{it} \qquad [4]$$

In equation [3] the model is estimated with only interregional trade flows within Spain (T_{ijt}^{ee}) as dependent variable, while equation [4] predicts the interregional exports from Spanish regions to other EU regions (T_{ijt}^{eu}) assuming the elasticities ($\hat{\beta}_0, \hat{\beta}_1, \hat{\beta}_2, \hat{\beta}_3, \hat{\beta}_4$) obtained in [3]. The right-hand side in both equations includes the log for the multiplication of the corresponding GDPs, the distance variables, the contiguity dummy and the fixed effects for the origin and year (μ_{it}). The fixed effects for destinations are not included since the importing regions in the estimation sample (regions within Spain) and the forecast sample (regions in the other seven EU countries) are different.

At this point, it is convenient to briefly discuss a potential drawback to the quadratic approach. Although widely used for dealing with non-linear functions, the quadratic model suffers from a potential limitation: the reversal of the effect's direction. Normally, the quadratic model is used under the assumption that the *turning point* lies outside the sample (Gould, 1993). In order to compute the point at which the effect changes direction, we use the following expression: $-\beta_3/(2\beta_2) = (-(-4.062)/2 * (1.974)) = 1.028$, where β_2 and β_3 are, respectively, the coefficients for the distance and the square of distance in our equation [3]. Thus, when estimating [3] with only interregional flows within Spain, the turning point arises at 1,028 km. Although this value is not problematic for the modeling of flows within Spain (the largest trip within Spain is around 1,120.422 km), Figure 7 shows how harmful it would be for the prediction of exports to the other EU regions (with a maximum distance of 3,100 km in our sample)[13].

For this reason, we use an alternative specification described in equation [5] and [6], where the non-linear relationship between trade and distance is captured by a specification equivalent to the one considered before: i.e., one that takes logarithms for the distance variable. The rest of the variables and samples are exactly the same as in equations [3] and [4]:

[13] Note that this effect will not be problematic with the equation [2], used to estimate external border effects in previous sections. Because the estimation there mixes intra-national and inter-national flows, the turning point varies by specification for Spanish origin region, and sits around 1,750 kms for the average estimate in which all origin regions are included.

$$T_{ijt}^{ee} = \alpha_0 + \alpha_1 ln(Y_{it} * Y_{jt}) + \alpha_2 ln(dist_{ij}) + \alpha_3 Contig + \mu_{it} + \varepsilon_{ij} \quad [5]$$
$$\widehat{T}_{ijt}^{eu} = \widehat{\alpha}_0 + \widehat{\alpha}_1 ln(Y_{it} * Y_{jt}) + \widehat{\alpha}_2 ln(dist_{ij}) + \widehat{\alpha}_3 Contig + \mu_{it} \quad [6]$$

<< **Figure 7 about here** >>

Figure 7 plots the two alternative predictions (one based on equation [4] and the other on equation [6]) for Spanish exports to regions of the seven European countries under full integration, along with the actual flows. Three points are worth mentioning: (i) as expected, the level of predicted flows in both predictions is clearly above the actual level; (ii) although a large number of actual flows are null, the predicted values for the dyads are clearly positive regardless of the specification used in the forecast (we will explore this result to some extent later); (iii) the gap between flows predicted with the quadratic specification and actual flows clearly expands as distance from Spanish exporting region to European importing region increases. The reason, as previously discussed, is the turning point of the quadratic form. We now use the log specification (equation [6]) as a benchmark, to compare predicted flows with actual flows, and compute the corresponding "trade potentials". The results are reported in Table 4.

<< **Table 4 about here** >>

The first seven columns of Table 4 report the ratio of predicted flows over actual flows between each Spanish region and each of our seven European countries. This ratio expresses the increase necessary for actual flows (AV) to reach the trade value predicted (PV) for a no-boundaries scenario. Note that both the actual and the predicted values are initially inter-regional flows. For the sake of brevity, however, we report the results in terms of region-to-country aggregation. At the same time, for this analysis we have used the sub-period (2004–2008), whose values are annual trade-flow averages. Column (8) reports the same ratio as the previous columns but for total international Spanish outflows for each region. Columns (9–10) split the previous total into two components: (i) on the one hand (column 9), predicted trade flow can exceed actual flow because actual flow is zero[14] ; (ii) on the other (column 10), actual

[14] Note that the origin-destination pairs included in the sample report trade for at least one year of the period. Their trade can therefore be zero for the rest of the period.

flow can be positive but lower than expected. Column (9) is related with the percentage of actual zero flows (plotted and described in Figure 7). Note that this approximates the *"extensive margin"* of trade, since it implies that a Spanish region should start exporting to a new market (and thereby increase the number of importing regions within the seven countries considered)[15]. By contrast, column (10) is related with the percentage of non-zero flows observed, which approximates the *"intensive margin"* of trade, because it relates to the increase in positive actual flows from each Spanish region necessary for full integration with the regions of the seven European countries.

Finally, using the ratio of predicted flows (PV) to actual flows (AV) (columns 1–7) and considering each Spanish region's different rhythm of export penetration into each of the seven countries for two alternative scenarios (column 11 and 12) as reported by the official Spanish trade statistics[16], we report (in column 11 and 12) the maximum number of years[17] that it will take each Spanish region to achieve full integration with the seven countries. More specifically, the two alternative scenarios are described as follows: i) in column (11) we report the maximum number of years that it will take each Spanish region to achieve full integration if the Spanish exports to these seven countries follows the same rhythm than the one observed between 2001 (the introduction of the euro) until 2008 (the last year before the sharp downturn in 2009); ii) the second scenario reported in column (12) corresponds to the maximum number of years to achieve full integration if the Spanish exports follows the same trend than in the period of recovery (2011-2013)[18]. All the calculations are available upon request. These averages give a

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[15] It is important to remark that all zero trade flows considered in this paper correspond to European regions that have had a positive flow with any of the Spanish regions during the period 2004–2008. Thus, we do not consider the "effort" of entering into regions where non-trade flows were observed at all in this period. In this sense, we consider our calculation to be cautious.

[16] For comparability, the rhythm of each Spanish exporting region's penetration into each of the eight European countries considered is computed with official trade statistics (http://datacomex.comercio.es/) but only with trade flows by "road".

[17] The formula used to compute the number of years required to achieve the predicted volume of trade in a full integration scenario is based on the compound-interest expression, where, according to an interest rate (i: annual average growth rate of the international trade), the final value (PF: predicted flow) is related to the initial value (AF: actual flow) during a period of time (n: number years) through the following equation: $n = \ln\left(\frac{PF}{AF}\right)/\ln(1+i)$.

[18] Note that the growth rates used for computing this second scenario of full integration take into account the period (2011-2013), which is slightly different than the one considered in section 4.1 for analyzing the

better idea of the path to full integration. Note that although all these numbers are considerably large, they can be considered as a potential timeline for full regional integration if the rhythm of trade is equivalent to that observed during these two paradigmatic periods described in section 4.1.

From the results we can see that expected value exceeds actual value in all cases, but especially for some regions and countries (i.e.: the United Kingdom). At this point, we must point out that our naïve prediction does not take into account the geography of destination countries, which is essential in the case of the UK when considering trade flows by road. Although our results are thus gross approximations, they provide an opportunity to explore what would happen, hypothetically, in a scenario with no political frontiers and no obstacles other than distance.

It is worth mentioning that, as per the results in column (11), all Spanish regions should have to wait more than 30 years to attain with these other countries—on average—a level of integration similar to the level they enjoy now with the rest of Spain. The lowest period (30 years) is obtained for Galicia when one assumes its exporting dynamics for the period 2001-2008 (column 11). The longest periods of adjustment occur in regions with the lowest international trade growth and/or highest proportion of zero values. Among these regions are Asturias (425 years on average in column 11 and 1,124 in column 12), Aragón (270 years on average in column 11, and 1,337 in column 12) La Rioja (50 years on average in column 11, but 617 in column 12), Comunidad Valenciana (48 years on average in column 11, but 542 in column 12) or Madrid (275 years on average in column 11, and 441 in column 12). Full integration is also a long way off for other important Spanish regions, such as Cataluña (84 years on average in column 11, and 295 in column 12) or the País Vasco (47 years on average in column 11, and 397 in column 12)[19].

evolution of the border effect. The reason is that in former analysis the growth rates are computed using the official data, which is available at the region-to-country level until 2013. Bu contrast, the latter analysis included in section 4.1. uses our dataset with region-to-region flows, which ended in 2011.

[19] Note that these calculations are intended only to suggest a reference timeline for discussion, and are therefore open to much criticism. For example, our estimates do not consider any kind of trade-off

Focusing on the difference obtained between the two scenarios (column 11 *vs* 12), the result shows that during the second period (2010-13), the average number of years obtained were higher than in the previous one (the range varies between 31 in Castilla-La Mancha and 1,337 in Aragón). This result seems to be contradictory with our previous comments regarding the evolution of the border effect during the cycle. However, as it was mentioned at the end of section 4.1. it is important to remark that, although the Spanish exports boosted after 2009, they tended to have non-EU countries as destinations. Note that during this period some of the seven European economies considered in the sample were also trapped into a deep recession, a fact that limited its potential demand capacity. Therefore the results obtained suggest that the exporting effort made during the recovery period by the Spanish exporting firms, did not have a special effect on an increase in the regional integration with the main partners in Europe, since the bulk of this exports were delivered to further and more dynamic markets. Instead, when the pre-crisis rhythm are used in the first scenario (column 11), the range of years decreased, from a minimum of 30 years in Galicia to a maximum of 425 years in Asturias.

The conclusion of this analysis is threefold: i) the full integration scenario is still very far away for every region; ii) the observed differentials and integration schemes are relative to the relative location and size with respect to potential importers; iii) Thus, it is important to highlight that our approach imposes a greater effort of integration to the regions with larger intensities of trade within Spain and locational advantages towards the European core. Such approach could be more reasonable than just demanding the same level of integration notwithstanding the relative location and since regarding the biggest markets.

between internal integration within Spain and external integration with European regions. This assumption implies that the difference between predicted and actual trade intensity should be fully explained by a pure "creation effect", with no deviation of trade from the internal Spanish market to the European market. Moreover, we do not take into account competing effects stemming from equivalent attempts by other regions (and countries) to enter and increase their export shares in these same importing European regions. Consequently, we are assuming that trade potentials will be absorbed by importing regions without constraint from their demand capacity. Moreover, our estimates are always constrained to road-delivery flows. Although this mode of transport represents more than 70% of Spanish exports to these countries, it should be completed with extended datasets (unavailable at present in any country).

5. Conclusions

In this article we aim to measure the internal and external trade integration of Spanish regions by quantifying the *external* and *internal border effects* in Spain, taking into account intra- and inter-national trade between Spanish regions (NUTS 2) and the regions of Spain's eight main European partners. Lack of information on inter-regional flows, both domestic and international, has hitherto impeded pristine estimates of *border effects* like those obtained for Canada and the US by McCallum (1995), Anderson and van Wincoop (2003) and others. Until now, *external border effects* in Europe have been computed with country-to-country or region-to-country flows. We can thus suppose there to have been a loss of relevant information, because of aggregation and the use of non-homogeneous spatial units. The computation of distance as well, both for intra-national trade and for region-to-country dyads, has seemed a source of bias in previous border-effect estimates.

In this paper we have made use of a novel dataset for inter-regional trade flows by road, including intra-national and inter-national flows and considering actual distance for the shipments. From this starting point we have borrowed classic specifications previously used to compute *external* and *internal border effects* both between Canada and the US and between Spain and other countries. As our results attest, the new dataset generates similar but not identical figures when channeled into these classic specifications. For one thing, we find a higher level of integration (i.e., a lower external border effect) between our region pairs than previous authors have found between Canadian provinces and US states (15 vs. 22). When we aggregate our dataset to a format of region-to-country Spanish flows, we obtain a greater border effect than the benchmark paper found. However, when we use the dataset with full disaggregation (with zeros and region-to-region) and alternative estimation procedures, external and internal border effects decrease or become non-significant. We also observe a certain variation of the internal and external border effect due to the non-linear relationship between distance and trade. With most of the specifications considered here, we obtain internal and external border effects that are positive and significant, although smaller than in previous papers that do not consider region-to-region international flows. Finally, we repeat the analysis for region- and country-specific border effects, obtaining relative measures of integration between Spanish regions and their main partners. We conclude with an extrapolation exercise, where we predict trade potentials assuming a scenario of full integration between Spanish regions and the regions of the eight European countries considered. With this final analysis we find, on the basis of the recent dynamics of exports to these countries, that it will take 37 to 497 years on average for a Spanish region to attain such a level of integration. For some cases, however, we find very extreme values, which points out that in some cases, regions are moving against integration with some specific European countries.

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TABLES

Table 1. Selected Papers on External Border Effect for North America, OCDE, Europe and Spain, Classified by Data Type and Spatial Unit.

Paper	Country	Sectoral analysis	Time period	External border effect
Region-to-region				
1995. McCallum	Canada-United States	No	1988	22
1996. Helliwell	Canada-United States	No	1988–1990	22
1998. Hillbery	Canada-United States	No	1993	20
2001. Helliwell	Canada-United States	No	1991–1996	15–10
2002. Head & Mayer	United States (Wolf, 1997, 2000)	Yes	1997	11
Country-to-country				
1996. Wei	OCDE	No	1982–1994	10-2.6
1997. Helliwell	OCDE	No	1996	13
2000. $Nitsch_a$	EU-10	No	1979–1990 1983–1990	7–10
2000. Head & Mayer	EU-9 EU-12	Yes Yes	1976–1995 1993–1995	30-11 13
2004. Chen	EU-7	Yes	1996	6
Region-to-country				
1999. Anderson & Smith	Canada-United States	No		12
2005. Gil et al.	Spain (17 regions), Rest of Spain(*) and OECD-27	No	1995–1998	21
2003. Minondo	Basque Country, Rest of Spain(*), 201 countries	No	1993–1999	20–26
2007. Helble	France, EU-14 Germany, EU-14	No	2002	8 3
2010. Requena &Llano	Spain (17 regions) OECD-28	No Yes	1995 & 2000	13
2010. Ghemawat et al.	Catalonia, Rest of Spain(*), OECD	Yes	1995–2006	55
2011. Llano-Verduras et al.	Spain (17 regions; 50 provinces, OECD)	No	2000 & 2005	40

(*) Rest of Spain considered as a country, with total exports computed from one Spanish region to the rest of Spain (ROS). The purpose of this aggregation is to measure external border effects when region-to-region data is not available.

Table 2. Estimations with Classic Specifications from Previous Papers. Based on Eq. [1].

	M1	M2	M3	M4
	OLS	OLS	REM	REM
	Mc_1	AvW_1	Gil et al. 1	Gil et al. 2
	Ln(Tijt)	Ln(Tijt)	Ln(Tijt)	Ln(Tijt)
$\ln(Y_{it})$	0.577***		0.990***	0.977***
	(0.0782)		(0.0566)	(0.0572)
$\ln(Yj_t)$	0.546***		0.677***	0.658***
	(0.0876)		(0.0681)	(0.0689)
$\ln(dist_{ij})$	-0.988***	-1.174***	-1.626***	-1.439***
	(0.134)	(0.182)	(0.171)	(0.209)
External Border	3.190***	2.650***	2.594***	2.772***
	(0.192)	(0.666)	(0.179)	(0.210)
External Contig				0.406*
				(0.221)
Constant	-4.167	25.91***	-13.32***	-13.80***
	(3.145)	(1.545)	(2.213)	(2.279)
External Border = exp(β)	24	14	13	16
Observations	898	898	877	877
R-squared	0.400	0.549		
P-seudo R2	-	-	0.879	0.881
Multilateral resistance	NO	YES	NO	NO
Time fixed effect	NO	NO	YES	YES
Period	2011	2011	2004-2011	2004-2011

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

Table 3. Alternative Estimates for *External Border Effects*. M5- M10 are based on Eq [2].

	M5	M6	M7	M8	M10
	PPML	PPML	OLS	OLS	OLS
VARIABLES	Tijt corr	Tijt corr	Ln(Tijt corr)	Ln(Tijt corr)	Ln(Tijt corr)
$Ln(dist_{ij})$	-0.977***			-1.411***	
	(0.125)			(0.0596)	
$dist_{ij}$		-2.938***	-0.733**		-6.108***
		(0.335)	(0.299)		(0.401)
$dist^2_{ij}$		0.839***	-0.0212		2.761***
		(0.0972)	(0.0960)		(0.286)
Internal Border	-	-	-	0.324*	1.642***
				(0.171)	(0.142)
External Border	1.912***	2.104***	2.318***	-	-
	(0.172)	(0.185)	(0.296)		
Internal Contig	0.407*	0.662***	1.255***	-0.0427	0.0294
	(0.208)	(0.191)	(0.102)	(0.0660)	(0.0710)
External Contig	0.0726	0.120	1.319***		
	(0.339)	(0.334)	(0.251)		
Constant	-24.65***	-29.60***	-30.47***	-19.56***	-25.93***
	(0.938)	(0.314)	(0.341)	(0.390)	(0.151)
Internal Border	-	-	-	1	5
External Border	7	8	10	-	-
Observations	12,165	12,165	6,995	1,792	1,792
R-squared	0.821	0.809	0.652	0.851	0.850
Period: 2004-2011					

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

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

Tijt_corr = $\frac{T^{eu}_{ijt}}{Y_{i,t}Y_{j,t}}$

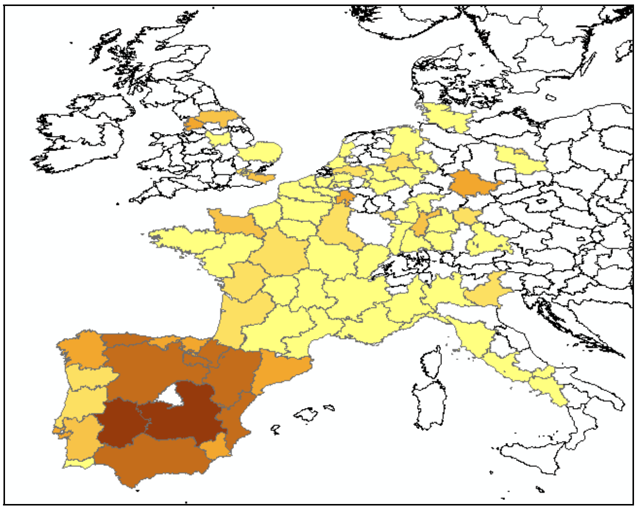
Table 4. Trade differentials in the case of full integration (no-external border effect). Predictions based on equations [6] and [7]: PPML with zero values. Period: 2004-2008.

	Trade potential with the regions in a specific country "u". Period: 2004-2008							Total trade potential				
	BE	DE	FR	IT	NL	PT	UK	Total (PV/AV)	Share of PV when AC is zero	Share of PV when AC is NOT zero	Average period for the integration: growth rates 2001-08	Average period for the integration: growth rates 2011-13
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Asturias	25	38	38	17	87	7	104	28	63%	42%	425	1,124
La Rioja	10	29	20	66	-	10	29	21	69%	44%	50	617
Castilla La Mancha	38	27	25	23	26	4	31	20	50%	50%	40	31
Castilla y León	21	29	12	22	36	7	16	16	43%	58%	55	208
Aragón	18	15	22	19	23	3	14	15	41%	59%	270	1,337
Andalucía	20	20	15	13	12	7	24	15	26%	74%	70	251
Cantabria	-	9	24	13	54	5	30	15	57%	44%	48	422
Comunidad Valenciana	12	17	12	21	14	4	21	14	23%	78%	94	542
Extremadura	181	18	24	25	53	6	8	14	54%	51%	39	48
País Vasco	11	10	13	9	21	5	24	12	34%	67%	47	397
Región de Murcia	16	13	15	15	9	7	10	12	29%	71%	259	145
Navarra	16	12	11	15	23	4	16	12	45%	55%	407	61
Comunidad de Madrid	15	14	13	10	16	3	11	11	49%	51%	275	441
Galicia	12	25	15	10	26	3	21	10	44%	57%	30	43
Cataluña	10	12	8	11	11	2	17	10	24%	77%	84	295

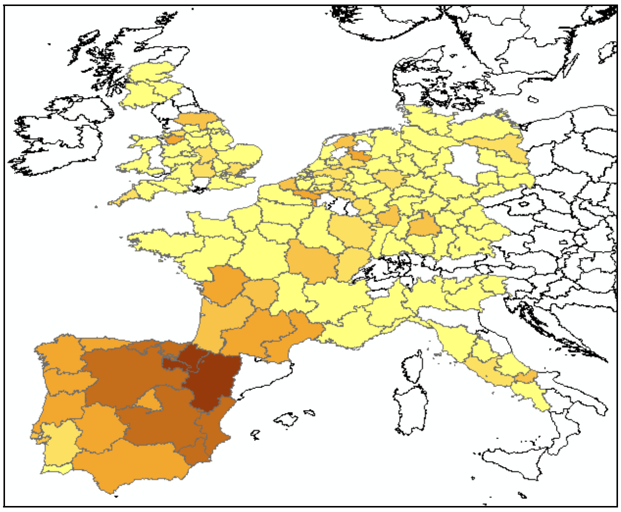
Note: PV=predicted value; AV= actual value.
*Columns (11-12) report the average number of years that each Spanish regions should expend in order to reach full integration with these countries considering the bilateral "trade differentials" reported in columns (1-7) and the bilateral growth rates of the international exports by road from each of the Spanish regions to the seven European countries considered. The observed periods runs correspond to a two structurally differentiate moments, one before to the crises from the 2001 to 2008 and the other from 2010 to 2013. Note that 2001 was one year before the introduction of the "euro" as a common currency in all these countries. It was during our selected period that the European Market was closest to our hypothesis of "full integration" (non-external border).

FIGURES

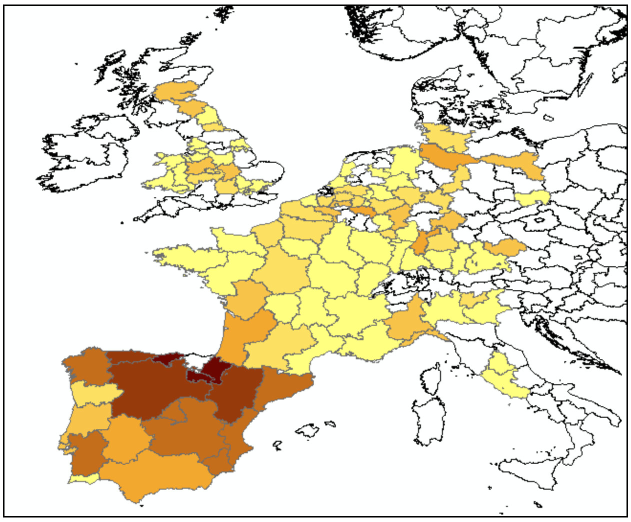
Figure 1: Main Intra-and Inter-National trade Flow by Road from Selected Regions (standard deviation over the full sample normalized). Data: average dyadic flows for 2004-2011



Madrid



Cataluña



País Vasco

Legend

Sd. over the trade normalized N(0,1)

- (-0,296) - (-0,263)
- (-0,264) - (-0,200)
- (-0,201) - (-0,092)
- (-0,093) - 0,198
- 0,199 - 0,704
- 0,705 - 2,971
- 2,972 - 6,200

Figure 2: Kernel Regression: Intra- & Inter-National Trade Relative to GDP (NUTS-2 Region-to-Region) on Distance. Zero Flows Excluded. (€). 2004–2011.

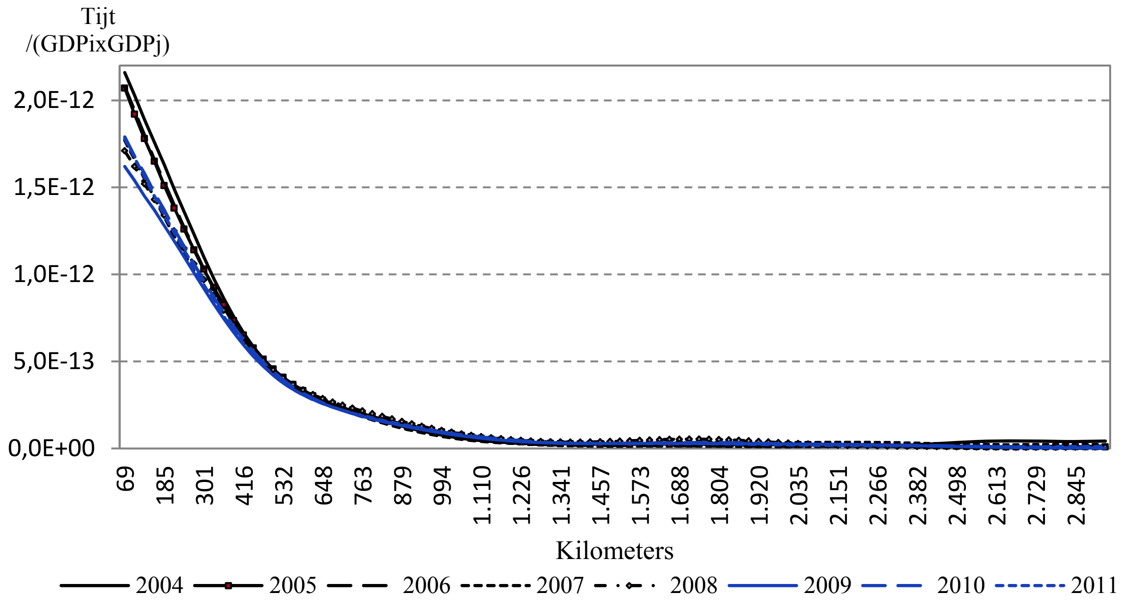


Figure 3. Temporal evolution of the Spanish external border effect. PPML. Results are reported in Table 6 (Annex). Period: 2004-2011.

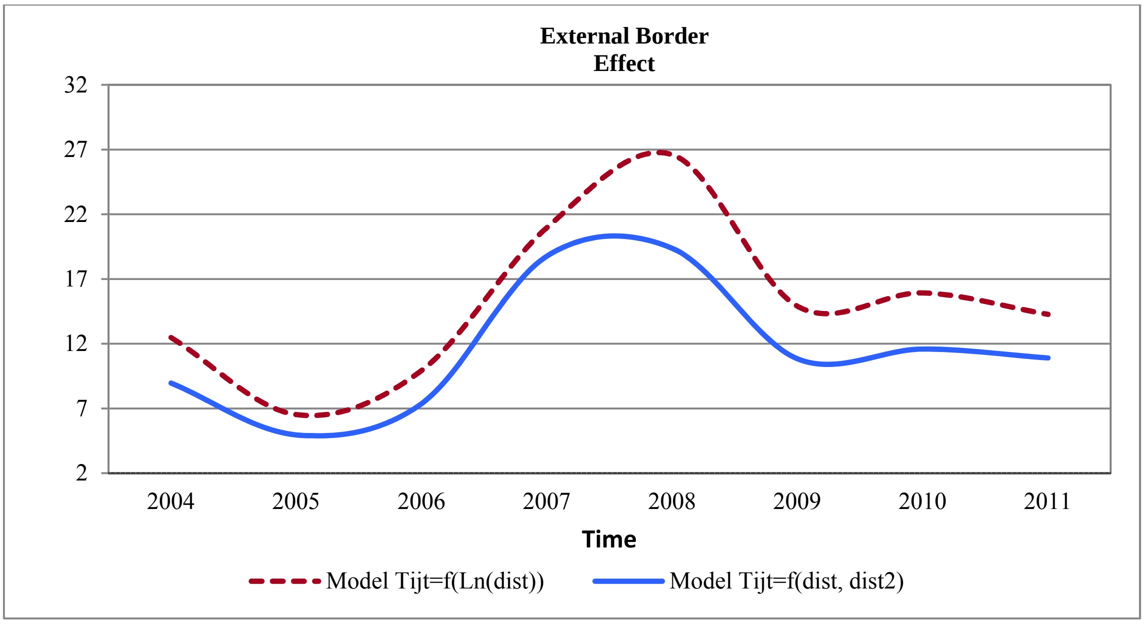
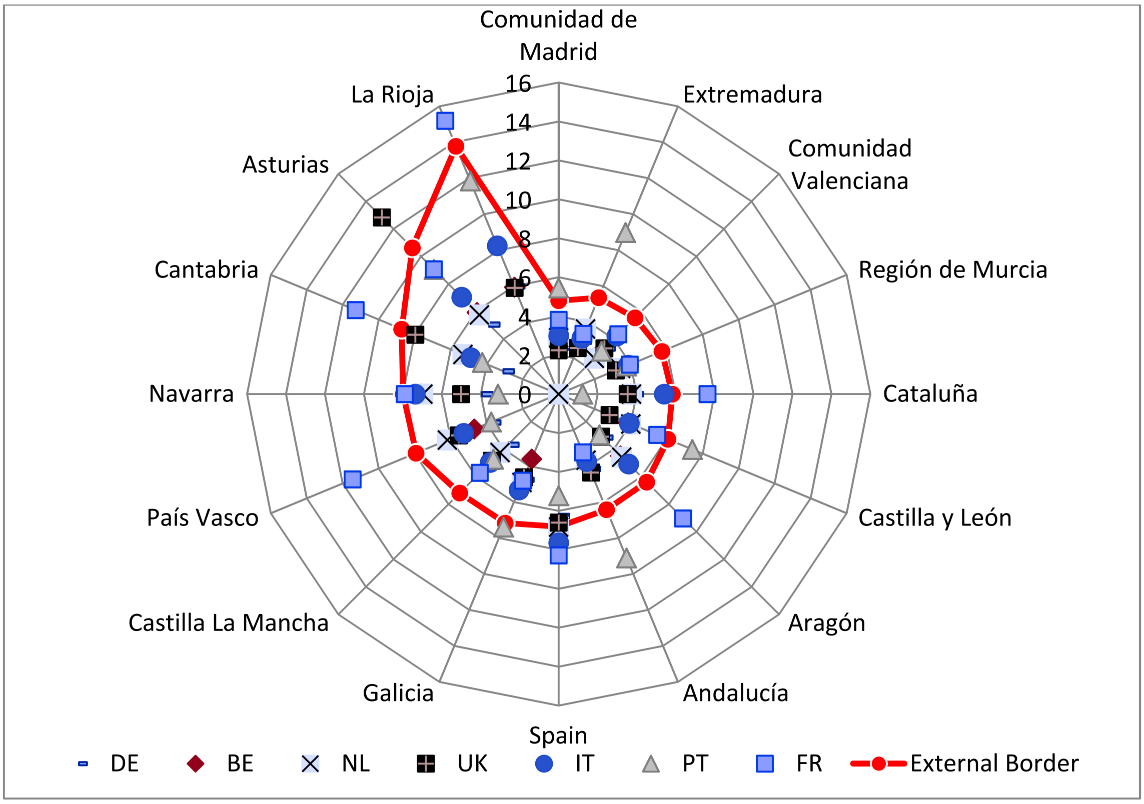
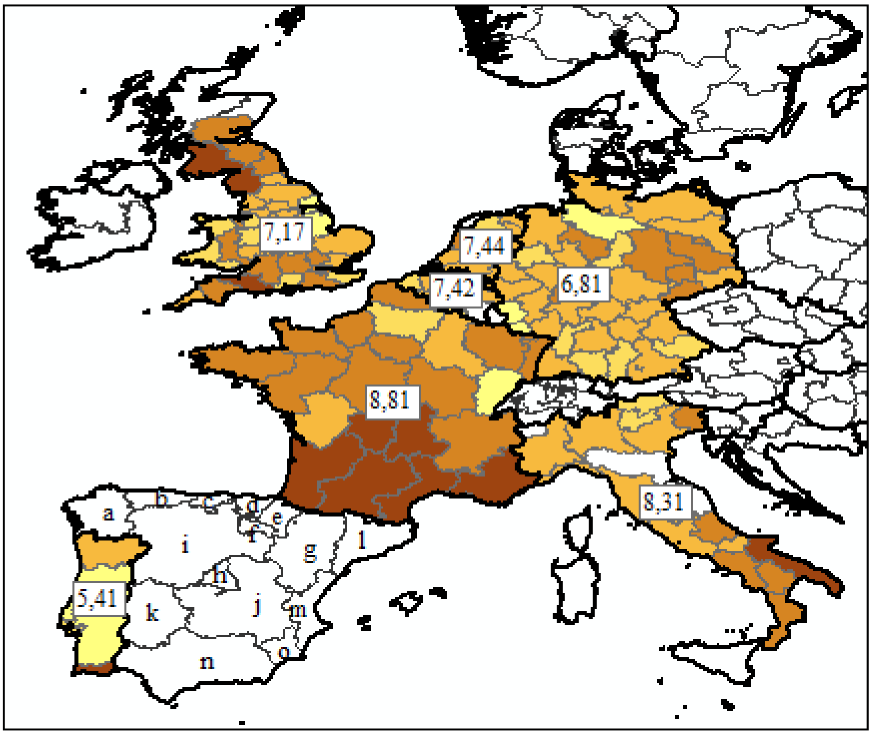


Figure 4. External border effect by destination country for each Spanish region. PPML. Period: 2004-2008.



The border effects plotted in this graph are based on Table 4 in the Annex. Procedure: PPML, equation [3]; region-to-region data (intra-regional flows excluded). The graph is ordered for the value of the External Border.

Figure 5: Map of the Spanish External Border Effect by importing region (colour) and country (numbers). Equation [2], PPML. Period: 2004-2008.



Note: The figures in the map represent the border effect for the destination countries; The lowercapital letters in the map represent the Spanish regions.

External Border Effect

Natual Break

- 1,04 - 3,15
- 3,15 - 4,22
- 4,22 - 5,19
- 5,19 - 6,88
- 6,88 - 10,09
- 10,09 - 20,98

ID	Name	Eurostat Code
a	Galicia	ES11
b	Asturias	ES12
c	Cantabria	ES13
d	País Vasco	ES21
e	Navarra	ES22
f	La Rioja	ES23
g	Aragón	ES24
h	Comunidad de Madrid	ES30
i	Castilla y León	ES41
j	Castilla La Mancha	ES42
k	Extremadura	ES43
l	Cataluña	ES51
m	Comunidad Valenciana	ES52
n	Andalucía	ES61
o	Región de Murcia	ES62

Figure 6: Scatterplot of Spanish External Border Effects (EBE) against the "market potential" (standardized to 100%) of EU regions ($GDPpc_j/D_{ij}$). The EBE is obtained from Equation [2], with PPML procedure. 2004-2008.

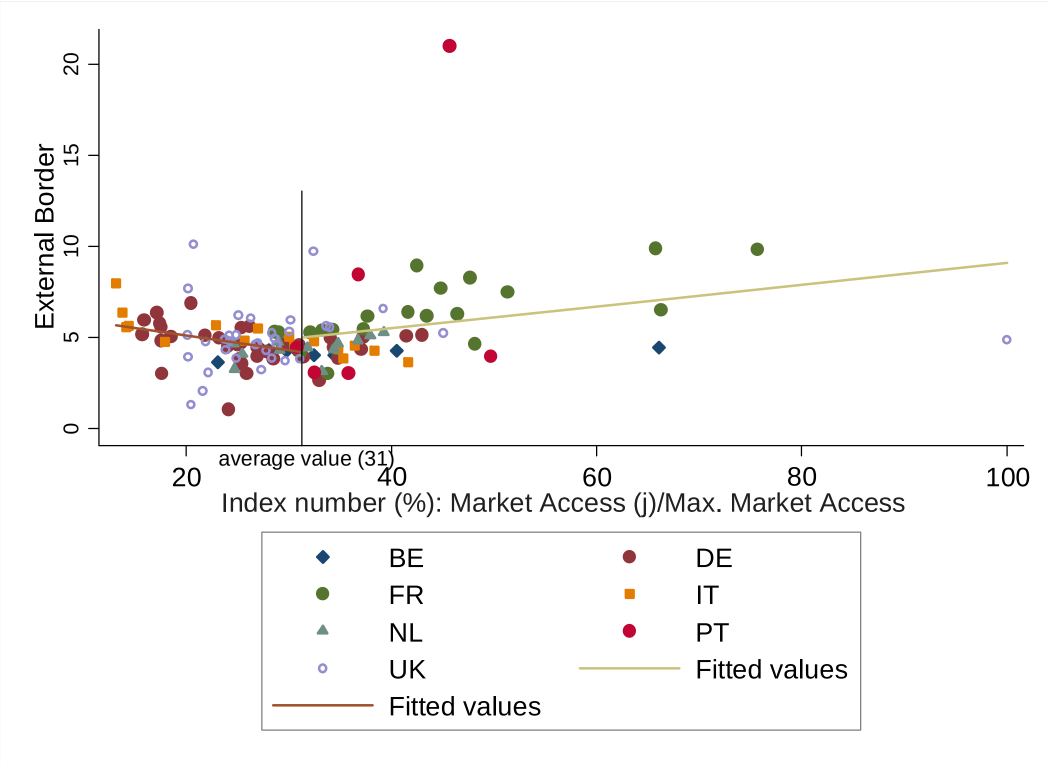
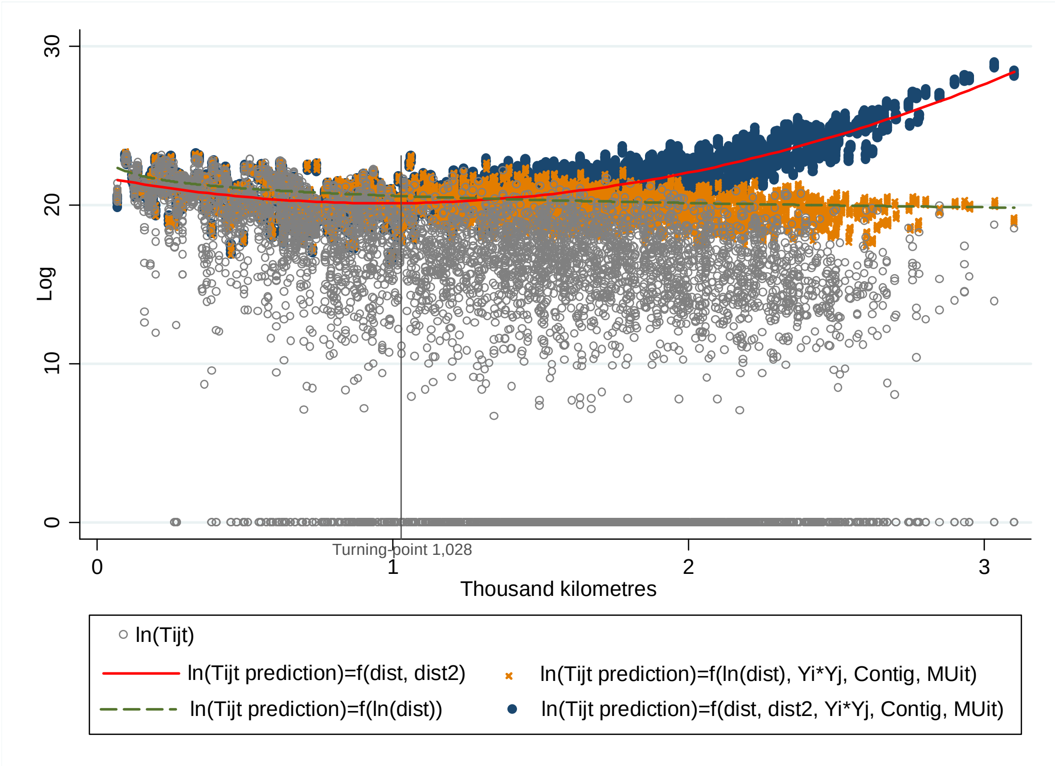


Figure 7: Scatterplot of Predicted and Actual Spanish Exports to the rest of Spain and to EU regions.
Predictions based on Equations [3] and [4], using PPML and the sub-sample 2004-2008 and with zeros.



Annex.

Table 5. Main coefficients obtained for each origin region by importing country. Procedure: PPML. Data: region-to-region (intra-regional flows are excluded). Period: 2004-2008.

Period: 2004-2008	$dist_{ij}$	$dist^2_{ij}$	BE	DE	FR	IT	PT	NL	UK	Internal Contiguity	External Contiguity	External Border (total)
Galicia			-1.284***	-1.561***	-1.572***	-1.674***	-2.001***	-1.592***	-1.533***			-1.970***
Asturias			-1.780***	-1.621***	-2.204***	-1.952***	-2.203***	-1.749**	-2.552***			-2.363***
Cantabria				-1.120***	-2.423***	-1.586***	-1.445***	-1.671**	-2.074***			-2.166***
País Vasco			-1.544***	-1.338***	-2.438***	-1.663***	-1.320***	-1.821***	-1.713***			-2.070***
Navarra			-1.955***	-1.369***	-2.067***	-1.996***	-1.136**	-1.941***	-1.611***			-2.077***
La Rioja			-1.781***	-1.791***	-2.721***	-2.110***	-2.472***		-1.775***			-2.623***
Aragón			-1.501***	-1.149***	-2.201***	-1.625***	-1.085**	-1.523***	-1.128***			-1.855***
Comunidad de Madrid	-3.956***	1.027***	-0.956**	-0.875***	-1.337***	-1.099***	-1.695***	-1.062**	-0.810**	0.343*	0.433	-1.568***
Castilla y León			-1.348***	-1.236***	-1.701***	-1.367***	-2.005***	-1.390***	-1.040***			-1.803***
Castilla La Mancha			-1.550***	-1.302***	-1.745***	-1.603***	-1.554***	-1.447***	-1.578***			-1.972***
Extremadura			-1.196**	-1.069**	-1.206***	-1.131***	-2.195***	-1.285**	-0.941*			-1.679***
Cataluña			-1.305***	-1.335***	-2.034***	-1.689***	-0.209	-1.320***	-1.265***			-1.764***
Comunidad Valenciana			-1.099***	-1.197***	-1.468***	-1.439***	-1.136**	-0.955**	-1.202***			-1.712***
Andalucía			-1.241***	-1.424***	-1.176***	-1.322***	-2.210***	-1.303***	-1.473***			-1.860***
Región de Murcia			-1.333***	-1.216***	-1.373***	-1.355***	-1.328***	-1.237***	-1.157***			-1.747***
Spain	-3.196***	0.894***	-1.922***	-1.833***	-2.115***	-2.033***	-1.652***	-1.921***	-1.887***	0.610***	0.223	

The results in the dark square and in the last column ("External Border") are region-specific border of a unique gravity equation, which include fixed effects for the interaction of destination region and time, and fixed effects by time. The results for Spain (bottom row) are obtained by a gravity equation that also considers all the origin regions.. This specification contains fixed effect for the interaction of origin region and time, and fixed effect by destination region and time.
Robust standard errors in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 6. Evolution of the Spanish external border effect during the period. Procedure: PPML. Data: region-to-region (intra-regional flows are excluded). Period: 2004-2011.

VARIABLES	M PPML T_{ijt}	$e^{(External\ Border)}$	M PPML T_{ijt}	$e^{(External\ Border)}$
ln(Yi *Yj)	0.747***		0.734***	
	(0.0264)		(0.0284)	
Ln($dist_{ij}$)	-1.067***			
	(0.0803)			
$dist_{ij}$			-3.212***	
			(0.221)	
$dist^2_{ij}$			0.771***	
			(0.0740)	
External_Border_2004	2.524***	12	2.193***	9
	(0.239)		(0.272)	
External_Border_2005	1.876***	7	1.602**	5
	(0.613)		(0.628)	
External_Border_2006	2.296***	10	1.998***	7
	(0.593)		(0.601)	
External_Border_2007	3.043***	21	2.932***	19
	(0.876)		(0.876)	
External_Border_2008	3.281***	27	2.964***	19
	(0.733)		(0.740)	
External_Border_2009	2.701***	15	2.383***	11
	(0.581)		(0.609)	
External_Border_2010	2.768***	16	2.450***	12
	(0.679)		(0.702)	
External_Border_2011	2.658***	14	2.389***	11
	(0.666)		(0.684)	
Internal_cong	0.123		0.273***	
	(0.0967)		(0.0929)	
External_cong	0.306		0.255	
	(0.220)		(0.205)	
Constant	-12.44***		-16.57***	
	(1.515)		(1.636)	
Observations	12,165		12,165	
R-squared	0.892		0.886	

Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1
All regressions include an "origin-region by year", "destination-region by year", "country destination" and "year" fixed effects.

Estimates in Table 6 are obtained using the following equations [8] and [9]:

$$T_{ijt}^{eu} = \beta_0 + \beta_1 ln(Y_{it} * Y_{jt}) + \beta_2 External\_Border + \beta_3 lndist_{ij} + \beta_4 Internal\_Contig +$$

$$+\beta_5 External\_Contig + \mu_i + \mu_j + \alpha_{ij} + \gamma_t + \varepsilon_{ij} \quad [8]$$

$$T_{ijt}^{eu} = \beta_0 + \beta_1 ln(Y_{it} * Y_{jt}) + \beta_2 External\_Border \quad + \beta_3 dist_{ij} +$$

$$\beta_4 dist_{ij}^2 + \beta_5 Internal\_Contig \quad + \beta_6 External\_Contig \quad + \mu_i + \mu_j + \alpha_{ij} + \gamma_t + \varepsilon_{ij} \qquad [9]$$