# Port Facilities, Regional Spillovers and Exports: Empirical Evidence from Spain


## Abstract

This paper analyses whether regions benefit from their neighbours' transport facilities. We focus on ports and we estimate a gravity model of trade that includes port facilities indicators as explanatory variables. The model is estimated by using exports from 19 Spanish regions to 45 countries from 2000 onwards. To test for the existence of regional spillovers, we construct a weight matrix that takes into account the relative importance of the neighbouring ports, as well as port efficiency in destination countries. The findings suggest that regional spillovers play a larger role than port facilities themselves for the growth of Spanish exports.



**Keywords:** port facilities; regional spillovers; gravity; spatial lags; panel.

**JEL Classification:** F14, H54, R10, R40


## 1. Introduction

Recently, the President of Catalonia pointed out:

*Catalonia is the Spanish region with less allocations of public infrastructure. It is the largest contributor and has less public investment, which we compensate with private investment* [...]

A few days later, the Minister of Transport said that Catalonia is the region where the Spanish Ministry of Transport has invested the most between 1996 and 2012.[1]

Without going into the details or the political context under which these claims are made, we argue that transport infrastructure investment in one Autonomous Region might impact on the facility with which activities may be reached from other Autonomous Regions (hereafter referred to as regions). Then, this paper empirically

[1] See "Rajoy lanza gestos con el AVE pero Mas recuerda los agravios a Cataluña", Elpais 8 January 2013 and "Cataluña lideró la inversión en infraestructuras de 1996 a 2012, según el Ministerio de Fomento", Elpais 15 January 2013.

analyses whether a region might benefit from its neighbours' transport facilities in terms of exports. To do so, we focus on a country characterised by an extensive network of roads, railways, rapid transit, air routes and ports, Spain. More interestingly, Spanish governance presents a decentralised nature, which is reflected in the transportation sector. In this line, the Spanish port system has moved away from state dependency and has allowed greater participation of regional governments (González-Laxe and Sánchez, 2007).

Among the infrastructure necessary to facilitate trade, the efficiency of ports has received specific attention (Sánchez et al 2003; Clark et al 2004). At national level, some indicators are available (from the World Bank or the World Economic Forum) that could be used as proxies for quality factors or port efficiency, namely time taken to handle freight, punctuality, customs clearance times, quality and ease of paperwork, etc. Unfortunately, similar indicators are not available for Spanish regions. Then, due to the lack of data at regional level we have to rely on comparable information provided by facilities. In particular, we use an *output* measure of port efficiency, thus being the percentage of sea traffic over total sea traffic in Spain which measures the relative importance of port facilities by region.

With regards Spain, Nuñez-Sánchez and Coto-Millám (2010) calculate an index of technical efficiency for Spanish ports and prove that despite this index averaging 78.6% for the port system as a whole (for the period 1986-2005), there are considerable differences between ports, those in Valencia, Tenerife and Algeciras being the most efficient. Using a GIS methodology, Gutiérrez et al (2010) find that the spatial distribution of spillover effects is found to be significantly affected by a series of geographical factors. For example, these authors find that the greatest economic potential gains of the construction of a motorway in Castile-La Mancha (see Map A.1 in

Appendix) correspond to Castile-La Mancha itself, as well as neighbouring regions: Murcia, Valencia, Extremadura and Andalusia. More recently, Márquez-Ramos et al (2011) focus on the effect of maritime networks, services structure and port infrastructure variables on maritime freight rates and they also analyse the relationship between freight rates and trade. In their section of policy implications, these authors point out that "although concentrating investments in a few ports and promoting their role as import/export gateways may be difficult from a political point of view in large countries with many kilometres of coast, as it is the case in Spain, investing in several small or medium sized ports all aiming at the same container segment of the market may not be a strategy that leads to increasing the competitiveness of the country's exports" (page 573).

In order to test the relevance of the abovementioned policy implication on port investment planning, regional spillovers should be taken into account. Then, we analyse whether Spanish regions benefit of neighbouring those regions with most efficient port facilities. To do so, we estimate a spatial auto-regressive version of a gravity model of trade that includes port facilities indicators as explanatory variables, as well as in the weight matrix. Specifically, the weight matrix is constructed by taking into account the relative importance of port facilities in regions neighbouring to the origin, as well as port efficiency in destination countries. The model is estimated by using bilateral exports over the period 2000-2008 from 19 Spanish regions to 45 countries.[2]

[2] Regions: Andalusia, Aragon, Asturias, Balearic Islands, Basque Country, Canary Islands, Cantabria, Castile-La Mancha, Castile and Leon, Catalonia, Ceuta, Extremadura, Galicia, La Rioja, Madrid, Melilla, Murcia, Navarra, Valencia.
Countries: Algeria, Argentina, Australia, Austria, Bangladesh, Belgium, Brazil, Canada, Chile, China, Colombia, Czech Republic, Denmark, Egypt, Finland, France, Germany, Greece, Hong Kong, India, Indonesia, Ireland, Italy, Japan, Jordan, Lebanon, Malaysia, Morocco, Mexico, Netherlands, New Zealand, Pakistan, Poland, Portugal, Singapore, South Africa, South Korea, Sweden, Thailand, Tunisia, Turkey, United Kingdom, United States, Venezuela, Vietnam.

The rest of the paper is organised as follows. Section two outlines the methodology. In the third section we specify the spatial approach for trade flows from Spanish regions. The fourth section details the results obtained and, finally, the last section presents the conclusions of this research.

## 2. Methodology

In order to address the relative impact of port facilities on trade, an augmented gravity equation is estimated. According to the gravity model of trade (Tinbergen, 1962; Linnemann, 1966; Anderson, 1979; Bergstrand, 1985 and 1989; Deardorff, 1995), the volume of aggregate exports between pairs of regions and/or countries, $X_{ij}$, depends on their income (Y), geographical distances (D) and a series of dichotomic variables (A), as indicated in equation 1:

$$X_{ij} = \gamma_0 Y_i^{\gamma_1} Y_j^{\gamma_2} D_{ij}^{\gamma_3} A_{ij}^{\gamma_4} u_{ij} \tag{1}$$

where $Y_i$ ($Y_j$) indicates Gross Domestic Product (GDP) of the exporter (importer), $D_{ij}$ measures the distance between capital cities or the economic centres of the two regions (countries), $A_{ij}$ represents any other factor that boosts or constrains trade between the pairs of regions (countries) and $u_{ij}$ is a random disturbance.

Trade is expected to be positively related to income and negatively related to distance. As equation 1 is not linear in parameters, most of the estimates of the gravity model are based on a log-linear transformation of different versions of equation 1. The linear version will be given by the following expression:

$$\ln X_{ij} = \gamma_0 + \gamma_1 \ln Y_i + \gamma_2 \ln Y_j + \gamma_3 \ln D_{ij} + \sum_k \delta_k A_{ij} + \varepsilon_{ij} \tag{2}$$

where ln denotes variables in natural logarithms and $\sum_k \delta_k A_{ij}$ represents variables that facilitate or hinder trade and are specified as dichotomic. Gravity models normally include dichotomic variables such as whether or not the trading partners share the same language or have a common border, as well as variables for free trade agreements in order to assess the effects of regional integration. That is, $A_{ij}$ takes a value of one when a given condition is fulfilled (for example, speaking the same language or belonging to the same free trade agreement) and zero otherwise. The coefficients of these variables that affect international trade ($\delta_k$) are expected to be positive. Population variables (or income per capita) are usually added to the list of explanatory variables to capture either an absorption effect (through an inverse relationship: the greater the population or income per capita, the lesser the flow of international trade) or the effect produced by economies of scale (through a direct relationship: the greater the population or income per capita, the greater the flow of international trade). Distance is also included in most empirical studies that employ gravity equations as a proxy for transport costs.

As regards the specification used by the authors, one of the variables that should be included as a control is that which measures how remote or far away regions (countries) i and j are from the rest of the world (*remoteness*) to control for so-called multilateral trade resistance (Anderson and Van Wincoop, 2003). Anderson and van Wincoop (2003) argue that dealing with the interaction structure across regions is important when estimating a gravity equation. They show that the proper inclusion of multilateral resistance terms, i.e., terms which capture the fact that bilateral trade flows do not only depend on bilateral trade barriers, but also on trade barriers across all trading partners, is crucial for the results obtained. There are several ways of capturing multilateral resistance. While Bergstrand (1985 and 1989) suggested the use of price indices, Anderson and Van Wincoop (2003) endogenously estimate multilateral resistance and Carrère (2006) uses remoteness variables as a proxy for it. Feenstra opted instead for using fixed effects at origin and destination. Although the fourth method is the simplest and yields consistent estimators (Feenstra, 2002), using it would entail discarding the port facilities variables from our regression and they are the main interest of this paper. For this reason, in keeping with the literature, we take account of this remoteness factor in our gravity analysis by means of incorporating proxy variables, in line with Carrère (2006).

In the case of trade between countries, nations can be expected to trade more intensely if they are far from alternative markets (for example, Australia and New Zealand). There are several versions of this variable in the literature (Wei, 1996; Wolf, 2000; Nitsch, 2000). In this paper, following Coca-Castaño et al (2005) and bearing in mind that we are analysing the exports of Spanish regions, the degree of remoteness of region i is the weighted average of the distances between region i and all its trading partners, using the share that each trading partner's income represents in regard to total income as a weighting device. That is, for a given origin-destination pair i and j, the degree of remoteness of region i is defined as:

$$\mathrm{Re}\,m_i = \sum_j \left( \frac{Y_j}{Y^w} \right) Dist_{ij} \quad (3a)$$

where $Y^w$ is the sum of the income of the importing countries of region *i* considered in this study. Similarly, the variable remoteness is also calculated for the importer:

$$\mathrm{Re}\,m_j = \sum_i \left( \frac{Y_i}{Y^w} \right) Dist_{ij} \quad (3b)$$

The highest values of the variable exporter remoteness ($Rem_i$) are recorded by the Canary Islands, Melilla, Ceuta and Murcia, while the highest values of this variable for importers ($Rem_j$) were registered by New Zealand and Australia.

According to trade theory and the gravity equation, remoteness should a priori display a positive sign, indicating that the more remote a country or region is, the greater its bilateral trade, as alternative partners are a long way away (Wei, 1996; Nitsch, 2000).

However, negative estimators are often obtained (Wolf, 2000; Nitsch, 2000). Furthermore, it is worth highlighting that the gravity equation estimated in this study is not conventional, as trade does not exist between all origins and destinations, so the expected sign of the variable $Rem_i$ ($Rem_j$) is ambiguous. On the one hand, it may display a positive sign if a Spanish region located far from the main economic hubs tends to trade more with the closest countries, or, on the other hand, it might be negative if the Spanish regions that are located furthest from the most important economic centres trade less with the nearest countries. For example, the Canary Islands and Murcia are relatively far from the main economic hubs in Europe, so freight could be exported directly from their ports to international destinations that are even further afield.

Considering a theoretical model that relates bilateral trade to income and using indicators for port facilities as a means of reducing trade costs, we obtain an augmented gravity equation that relates international trade to income, distance, port facilities and dichotomic variables:

$$\begin{aligned} \ln X_{ij} &= \alpha_0 + \alpha_1 \ln Y_{ij} + \alpha_2 \ln Yh_i + \alpha_3 \ln Yh_j + \alpha_4 \ln D_{ij} + \alpha_5 Lang_{ij} + \alpha_6 BP_{ij} + \alpha_7 BF_{ij} + \\ &+ \alpha_8 Coast_i + \alpha_9 FTA_{ij} + \alpha_{10} \ln rem_i + \alpha_{11} \ln rem_j + \alpha_{12} port_i + \alpha_{13} port_j + \upsilon_{ij} \end{aligned} \quad (4)$$

where $lnX_{ij}$ denotes exports from a Spanish region $i$ to an importing country $j$; $lnY_{ij}$ is the logarithm of the product of GDP for exporter $i$ and importer $j$;[3] $Yh_i$ ($Yh_j$) is GDP per capita in the exporting region (importing country); $rem_i$ ($rem_j$) is the variable exporter (importer) remoteness based on equation 3a (3b). $Lang_{ij}$, $BP_{ij}$, $BF_{ij}$, $Coast_i$ and $FTA_{ij}$ are dichotomic variables that take a value of one when the same language is spoken in i and

[3] Note that the size of the market as a whole is used. Researchers normally use the economic size of the exporter and importer separately in gravity equations. However, in this case exports are analysed from Spanish regions to 45 importing countries. A more flexible version of equation 4, where the income coefficients are specific for origin and destination, has also been estimated. The results are available to readers upon request.

j, when they share a common border with Portugal (BP) or France (BF), when i is a coastal region ($Coast_i$) or they have signed a Free Trade Agreement ($FTA_{ij}$).

This study also includes port facilities variables ($port_i$ and $port_j$). First, by using information about sea traffic from the Annual Accounts of the 28 Spanish Port Authorities, we construct an indicator (% of sea traffic over total sea traffic in Spain) that measures the relative importance of port facilities in the 19 Spanish regions over the period 2000-2008 (see Tables A.1 and A.2 in the Appendix). It is important to note that a number of ports concentrate the main flows of merchandise traffic in Spain. In particular, the most important ports in terms of sea traffic (tonnes) are Bahía de Algeciras (in Andalusia), Valencia (in the Valencia Region), Barcelona (in Catalonia) and Bilbao (in the Basque Country). Second, we use a variable based on the Global Competitiveness Report of the World Economic Forum to measure the quality of the destination port infrastructure. The data and variables used in this research come from different statistical sources, which are listed in the Appendix (Table A.3). Table A.4 presents the average and dispersion of the variables used in the empirical analysis in 2008.

## 3. Incorporating spatial dependence

In the first place, the equations are estimated using Ordinary Least Squares (OLS) and standard deviations robust to heteroskedasticity for equation 4. Second, due to the fact trade flows could be affected by spatial dependence, we estimate a spatial auto-regressive version of equation 4.

Map A.2 in the Appendix presents an example to illustrate the accuracy difference regarding the existence of facilities in neighbouring regions for export flows between both the traditional gravity model and the spatial approach. In Map A.2, the regions containing the highest number of facilities are dark red.[4] This example illustrates a case where a clear differentiation can be made between regions in terms of number of facilities. This should provide a good test of whether explicitly incorporating such prior information into the spatial structure of the model results in substantial differences in the estimates and inferences. In the example, Castile-La Mancha has seven neighbours (Andalusia, Aragon, Castile-Leon, Extremadura, Madrid, Murcia and Valencia) and, whereas in the traditional model only the three coastal regions will have positive values for the explanatory variable $port_i$ (see Table A.2), in the spatial approach the imposed filter weights the seven neighbouring regions with their relative importance of port facilities. This exercise results in two regions being allocated the highest weightings (Castile-La Mancha and Murcia). Nonetheless, one of them (Murcia) shows a real scarcity in the number of facilities devoted to transport activities.

LeSage and Polasek (2008) already introduced transport facilities into a spatial econometric model of commodity flows in the case of Austria, modifying the spatial weight matrix by considering the geographical criteria together with transport network structure. In this research, the authors considered the transportation routes that pass through these regions and they focused on interregional flows. Otherwise, we pay special attention to the role of port facilities on international trade flows. In this sense, ports connect interregional-international trade flows.

To test for the existence of regional spillovers, we construct a spatial matrix considering three criteria: geographical contiguity, relative importance of port facilities in origin regions, and port efficiency in destination countries. In particular, the weight matrix takes into account the relative importance of port facilities in (first-order) neighbours to

[4] The total number of facilities in Spain by region, including road, rail, port, airport and intermodal freight logistics nodes, is obtained from Suárez-Burguet et al (2012).

the origin, as well as the quality of ports in destination countries. First, we calculate an origin-destination matrix where rows identify origin regions and columns destination countries. Second, we use information in Table A.2 and we construct a matrix A that measures the relative importance of port facilities in neighbours to the origin, this matrix A varies by row. Third, we use information provided by the World Economic Forum and we construct a matrix B that measures port efficiency in destination countries, this matrix B varies by column.[5] Fourth, scores of every matrix are derived as an index relative to the maximum and minimum achieved by both origin regions and destination countries. Therefore, elements of matrixes A and B take a value between 0 and 1 calculated according to equation (5):

$$Port\ facilities = \frac{(actual\,value - observed\,\min value)}{(observed\max\ value - observed\min value)} \qquad (5)$$

If region i neighbours regions with a high relative importance of port facilities in Spain, the element in matrix A is near 1; in addition, if country j presents a high quality of port infrastructure, the element in matrix B is near 1. Fifth, Matrix W is constructed with the sum of A and B, and finally, by stacking a row-standardized spatial weight matrix W and multiplying it by the dependent variable we can estimate the spatial lag vector ρ, which captures the magnitude of port facilities in neighbouring regions addressed to different destinations on the dependent variable. Finally, in order to take into account the direction of the causality in our regressions (i.e. if the facilities in neighbouring regions are more efficient and regions exported intensively in previous years, then trade increases), the effect of the interaction of the lagged dependent variable and the weight matrix on trade volumes is analysed. In this way, we will be able to isolate the effect of the interaction of lagged bilateral exports (in year t-1 = for example, 2007) and

[5] As we only have data for 2007 and 2008, from 2000 to 2006 information provided by WEF's Executive Opinion Survey in 2007 is used.

neighbours' port facilities on trade (in t = for example, 2008). We run cross-section regressions and we use panel techniques to control for unobserved heterogeneity. The estimated equation is:

$$\begin{aligned}\ln X_{ijt} &= \beta_0 + \beta_1 \ln Y_{ijt} + \beta_2 \ln Yh_{it} + \beta_3 \ln Yh_{jt} + \beta_4 \ln D_{ij} + \beta_5 Lang_{ij} + \beta_6 BP_{ij} + \beta_7 BF_{ij} + \\ &+ \beta_8 Coast_i + \beta_9 FTA_{ijt} + \beta_{10} \ln rem_{it} + \beta_{11} \ln rem_{jt} + \beta_{12} port_{it} + \beta_{13} port_{jt} + \rho(W) \ln X_{ijt-1} + v_{ijt}\end{aligned} \quad (6)$$

## 4. Estimation results

### 4.1. Traditional approach

Table 1 presents the results from estimating equation 4 by OLS. The different columns show the obtained results for cross-section regressions from 2000 to 2008. We can see that the model estimated displays a high level of goodness-of-fit. According to the determination coefficient ($R^2$), the augmented gravity model explains approximately 74.8% of the variability in exports from Spanish regions in 2008.

Table 1 shows that income and income per capita in the exporting region present a positive and significant influence on trade in 2008, while income per capita in the destination country is only significant when analysing the determinants of exports from Spanish regions in previous years. The "economic mass" of trading partners has a coefficient approaching one, as theory predicts (Bergstrand, 1985). In addition, the effect produced by economies of scale predominates, as the greater the income per capita, the greater the flow of international trade. The coefficient of distance displays the expected sign (negative), but is not statistically significant.[6]

Two of the additional dichotomic variables that are included as extra factors that facilitate trade (sharing a border with Portugal, BP, and with France, BF) are significant, although the variable *border with Portugal* is found to be negative. In fact, according to

[6] When a baseline gravity model is estimated, which includes only income, income per capita and distance, the coefficient of distance is negative signed, higher in magnitude (in absolute terms), and significant. The results are available to readers upon request.

the results of equation 4, Spanish regions export 56% more to France {(exp[0,446] - 1)*100} than to other destinations in 2008. Spain also trades more with countries where Spanish is the official language. The coefficient of the dichotomic variable *coastal region* indicates that such regions export less than landlocked regions, this result might be partially explained by the effect of Madrid. The results obtained also show that the variable *Free Trade Agreement* (or FTA) is only significant in 2000 and 2004. Finally, the variable *remoteness* is significant and displays a negative sign, both in the case of exporters and importers, such that the Spanish regions furthest from the most important economic hubs trade less with the closest countries. The variable *exporter remoteness* registers a higher value than *importer remoteness* in absolute terms, as the various Spanish regions have only been considered as exporters and, therefore, the trading partners that trade with importing countries.

This analysis aims to obtain unbiased estimates of the port facilities variables. The model includes the standardised values of port facilities variables to be able to compare their relative importance in origin and destination. These variables have, *ceteris paribus*, a positive effect on international trade and when they are included in the regression, the variable distance is no longer significant.

Table 1. Results of the estimation. Augmented gravity equation

| | tr2000 | tr2001 | tr2002 | tr2003 | tr2004 | tr2005 | tr2006 | tr2007 | tr2008 |
|---|---|---|---|---|---|---|---|---|---|
| Ln Total income | 0.940*** | 0.911*** | 0.952*** | 1.010*** | 0.951*** | 1.021*** | 1.005*** | 0.963*** | 0.920*** |
| | 27.916 | 26.485 | 27.762 | 23.47 | 28.939 | 24.2 | 24.482 | 23.595 | 26.691 |
| Ln Regional per capita income | 0.283 | 0.419 | 0.448 | 0.279 | -0.011 | -0.269 | -0.096 | -0.173 | 0.876** |
| | 0.79 | 1.289 | 1.176 | 0.758 | -0.032 | -0.728 | -0.273 | -0.467 | 2.176 |
| Ln Destination per capita income | 0.191*** | 0.165*** | 0.156*** | 0.065 | 0.044 | 0.093 | 0.175*** | 0.155** | 0.025 |
| | 3.49 | 3.068 | 2.812 | 1.116 | 0.934 | 1.643 | 2.756 | 2.021 | 0.393 |
| Ln Distance | -0.113 | -0.119 | -0.249 | -0.361 | -0.388 | -0.382 | -0.005 | -0.433 | -0.089 |
| | -0.387 | -0.415 | -0.745 | -0.992 | -1.182 | -1.108 | -0.015 | -1.295 | -0.242 |
| Common language | 1.209*** | 1.093*** | 1.158*** | 1.412*** | 1.101*** | 1.119*** | 1.120*** | 1.022*** | 0.904*** |
| | 7.666 | 6.881 | 6.92 | 8.581 | 7.401 | 7.645 | 7.636 | 6.133 | 5.94 |
| Border with Portugal | -0.402** | -0.422** | -0.325* | -0.437*** | -0.315** | -0.364** | -0.252* | -0.218 | -0.069 |
| | -2.411 | -2.529 | -1.853 | -2.647 | -2.185 | -2.369 | -1.682 | -1.513 | -0.509 |
| Border with France | 0.566*** | 0.438*** | 0.479*** | 0.285** | 0.440*** | 0.424*** | 0.522*** | 0.611*** | 0.446*** |
| | 4.512 | 3.635 | 3.826 | 2.205 | 3.63 | 3.428 | 4.341 | 4.305 | 3.624 |
| Coastal region | -0.328** | -0.517*** | -0.423*** | -0.731*** | -0.366** | -0.270* | -0.324* | -0.315 | -0.463*** |
| | -2.04 | -3.37 | -2.615 | -3.972 | -2.299 | -1.659 | -1.739 | -1.56 | -2.962 |
| Free Trade Agreement | 0.302** | 0.235 | 0.077 | 0.14 | 0.275* | 0.08 | -0.019 | -0.032 | -0.068 |
| | 1.973 | 1.526 | 0.506 | 0.766 | 1.69 | 0.478 | -0.107 | -0.183 | -0.366 |
| Exporter remoteness | -25.785*** | -25.939*** | -25.060*** | -32.066*** | -26.012*** | -28.995*** | -27.575*** | -24.293*** | -23.093*** |
| | -10.946 | -11.666 | -11.183 | -13.382 | -10.158 | -10.768 | -11.928 | -10.746 | -10.708 |
| Importer remoteness | -1.148*** | -1.128*** | -0.998*** | -0.948** | -0.817** | -0.868** | -1.350*** | -0.833** | -1.188*** |
| | -3.796 | -3.935 | -2.915 | -2.519 | -2.453 | -2.441 | -4.197 | -2.377 | -3.24 |
| Regional port facilities | 0.451*** | 0.500*** | 0.462*** | 0.620*** | 0.483*** | 0.413*** | 0.445*** | 0.444*** | 0.504*** |
| | 5.612 | 6.412 | 5.812 | 6.525 | 5.978 | 5.489 | 4.811 | 4.549 | 6.626 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Destination port facilities | | | | | | | | 0.049 | 0.172** |
| | | | | | | | | 0.558 | 2.035 |
| Constant term | 194.341*** | 197.876*** | 190.597*** | 251.142*** | 199.644*** | 221.578*** | 201.901*** | 182.186*** | 172.268*** |
| | 9.76 | 10.847 | 10.447 | 12.462 | 9.644 | 10.363 | 10.968 | 9.805 | 10.339 |
| Observations | 766 | 774 | 774 | 780 | 767 | 767 | 772 | 773 | 776 |
| R2 | 0.7556533 | 0.759763 | 0.7419709 | 0.7414907 | 0.7524617 | 0.7479013 | 0.7462654 | 0.6950712 | 0.7485961 |

Notes: ***, **, *, indicate significance at the 1%, 5% and 10% levels, respectively. T-statistics are displayed below each coefficient. The dependent variable is exports in value (in logs).

### 4.2. Spatial approach

Columns 1-8 in Table 2 present the results from estimating equation 6 by OLS. The different columns show the obtained results for cross-section regressions from 2000 to 2008. We can see that the model estimated displays a higher level of goodness-of-fit than equation 4. For example, equation 6 explains approximately 88.1% of the variability in exports from Spanish regions in 2008. The results show that income, common language, border with France and port facilities in origin present a positive and significant influence on trade in 2008, while coastal dummy, remoteness and destination port facilities are negative and significant. The most important difference with respect to Table 1 is that the variable "destination port facilities" is negative and significant when spatial dependence is taken into account, whereas it was positive in Table 1. Furthermore, the results obtained show that the additional explanatory variable $(W)\ln X_{ijt-1}$ presents a positive sign and it is significant. Therefore, our findings support that both exporters' port facilities themselves and those located in neighbouring regions are indeed important for the analysis of international trade flows.

Finally, obtained results point towards the idea that spatial dependence across Spanish regions has increased from 2000 onwards, as $\rho$ increases in magnitude over the period considered. To assess this possibility, equation 6 is estimated by using panel techniques. To estimate a panel, special estimation techniques are required. The presence of unobserved heterogeneity could be modelled as being random or fixed. A Hausman test indicates that fixed effects are preferred and we therefore rely on fixed effects estimates. Column 9 in Table 2 shows the estimation results. According to these results, income and income per capita are not significant; exporter remoteness and destination port facilities present a positive sign and are significant, while exporter's port facilities are negative and significant. Overall, the findings suggest that regional spillovers seem to play a larger role than port facilities themselves for the growth of Spanish exports.[7]

One could argue that as we are considering total exports, the effect of the dependence on port facilities of the neighbours is not isolated. For example, in the case of trade between Catalonia and France, which is the highest export flow in the sample (see Table A.4), road is a very important mode of transport. Therefore, panel regressions are also performed using maritime exports as the dependent variable. Column 10 in Table 2 shows the obtained results, which confirm the importance of regional spillovers for international trade.

[7] This result is also obtained when year dummies are included in equation 6 and when random effects estimates are obtained. The results are available to readers upon request.

Table 2. Results of the estimation. Spatial approach

| | sp2001 | sp2002 | sp2003 | sp2004 | sp2005 | sp2006 | sp2007 | sp2008 | panel_lxij | panel_lxij_mar |
|---|---|---|---|---|---|---|---|---|---|---|
| Ln Total income | 0.787*** | 0.821*** | 0.827*** | 0.828*** | 0.890*** | 0.861*** | 0.713*** | 0.375*** | 0.263 | 0.378 |
| | 23.861 | 24.711 | 25.818 | 25.484 | 25.206 | 27.338 | 16.059 | 9.149 | 1.029 | 1.058 |
| Ln Regional per capita income | 0.214 | 0.206 | -0.076 | -0.055 | -0.283 | -0.139 | -0.417 | 0.126 | -0.078 | -0.468 |
| | 0.699 | 0.616 | -0.215 | -0.164 | -0.78 | -0.408 | -1.139 | 0.412 | -0.239 | -1.024 |
| Ln Destination per capita income | -0.064 | -0.116** | -0.143** | -0.194*** | -0.162** | -0.149** | 0.04 | 0.029 | 0.411 | 0.179 |
| | -1.058 | -2.046 | -2.466 | -3.507 | -2.502 | -1.99 | 0.593 | 0.59 | 1.473 | 0.459 |
| Ln Distance | -0.083 | -0.215 | -0.365 | -0.222 | -0.231 | 0.033 | -0.044 | 0.325 | . | . |
| | -0.325 | -0.771 | -1.197 | -0.779 | -0.76 | 0.126 | -0.167 | 1.211 | . | . |
| Common language | 1.275*** | 1.204*** | 1.383*** | 1.241*** | 1.294*** | 1.253*** | 0.980*** | 0.368*** | . | . |
| | 8.377 | 7.75 | 9.515 | 8.832 | 9.188 | 8.836 | 6.24 | 2.803 | . | . |
| Border with Portugal | -0.380** | -0.294* | -0.356** | -0.260* | -0.323** | -0.192 | -0.216* | -0.135 | . | . |
| | -2.452 | -1.909 | -2.335 | -1.939 | -2.233 | -1.421 | -1.682 | -1.432 | . | . |
| Border with France | 0.438*** | 0.479*** | 0.415*** | 0.442*** | 0.415*** | 0.519*** | 0.558*** | 0.274*** | . | . |
| | 3.737 | 4.008 | 3.432 | 3.746 | 3.336 | 4.623 | 3.794 | 2.881 | . | . |
| Coastal region | -0.323** | -0.247* | -0.320** | -0.151 | -0.171 | -0.061 | -0.137 | -0.225** | . | . |
| | -2.296 | -1.741 | -2.265 | -1.103 | -1.138 | -0.454 | -0.814 | -2.322 | . | . |
| Free Trade Agreement | 0.339** | 0.373*** | 0.368** | 0.492*** | 0.259 | 0.298** | 0.141 | -0.06 | . | . |
| | 2.403 | 2.701 | 2.377 | 3.285 | 1.628 | 1.971 | 0.89 | -0.515 | . | . |
| Exporter remoteness | -21.181*** | -21.032*** | -24.316*** | -21.870*** | -23.679*** | -21.554*** | -17.581*** | -11.061*** | 2.337*** | 1.169 |
| | -9.801 | -9.586 | -11.554 | -9.343 | -10.117 | -11.596 | -9.806 | -6.096 | 3.177 | 1.151 |
| Importer remoteness | -0.998*** | -0.872*** | -0.711** | -0.860*** | -0.847*** | -1.147*** | -0.840*** | -0.890*** | 0.512 | 0.598 |
| | -3.907 | -3.011 | -2.247 | -2.971 | -2.74 | -4.331 | -3.13 | -3.339 | 1.315 | 1.115 |
| Regional port facilities | 0.374*** | 0.337*** | 0.394*** | 0.350*** | 0.337*** | 0.274*** | 0.259*** | 0.203*** | -0.860*** | -0.857*** |
| | 5.493 | 4.738 | 5.729 | 5.189 | 4.966 | 4.427 | 3.499 | 4.671 | -5.955 | -4.373 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Destination port facilities | | | | | | | -1.253*** | -1.639*** | 0.050*** | 0.051*** |
| | | | | | | | -6.124 | -11.056 | 4.047 | 3.005 |
| $(W)\ln X_{ijt-1}$ | **4.916*** ** | **4.491*** ** | **5.082*** ** | **4.778*** ** | **5.155*** ** | **5.307*** ** | **11.966*** ** | **24.744*** ** | **4.483*** ** | **7.177*** ** |
| | **8.552** | **7.427** | **7.778** | **7.637** | **7.07** | **6.663** | **7.598** | **16.959** | **11.972** | **15.414** |
| Constant term | 160.940*** | 160.734*** | 190.554*** | 166.545*** | 179.359*** | 157.003*** | 128.593*** | 80.388*** | -20.851* | -14.837 |
| | 9.23 | 8.993 | 10.773 | 8.894 | 9.638 | 10.633 | 9.364 | 6.168 | -1.817 | -0.928 |
| Observations | 756 | 761 | 761 | 761 | 760 | 762 | 767 | 767 | 6095 | 5803 |
| R2 | 0.7779653 | 0.774544 | 0.781206 | 0.7891537 | 0.7682601 | 0.804509 | 0.7683049 | 0.8816736 | . | . |
| R2_within | . | . | . | . | . | . | . | . | 0.1807721 | 0.1078403 |

Notes: ***, **, *, indicate significance at the 1%, 5% and 10% levels, respectively. T-statistics are displayed below each coefficient. The dependent variable is exports in value (in logs).

## 5. Conclusions

The latest developments in transport infrastructure are decisive when it comes to fostering trade and, therefore, the competitiveness of national products on international markets. This paper analyses the effect of transport facilities on trade flows in Spain. With this purpose in mind, we estimate an augmented gravity model from both a traditional and a spatial approach. The main results not only confirm the importance of the port facilities themselves but also those located in neighbouring regions when compared to other variables that are traditionally considered in standard trade models. In addition, the findings suggest that regional spillovers seem to play a larger role than port facilities themselves for the growth of Spanish exports

This research has important policy implications in a country characterised by an extensive network of roads, railways, rapid transit, air routes and ports, and for which governance presents a decentralised nature that is reflected in the transportation sector. By focusing in the Spanish port system, this research concludes that regional indirect effects should be taken into account in planning the port investment. For example, the selected measure of relative importance of port facilities over the period 2000-2008 has increased the most in Valencia (a 41.94 per cent). According to the obtained results, neighbouring regions (Aragon, Catalonia, Castile-La Mancha and Murcia) benefit from this improvement. Therefore, concentrating investments in ports more efficient and enhance their role as gateways can be a strategy today to consider in the European context of austerity.

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**Appendix**

Map A.1. Regions in Spain


Map A.2. Traditional model versus spatial approach

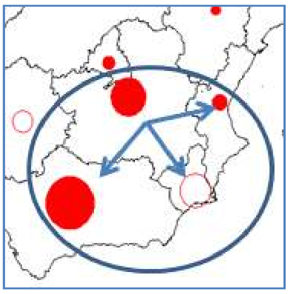

Table A.1. Spanish Sea Ports

| Sea Ports | Province (NUTS3) | Autonomous Region (NUTS2) |
|---|---|---|
| A Coruña | La Coruña | Galicia |
| Alicante | Alicante | Valencia |
| Almería | Almería | Andalusia |
| Avilés | Asturias | Asturias |
| Bahía de Algeciras | Cádiz | Andalusia |
| Bahía de Cádiz | Cádiz | Andalusia |
| Baleares | Palma de Mallorca | Balearic Islands |
| Barcelona | Barcelona | Catalonia |
| Bilbao | Vizcaya | Basque Country |
| Cartagena | Murcia | Murcia |
| Castellón | Castellón | Valencia |
| Ceuta | Ceuta | Ceuta |
| Ferrol-San Cibrao | La Coruña | Galicia |
| Gijón | Asturias | Asturias |
| Huelva | Huelva | Andalusia |
| Las Palmas | Las Palmas | Canary Islands |
| Málaga | Málaga | Andalusia |
| Marín y Ría de Pontevedra | Pontevedra | Galicia |
| Melilla | Melilla | Melilla |
| Motril | Granada | Andalusia |
| Pasajes | Guipúzcoa | Basque Country |
| Santa Cruz de Tenerife | Santa Cruz de Tenerife | Canary Islands |
| Santander | Cantabria | Cantabria |
| Sevilla | Sevilla | Andalusia |
| Tarragona | Tarragona | Catalonia |
| Valencia | Valencia | Valencia |
| Vigo | Pontevedra | Galicia |
| Vilagarcía | Pontevedra | Galicia |

Table A.2. Relative importance of port facilities by region (% of sea traffic over total sea traffic in Spain)

| Year | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | % increase |
|---|---|---|---|---|---|---|---|---|---|---|
| Valencia | 11.33 | 12.10 | 12.68 | 12.81 | 12.81 | 13.22 | 13.97 | 14.57 | 16.07 | 41.94 |
| Murcia | 5.13 | 5.83 | 6.03 | 5.60 | 5.69 | 6.12 | 5.55 | 4.98 | 5.44 | 6.03 |
| Catalonia | 17.06 | 16.80 | 17.12 | 16.98 | 17.28 | 17.33 | 17.13 | 18.12 | 17.93 | 5.12 |
| Andalusia | 25.18 | 26.15 | 25.34 | 26.13 | 25.75 | 25.61 | 26.02 | 25.80 | 24.94 | -0.94 |
| Canary Islands | 9.80 | 10.05 | 9.79 | 10.34 | 10.31 | 10.16 | 9.91 | 9.64 | 9.32 | -4.92 |
| Basque Country | 9.84 | 9.10 | 8.64 | 8.96 | 9.49 | 8.98 | 9.54 | 9.33 | 9.32 | -5.28 |
| Balearic Islands | 3.12 | 3.12 | 3.08 | 3.11 | 2.92 | 3.02 | 3.15 | 3.03 | 2.84 | -9.04 |
| Galicia | 7.92 | 7.55 | 7.77 | 7.66 | 7.50 | 7.30 | 7.00 | 7.06 | 7.09 | -10.47 |
| Cantabria | 1.58 | 1.48 | 1.50 | 1.43 | 1.46 | 1.52 | 1.28 | 1.30 | 1.16 | -26.47 |
| Asturias | 7.07 | 6.58 | 6.74 | 6.30 | 6.13 | 6.09 | 5.73 | 5.46 | 5.12 | -27.58 |
| Ceuta | 0.86 | 0.69 | 0.66 | 0.49 | 0.48 | 0.46 | 0.53 | 0.55 | 0.60 | -30.45 |
| Melilla | 1.11 | 0.55 | 0.66 | 0.20 | 0.18 | 0.19 | 0.18 | 0.17 | 0.16 | -85.39 |

Source: Annual Accounts from Port Authorities (2000-2008)

Table A.3. Variables and data sources used

| Variable | Description | Source |
|---|---|---|
| Exports | Bilateral exports in thousands of euro | Datacomex |
| Regional income | Nominal income of Spanish Autonomous Regions (in millions of euro) | Eurostat (2012), http://epp.eurostat.ec.europa.eu/portal/page/portal/eurostat/home/ |
| Regional population | Number of inhabitants | Eurostat (2012), http://epp.eurostat.ec.europa.eu/portal/page/portal/eurostat/home/ |
| Country income | GDP (current US$) | The World Development Indicators (World Bank) |
| Country population | Population, total | The World Development Indicators (World Bank) |
| Distance | Distance between regional capitals (km) | http://www.indo.com/distance/ |
| Common border | Dichotomic variable that takes a value of 1 when the origin region neighbours France (BF) or Portugal (BP) | Own elaboration |
| Common language | Dichotomic variable that takes a value of 1 when the destination country speaks Spanish | Own elaboration |
| Coastal region | Dichotomic variable that takes a value of 1 when the origin region is on the coast | Own elaboration |
| Free trade agreement | Dichotomic variable that takes a value of 1 when Spain and the destination country belong to the same trade agreement | Own elaboration |
| Regional port facilities | Standardised values of the relative importance of port facilities (by region) | Annual Accounts from Port Authorities (2000-2008). See http://www.puertos.es/ |
| Destination port facilities | Standardised values of quality of port infrastructure (1=extremely underdeveloped to 7=well developed and efficient by international standards) | WEF- World Economic Forum's Executive Opinion Survey (2007 and 2008) |

Table A.4. Descriptive statistics in 2008

| Variable | Obs | Mean | Std. Dev. | Min | Max |
|---|---|---|---|---|---|
| lxij | 776 | 9.962631 | 2.600192 | -2.481114 | 16.11 (Catalonia-France) |
| lxij_maritime | 742 | 8.867702 | 2.495754 | -3.816713 | 15.31 (Galicia-France) |
| lyij | 855 | 37.07548 | 1.913308 | 31.02228 (Melilla-Jordan) | 42.49604 (Catalonia-United States) |
| lyhi | 855 | -3.765792 | 0.178516 | -4.114046 (Extremadura) | -3.467954 (Madrid) |
| lyhj | 855 | 9.43793 | 1.311853 | 6.304114 (Bangladesh) | 11.04452 (Denmark) |
| ldist | 855 | 8.347339 | 0.9704664 | 5.495445 (Extremadura-Portugal) | 9.897844 (Castile and Leon-New Zealand) |
| lang | 855 | 0.0888889 | 0.2847499 | 0 | 1 |
| bport | 855 | 0.2105263 | 0.4079211 | 0 | 1 |
| bfrance | 855 | 0.2105263 | 0.4079211 | 0 | 1 |
| coast | 855 | 0.6315789 | 0.4826587 | 0 | 1 |
| fta | 855 | 0.3777778 | 0.4851154 | 0 | 1 |
| lremi | 855 | 8.845932 | 0.0349801 | 8.813572 (Cantabria) | 8.964554 (Canary Islands) |
| lremj | 855 | -9.321997 | 0.9437973 | -11.16977 (Portugal) | -7.792886 (New Zealand) |
| porti | 855 | -1.15E-08 | 1.018908 | -0.751892 | 2.811469 (Andalusia) |
| portj | 855 | 1.749446 | 0.7300264 | -0.5013939 | 2.932286 (Singapore) |