UNIVERSITAT DE BARCELONA

Transport Economics and Infrastructure: An Empirical Analysis of the Port Sector

Marta Gonzalez Aregall

PhD in Economics

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Als meus pares, Carme i Josep

Als meus germans, Albert i David

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Table of Contents

List of Tables

List of Figures

Chapter 1

Introduction

This present research deals with the analysis of economic issues in the field of maritime transportation. Particularly, the idea is to analyze the role of port infrastructure considering the effect of competition, regulation and its economic impact. Within a context of container influence in a complex shipping industry, the main goal of this dissertation is to quantify seaport influence through three different approaches by evaluating its effects and its consequences.

This dissertation encompasses three main topics: (1) the study of the economic impact of port infrastructure; (2) the effect of port competition on traffic demand; (3) and the evaluation of port management and finance through an analysis of port charges.

We cannot comprehend how different our lifestyles would be without maritime transportation. The majority of goods surrounding us have spent most of their time offshore. Society has "sea blindness" to out-of-season fruit or t-shirts produced miles away transported by container ships, unlike the consciousness of commercial flight tickets and tourist cruises (George, 2013).

To illustrate this point, Rose George (2013) suggests the supply chain pendulum idea, wherein countries would rather pay for shipment of goods to other regions that offer cheaper labor than to pay their own inhabitants to complete the job locally. Such as the Scottish cod that it sent ten thousand miles overseas and back merely to be filleted. She stated, "*The geographic boundary of the Suez Canal is also a gateway to plenty: beyond it Kendal [ship] will begin to collect what the East has made for the West, gathering up goods all the way to Thailand before turning around and bringing the bounty home. This is the pendulum of the supply chain and it swings with its own curios logic.*" (George, 2013:18).

During recent decades, there has been a change in shipping traffic, which has generated a new international trade scene. Trade flows are directly related to economic growth (Stopford, 2009). Thus, the transatlantic route between America and Europe, which was extremely important during the Industrial

Revolution, has maintained six million full TEUs[1] of stable traffic every year. However, the economic growth of Asia has led to a shift in the center of world trade; Firstly, giving rise to the importance of the transpacific route (between Asia and America), with traffic of 20 million full TEUs per year, and secondly, a surge in the main route between Asia and Europe through the Suez Canal and the Mediterranean Sea, yielding traffic of 20 million full TEUs per year (UNCTAD, 2013).

Globalization is a consequence of the container revolution (Stoford, 2009). Moreover, the interplay of policy-oriented factors such as the elimination of trade barriers and the liberalization and deregulation of markets have changed the port and shipping industry (Notteboom, 2004). The historical, cultural and economic relevance of shipping has been developing since the invention of these standard "boxes" in the fifties. The influence of this new situation was the starting point of radical changes in transportation, industry and economic growth.

As a result of new trunk routes, the location of the industry became less important due to cheaper, faster and safer transportation afforded by containers (Stopford, 2009). Although the reduction of transport cost has caused ports to become less significant for the location industry, regions with large ports benefit in terms of industrial employment. In the context of vital interface between land and sea, the role of port infrastructure into global logistic chains becomes a fundamental element for firms. While it is generally accepted that better transport infrastructures implies a positive effect on economic growth, it is still a subject of debate the quantification of such impact and which transportation modes have a more relevant effect.

The first topic of this dissertation concerns the economic impact of port infrastructures. In this regard, the hypothesis defended in the first part of this dissertation is based on measuring how transport infrastructures that improve its international connectivity have an impact on industrial employment. Specifically, through a methodology based on spatial econometric techniques, this analysis is based on the evaluation of the influence that better infrastructures of one region have on its neighbors. Thus, infrastructure improvement may lead to an increase of competition associated with the agglomeration of activities in the region with better infrastructure and a

[1] TEUs: Twenty-foot Equivalent Units. It is a standard unit of cargo capacity of containers. The standard volume of a container of one TEU is equivalent of 20-foot-long container (approximately 6.1 long meters).

complementary effect associated with improved access to other regions or international markets.

The importance of port infrastructure and its effect on the integration between maritime and inland transport system generates multiple economic effects. As a result, the public sector should establish national port policies that support public economic objectives and allow port private operators to execute development plans that promote favorable competition (World Bank, 2007). Denominated as Port Devolution concept, port management has been transferred from central governments to other entities and has induced the emergence of different port administration models[2] that have influenced the manner in which ports are organized, structured and managed (Brooks, 2004; World Bank, 2007).

Against this backdrop of globalized markets, the world's ports are subject to increasingly intense competition as they seek to attract more traffic from global competitors as well as from local ports in overlapping hinterlands (Xiao et al., 2012). In this regard, the second topic of this dissertation is to determine whether a more competitive scenario benefits port traffic. An equation model is develop to consider the role of port attributes, surface transport connectivity and governance management models in traffic of European ports; It is observed that greater public government control and competition within the terminal can harm port traffic levels, while traffic from neighboring ports and better rail facilities can all serve to boost traffic. Overall, this chapter provides some evidence that inter-port competition may spur traffic while it is less clear whether intra-port competition is so effective.

In this context, the role of Port Authority has the additional challenge of defending public and local interests. Hereof, it is important to establish a strict organizational separation and regulation of port management tasks. Considering the general trend to limit the role of the central government in

[2] Firstly, the Service Port Model is controlled by the public sector. Thus, Port Authority owns the land and executes port function and regulation. There is a lack of internal competition. Secondly, Tool Port Model is similar than the previous category but in this case it aims to share public port stevedoring participation with small private firms. However, this fraction of responsibilities can lead to conflicts between cargo-handling firms. Thirdly, in the Landlord Port Model, Port Authority owns and preserves port basic infrastructure whereas the port infrastructure is leased to private firms that provide their own infrastructure. In this category, there can be a risk of over-capacity. Finally, in the Private Service Port model, private sector owns port land and controls port services and self-regulation; i.e. port development and tariff policies tend to be market-oriented.

financing basic infrastructures, a number of Global Terminal Operators and Shipping Line Companies have emerged as private port operators (World Bank, 2007).

Therefore, globalization and containerization have brought an increase in freight traffic. Consequently, from a shipping line companies' perspective, the use of larger container ships has permitted greater economies of scales and reduced carrier costs. Thus, as a consequence of alliances between large multinational companies, the shipping market has become increasingly concentrated in a few ports that operate as logistic platforms. From the terminal operator's point of view, the accommodation of large vessels and suitable handling facilities implies higher-priced port investment pressures. In short, terminal operators aim to offer terminal services and controls at all stages of the transport chain so as to provide competitive and efficient port systems; whereas shipping companies are focused on their customers' logistical requirements (ITF, 2010).

Thus, ports are competing to attract investment companies specialized in the management of terminals, which are also large multinational firms. They are also competing for attracting the business of shipping companies that operate with huge ships.

In a context of a global competition, the role of Port Authority is challenging. So, the regulation framework of port authorities through port charges to terminal operators and shipping company has different effects. Port charges affect port selection of shipping companies; it influences the revenues to finance its investment and current operations and it helps alleviate problems of port congestion as well. Therefore, the hypothesis defended in the last part of this dissertation is related with the influence of regulation and different types of competition on the revenues a port authority is able to generate. Furthermore, it provides evidence about which actor in the port system wields the effective market power. The focus of this analysis is based on the role of port charges on port traffic volumes and the revenues of port authorities. The methodology used is based on the estimation of an equation system consistent of prices and traffic of Spain port authorities.

Within this framework of container influence in port infrastructure, this study comprehends three main topics. Thus, the relevance of this study is trying to contribute to the literature on port economics from different trends[3]. First of all, this research intends to figure out the economic impact of port infrastructure in employment industry. Secondly, it measures the impact of different competition scenarios on traffic demand. And finally, it evaluates port management and finance through an analysis of port charges.

Moreover, this dissertation is devoted to different port system approaches such as an analysis of European port authorities as a common competitive market place with diverse port management policies and also, with the singular Spanish port organization with a strict regulation and industrial dynamic regions. In fact, Europe is one of the most dynamic regions with a highly developed economy and a large population (Stopford, 2009); while, the Spanish case is of particular interest because of the heterogeneity of the 28 port authorities but subject to a common regulation.

The current investigation has assessed different database data and sources of information despite the difficulties to access appropriate data due to the lack of it in the opaque shipping industry.

Given the contents discussed above, I presented the rest of this dissertation into four different chapters. As mentioned before, industrial areas with lower transportation costs may have advantage in terms of competitiveness. The relationship between transport costs and economic activity makes investment and management of transport infrastructure a key factor for economic growth. In this regard, Chapter 2 entitled **"Do all transport modes impact on industrial employment? Empirical evidence from Spanish regions"** studies the effect of how better international market connectivity can benefit employment in the manufacturing industry in Spain. This international connectivity through an increase in maritime freight traffic has led to a rise in long-distance containerized trade. This situation has caused an increasingly intense competition as they seek to attract more traffic from global competitors as well as from local ports in overlapping hinterlands (Xiao et al., 2012).

To question whether a more competitive scenario benefits port traffic is precisely the main objective of **Chapter 3** entitled "**What drives European port traffic? The role of competition"** devoted to an examination of

[3]According to the review of research trends on container shipping by Lau et al. (2013), the hot topics since 1990 were shipping networks, technical efficiency, short sea shipping and, intermodal transport and hinterland access. The authors also suggest that rising topics are shipping safety, piracy and, empty container repositioning.

different determinants of port traffic in European port authorities; this study observed that competition within the terminal can harm port traffic levels, while traffic from neighboring ports, a more market-oriented governance model and better rail facilities can all serve to boost traffic.

Finally, after studying the effects on ports subject to different competition scenarios, this dissertation analyzed the role of the different port agents which are operating in port system and how price regulation affect port traffic and also, port authority' revenues. In a context of large entry sunk cost for terminal operators and higher shipping line market concentration, the idea of bargaining power become relevant. Thus, the port authority has established a regulation pattern in order to defend public and local interests and also to finance the basic port infrastructure. In this regard, **Chapter 4 "Port charges in Spain: the role of regulation and market forces"** analyses the effect of port regulation in traffic demand and revenues per tones in the Spanish port system and its consequences to port terminal facilities.

Finally, **Chapter 5** summarizes all the conclusions and policy implications in all the different phases of the thesis.

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Chapter 2

Do all transport modes impact on industrial employment? Empirical evidence from the Spanish regions[1]

2.1. Introduction

Transport infrastructure is crucial for the economic development of regions, since better infrastructure implies a greater outlay of public capital and, hence, the higher productivity of private factors, fewer transport costs for firms and greater accessibility to territories. However, as suggested by Redding and Turner (2014), the analysis of the economic impact of transport infrastructure on regions requires that the effects related to growth be distinguished from those related to the reorganization of economic activity.

Numerous empirical studies have examined the impact of infrastructure on economic growth, most of them using production functions (Aschauer, 1989; Munell, 1990; Garcia-Milà and McGuire, 1992; Holtz-Eakin, 1994) or cost functions[2] (Nadiri and Mamuneas, 1994; Morrison and Schwartz, 1996) to analyze the impact of public capital on countries or regions.

While a vast literature has been built up on the link between public capital and output (and, to a lesser extent, costs), few studies examine the impact of different modes of transport infrastructure on employment, using country or regional level data, and those that do generally focus on just one specific mode. In fact, most of these studies have analyzed the effect of highways on employment with mixed results (Clark and Murphy, 1996; Duranton and Turner, 2012; Jiwattanakulpaisarn et al., 2009; Jiwattanakulpaisarn et al., 2010), some have focused on seaport infrastructure and obtain evidence of positive effects for European and Italian regions (Bottasso et al., 2013; Ferrari et al.,

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[1] *Chapter written with Xavier Fageda. Comments from Valeria Bernardo, J.Paul Elhorst, Juan Luis Jimenez, Enrique Lopez-Bazo, Rosina Moreno, Vicente Royuela really contributed to improve this paper. I thank as well PhD Workshop comittee and participants to the PhD in Economics Workshop 2014 and seminar audience at the UBC and at the ULPGC, for helpful comments. Working paper version available at IREA-UB.*

[2]Melo et al. (2013) provide a meta-analysis of the impact of transport infrastructure on economic activity.

2010, respectively), and another group of studies has reported positive effects of airport infrastructure (Albalate and Fageda, forthcoming; Brueckner, 2003; Bloningen and Cristea, 2015; Percoco, 2010).

In this chapter, we examine the determinants of industrial employment in Spanish regions using data for the period between 1995 and 2008. Controlling for various regional attributes, we examine the direct, indirect and total impacts of various modes of transportation, including roads, railways, ports and airports. We focus specific attention on identifying whether the different transport modes have an effect in terms of the growth of economic activity or in terms of its reorganization within regions.

The methodology employed is based on the use of spatial econometric techniques. Specifically, we consider a spatial Durbin model (SDM), which measures the spatial interaction of the dependent and explanatory variables (LeSage and Pace, 2009) so that we can examine the direct effects on the areas in which the infrastructure is located and the spillover effects on neighboring regions. On this point, the impact on employment of a better endowment of transport infrastructure in one region than in that of its neighbors is not, a priori, clear. Indeed, improved infrastructure may give rise to a competition effect associated with the agglomeration of activities in the region with better infrastructure and a complementary effect associated with improved access to other regions or international markets.

We focus on the industrial sector given its relevance for regional economies.[3] Cohen and Morrison Paul (2004) argue that the focus on a particular sector offers more plausible and more interpretable results than a macroeconomic approach, while Holtz-Eakin and Lovely (1996) show that manufacturing activity benefits more than other productive sectors from improved transport infrastructure.

The industrial sector is clearly very important for regional economies, given that a high proportion of exports and R&D expenditure are associated with manufacturing activities. Note also that industrial establishments can occupy a variety of locations, while service industries tend to be located in the central business districts of major urban areas. In this regard, rather than addressing

[3] Other studies that examine the role of transportation or public capital on the industrial sector include Hulten and Schwab (1991), Cohen and Morrison Paul (2003, 2004), Morrison and Schwartz (1996) and Moreno and López-Bazo (2007).

transport infrastructure that only improves intra-urban mobility, we focus on infrastructure that influences intra- and inter-regional mobility.

The main hypothesis tested in this chapter can therefore be stated as follows: the amount of industrial employment in a country is particularly influenced by the transport infrastructure that improves its international connectivity. The improvement in connectivity between regions may lead to a zero-sum game so that the regions that attract industrial employment may do so at the expense of other nearby regions. In contrast, better international accessibility attributable to transport infrastructure may have an aggregate positive effect on the total amount of industrial employment in a country. In the case of industrial activity, the effects of the infrastructure that supports a country's international connectivity may be related to growth, while the effects of the infrastructure that improves the connectivity of regions within a country may be related to the reorganization of its economic activity.

We find that the aggregate effects of transportation on industrial employment are only positive and statistically significant in the case of ports. Regions with more kilometers of roads are able to attract more industrial employment but this is at the expense of nearby regions. In contrast, regions that benefit from having a large port, along with the regions located nearest to these port regions, obtain more employment in manufacturing activities without harming the other regions. We do not find any significant impact for airports and railways.

The rest of the chapter is organized as follows: Section 2 describes the data sources and justifies the explanatory variables selected; Section 3 describes the econometric techniques used; Section 4 gives the details of our empirical model; and Section 5 presents our main findings. The last section summarizes those findings and discusses policy implications.

2.2. Data analysis and variables

In this section, we describe the data and variables used to estimate the determinants of industrial employment across the Spanish regions by building a balanced panel dataset for the period 1995-2008. We consider the 47 Spanish provinces that correspond to the NUTS-3 level in the European territorial unit classification[4]; however, we exclude the Island regions (Balearic and Canary) and the two territories located in the North of Africa (Ceuta and Melilla) as we are unable to assess the indirect impact of surface transportation in these regions. Note also that, unfortunately, the data for the motorway and railway endowment variables are only available at the NUTS-2 level (in Spain, that of the Autonomous Communities).

Our employment data are based on the sector classification provided by Spain's National Institute of Statistics, which disaggregates employment statistics as follows: 1) Agriculture, livestock and fisheries; 2) Energy; 3) Industry; 4) Construction; 5) Market services; and 6) Non-market services. In this regard, we focus our analysis on the industry sector.

While the literature generally considers the impact of the value of the public capital stock (related to transport infrastructure) on the monetary gross domestic product, here we focus on the relationship between industrial employment and physical indicators of transport infrastructure. Specifically, we use the number of kilometers of highways and railways, and port and airport traffic measured in tonnes and in kilograms of goods, respectively.

Investment in transport infrastructure has two effects (Vickerman, 1987): in the short run, the investment itself reactivates the construction sector while, in the long run, the investment has an external effect on the region's production costs by reducing accessibility costs. Here, the use of physical indicators, as opposed to monetary indicators, should help isolate this long-run effect. Indeed, the use of physical measures should capture the services provided by the infrastructure more appropriately, while the stock of capital is essentially an indicator of construction costs.

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[4] Eurostat's NUTS classification (Nomenclature of Territorial Units for Statistics) is the European Commission's hierarchical statistics system for referencing the economic territory of the EU. A NUTS-2 area should have a population between 800,000 and 3,000,000 inhabitants, while that of a NUTS-3 area should range between 150,000 and 800,000 inhabitants. In practice, the statistical territorial units are defined in terms of the existing administrative units in the Member States and do not necessarily fulfill these population limits. In Spain, NUTS 2 are the *Comunidades Autónomas* (autonomous communities, or first-level political and administrative divisions) and NUTS 3 are the provinces.

All variables used in this analysis are in log-linearized form in order to estimate the output elasticity of our variables. Table 2.1 reports the variables used in the empirical analysis, the sources of information drawn upon and their descriptive statistics. Note that the dependent variable is total employment in the industrial sector, while the explanatory variables include physical indicators of transport infrastructure, density of population and levels of education. As additional explanatory variables, our model also includes the spatial lag of the dependent variable and spatial lags of the rest of the explanatory variables (for more details on the econometric approach, see the next section).

Table 2 1. Descriptive statistics of the variables

Variable	Description	Source	Mean	Std. Dev.	Min. Value	Max. value
Log (Ind_Employment)	Total number of employees in the industrial sector in the Spanish provinces. (NUTS-3 level)	National Statistics Institute (INE)	3.56	0.98	1.76	6.44
Log (Motorways)	Infrastructure endowment in kilometers. (NUTS-2)[5]	European Commission's Eurostat agency	6.65	0.73	4.70	7.75
Log (Railways)	Infrastructure in kilometers of tracks.(NUTS-2 level)	European Commission's Eurostat agency	6.97	0.79	4.64	7.78
Log (Port)	Total amount of traffic of each Port Authority aggregated by province (NUTS-3) and in tones[6]	Spanish Ministry of Transport	0.33	0.52	0	2.15
Log (Airport)	Total amount of freight in kilograms moved in the airports of each province (NUTS-3)	Spanish airports operator (Aena)	0.22	0.62	0	3.54
Log (Population density)	Total amount of the population of the region divided by the area of this region. (NUTS-3)	National Statistics Institute (INE)	4.07	0.48	2.2	6.65
Log(Education)	Percentage of people with secondary education studies within the total working age population. (NUTS-3)	BBVA Foundation-IVIE	2.00	1.06	0.56	2.97

Source: Own elaboration based on different sources of information.

[5] In Spain, NUTS- 2 are the autonomous communities, or first-level political and administrative divisions.

[6] The ports of Almeria (province of Almeria) and Motril (province of Granada) were managed by a joint port authority until 2002. To assign traffic to each province when they were managed by a joint port authority, we calculated the relative weight of traffic in each port when they were managed separately.

As discussed above, our objective is to examine the determinants of manufacturing employment controlling for regional attributes and physical indicators of different modes of transport infrastructure. When interpreting the resulting coefficients, we need to consider that a change in a single observation associated with any given explanatory variable affects the region itself (a direct impact) and may affect all the other regions indirectly (an indirect impact).

Overall, we expect a positive sign for the coefficient associated with the non-spatial variables: in other words, all direct effects should be positive. Specifically, a better endowment of transport infrastructure is expected to lead to lower transportation costs so that local producers can buy cheaper inputs, specialize in those activities for which the region has a comparative advantage or find new markets and products.[7]

Within a given province, a better endowment of surface transport infrastructure (motorways and railways) may lead to a reduction in transportation costs for firms and increase accessibility to territories. Both factors may attract new manufacturing firms and promote the expansion of established firms. Note we assume that when better surface transportation modes improve mobility within the region, this will lead to improved mobility between neighboring regions. Likewise, we assume that an increase in provincial port and airport freight traffic will improve national and international accessibility so that both exports and imports become cheaper for local firms.

Employment in manufacturing activities should also be higher in provinces with a higher density of population given that the exploitation of scale economies is easier and transportation costs decrease. As our empirical analysis exploits differences between provinces, we do not expect to find a centrifugal effect attributable to congestion, as such an effect would only be of relevance when analyzing the location of manufacturing firms within a given province. Finally, the availability of skilled workers may also have a positive effect on the employment level in the manufacturing sector in a given province.

[7] Interestingly, some theoretical models suggest that improvements to transport infrastructure lead to the opening up of markets and increase the degree of competition to which local producers are exposed (Ferrari et al., 2012). If local producers are not efficient, improvements to transport infrastructure may spur the import of cheaper goods so that local employment actually decreases.

The expected sign of the coefficient associated with the spatially lagged dependent variable is not, a priori, clear. A high level of employment in the manufacturing sector in one province may positively affect nearby provinces because the closest locations will benefit from easier access to suppliers and specialized employees. However, provinces with high employment levels in this sector may benefit from the exploitation of agglomeration economies and draw employees from less productive regions.

The expected direction of the indirect effect of the transport infrastructure variables is likewise, a priori, unclear. On the one hand, it may be positive as the connectivity provided by highways and railways extends beyond the region in which the infrastructure is located. However, it may be negative because the nearby region with better infrastructure attracts employees from other regions. Similarly, provinces that are close to others that are endowed with large ports and/or airports may take advantage of easier access to the goods produced in distant markets, while those provinces with large ports and/or airports may also attract employees from nearby provinces without large ports or airports.

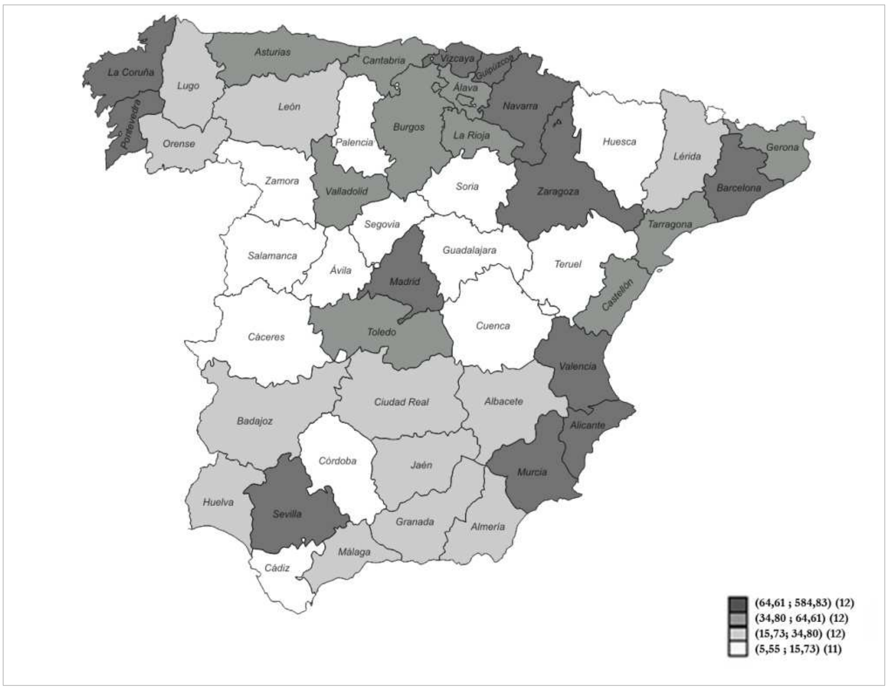
Several studies have examined the spillovers between regions generated by transport infrastructure with inconclusive results. On the one hand, we can expect transport infrastructure to lead to positive spillovers as it improves the connectivity of geographically linked regions (Cohen and Morrison Paul, 2003; 2004; Chen and Haynes, 2013; Tong et al. 2013; Yu et al.; 2013; Arbués et al, 2015; Bronzini and Piselli, 2009). On the other hand, negative spillovers are typically attributed to the migration of mobile production factors (Boarnet, 1998; Cohen and Monaco, 2007; Moreno and López-Bazo, 2007).

The indirect effect of the density population variable is not, a priori, clear either as transport costs should be lower due to the proximity to dense markets; however, the more densely populated region may attract production factors due to the higher returns associated with agglomeration economies. The indirect effect of the education variable is expected to be negative because more productive provinces, thanks to their greater endowment of skilled employees, may draw resources from other nearby provinces.

Finally, in this section we also give a brief descriptive analysis of the regional distribution of our dependent variable and transport variables in Spain. An examination of the geographical distribution of employment in the manufacturing sector reveals a marked difference between coastal areas and the interior.

Figure 2.1 depicts the regional allocation of employment in manufacturing industry.[8] Of the twelve Spanish provinces presenting the highest manufacturing employment figures (accounting for more than half the country's total), nine are located on the coast and three in the interior. These twelve provinces can be grouped in three geographical areas: the Mediterranean coast (including Barcelona and Valencia), the Ebro Valley (including Bilbao and Zaragoza), and Madrid. On the other hand, with the exception of Madrid, the provinces with the lowest employment values are located in the interior.

Figure 2 1 Distribution of manufacturing employment



Source: Own elaboration based on the data on manufacturing employment

In terms of transport infrastructure, maritime and air transport services are more competitive on medium and long-haul routes, while road and railways may be better suited to short-haul routes. Figure 2.2 shows freight traffic distribution in Spain considering different modes of transportation at national and international levels. Data for the considered period are only available for 2007 and 2008.

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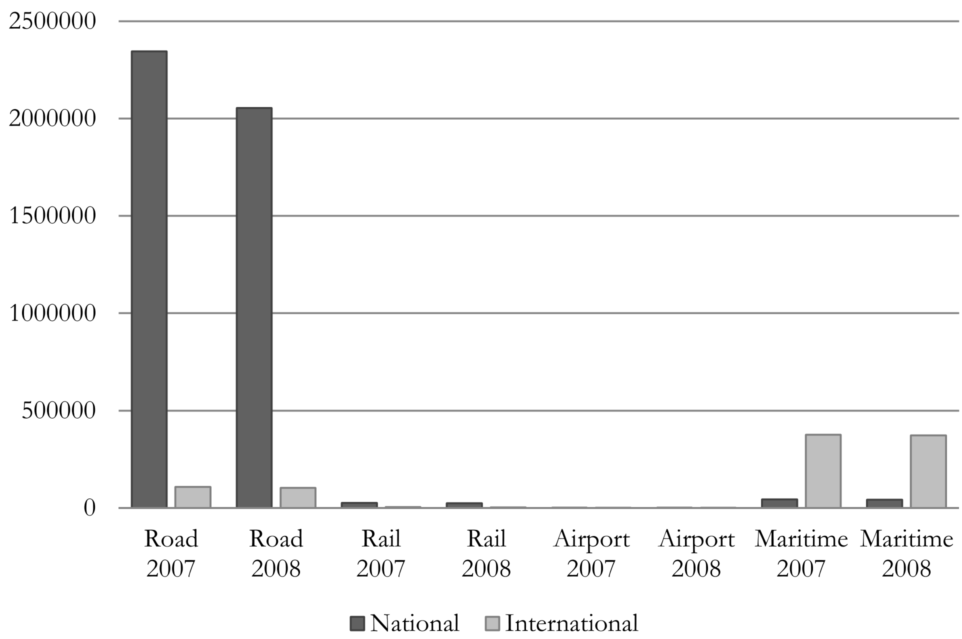
[8] Stata software provides us with the map of the distribution of employment in the manufacturing industry by quantile measures grouped in four different intervals of values.

As can be seen, road transportation dominates freight traffic distribution at the national level; whereas maritime transportation handles the majority of cargo movements at the international level. In contrast, rail freight traffic and air cargo are not relevant in the overall freight traffic distribution. Thus, the international accessibility of the regions in Spain in terms of cargo seems to be based on ports.

Figure 2 2 Freight transportation in Spain (thousand tones)



Source: Own elaboration based on Transportation and Logistics Observatory (OTLE-Ministry of Transportation).

An examination of the infrastructure variables reveals the geographical distribution of network modes (railways and motorways) to be quite similar. As one of Spain's transport objectives has been to improve connections between the political capital and the provincial capitals (Albalate et al., 2012), the region of Madrid has the highest density of motorways and railways in Spain — more than twice that of the regions with the next largest endowments, namely Catalonia, Valencia and the Basque Country. The density figures are quite similar in the case of railways.[9] Note also that in the period

[9] Since 2000, one of Spain's main transport objectives has been to provide a high-speed rail link between the political capital and all provincial capitals. The specific objective is that Madrid should be reached from all provincial capitals in a journey time of less than four hours.

under study, many of the motorways linking cities along the Mediterranean Coast and the Ebro Valley were tolled, while all motorways in the region of Madrid were toll-free (Bel and Fageda, 2005). In surface transportation modes, the mismatch between infrastructure demand and supply has become a significant characteristic of the policy aimed at connecting the political capital with all the provincial capitals (Albalate et al., 2015).

In contrast, the main ports are generally located on the Mediterranean coast. The Spanish port system comprises 28 port authorities managing 44 ports of general interest. The three largest, Algeciras, Barcelona and Valencia, are amongst Europe's top ten ports in volume of container traffic. Their privileged location in the Mediterranean Sea corridor allows them to channel the traffic from Asia to the South of Europe. Other ports with significant volumes of traffic are Bilbao, Tarragona and Cartagena, the last two also being located in the Mediterranean corridor.

Finally, the Spanish airport system comprises 47 airports of general interest. The two largest, Madrid and Barcelona, concentrate about 75% of the system's total air traffic of goods. Other airports with significant volumes of freight traffic are Zaragoza and Vitoria and, to a lesser extent, Valencia and Seville. Airport freight traffic is therefore mainly concentrated in the most populous cities and in the two specialized facilities in Zaragoza and Vitoria.

2.3. The Empirical strategy

In this section we outline the methodology used for estimating the determinants of employment in the manufacturing sector. Given that the spatial spillovers between provinces may be especially relevant to our study, the regressions are conducted using spatial econometric techniques.[10]

According to LeSage and Pace (2009), the spatial Durbin model (SDM) is the most suitable specification for modeling spatial effects. This model is characterized by including a spatially lagged dependent variable and spatially lagged explanatory variables (Elhorst, 2010a; 2010b; LeSage and Pace, 2009). Thus, in order to analyze the spatial interaction effects of the dependent variable and all the explanatory variables, we specified the equation for estimating the determinants of employment for the corresponding province i in year t using a spatial Durbin regression as follows:

$$\begin{aligned}\mathrm{Ind\_employment}_{it} = {} & \alpha_0 + \alpha_1 W^{*}\mathrm{Ind\_employment}_{it} + \alpha_2 \mathrm{Motorways}_{it} \\ & + \alpha_3 \mathrm{Railways}_{it} + \alpha_4 \mathrm{Port}_{it} + \alpha_5 \mathrm{Airport}_{it} \\ & + \alpha_6 \mathrm{PopDens}_{it} + \alpha_7 \mathrm{Education}_{it} + \alpha_8 W^{*}\mathrm{Motorways}_{it} \\ & + \alpha_9 W^{*}\mathrm{Railways}_{it} + \alpha_{10} W^{*}\mathrm{Port}_{it} + \alpha_{11} W^{*}\mathrm{Airport}_{it} \\ & + \alpha_{12} W^{*}\mathrm{PopDens}_{it} + \alpha_{13} W^{*}\mathrm{Education}_{it} + \mu' D_t^{year} \varepsilon_i\end{aligned}$$

where, the dependent variable (Ind_employment) corresponds to the number of employees in the industrial sector in province i at time t. As discussed above, we include as the main explanatory variables measures of the respective endowments of transport infrastructure (motorways, railways, port and airports) and two control variables: density of population and education. Furthermore, in this equation we include the spatial lag of the dependent variable and the spatial lag of the explanatory variables where W (N x N) is a spatial weight matrix that defines dependence across N regions.[11] By

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[10] We also estimated dynamic regressions with the GMM estimator. The results are disappointing because the only significant variable is the lag of the endogenous variable and the variable Motorway. One explanation might be that the sample does not have enough time variability to identify the relevant effects of the growth rates. Note also that the GMM estimator does not capture the heterogeneity between regions and, more importantly, it does not allow us to identify the spatial effects (one of this chapter's main concerns).

[11] According to Hughes (2011), when the number of time periods is higher than ten, it is reasonable to estimate a model with a spatially lagged dependent variable. In our case, the number of time periods is fourteen.

introducing these additional spatial variables, the SDM takes into account the way in which the variation in the explanatory variable for a single region can affect the dependent variable in all other regions.

A central element in our analysis is the specification of the spatial weight matrix (W). The W is a positive matrix (NxN) that illustrates the dependence between units, where the elements (wij) reflect the link between i and j. Here, different specifications of the weight matrix can be applied. The most common approach is to apply a spatial weight matrix based on physical contiguity (i.e., when regions share borders) and a spatial weight matrix based on geographic distance between regions. Other spatial weight matrices are based on the similarity between regions' economic characteristics (for example, income levels) or on their trade relations. Anselin (1988) considers that the elements in the weight matrix should be non-stochastic and exogenous to the model. Thus, an advantage of specifying the matrix W based on location is that the elements are exogenous (Elhorst and Halleck-Vega, unpublished results).

In our analysis, we estimate an SDM with four different specifications according to the spatial weight matrix used. In order to consider the closest neighbors but also more distant regions, we construct binary weight matrices with four different classifications: contiguity, a radius of 150 km, a radius of 300 km and a radius of 450 km. The use of these different distance thresholds allows us to check the sensitiveness of the results for the spatial variables to the spatial weight matrix chosen.

To begin with, we consider a binary contiguity matrix (Wc) with elements wij=1 when two units share a common border and wij=0 in all other cases. Second, we create three different binary weighted matrices with elements wij=1 for those provinces located within a distance of 150 km (W150), a distance of 300 km (W300) and a distance of 450 km (W450) from the capital city of the province of reference and wij=0 for the other provinces. The first weight matrix assumes that spillovers only take place between regions within the considered threshold of geographic proximity, while the others assume that more distant regions also contribute to geographical spillovers.

In order to calculate the spatial interaction effects, we estimate equation (1) using the maximum likelihood method with a bias-correction procedure, and then we calculate the marginal effects. Specifically, we are able to distinguish between direct, indirect and total effects.

First, we test whether the SDM can be simplified to the spatial error model or to the spatial lag model. To this end, we consider the results from the Wald test and the likelihood ratio (LR) test. However, all the results confirm that the SDM is appropriate for our analysis.

Second, we have to evaluate fixed and random spatial effects models in order to determine which of the two models is most suitable. According to Arbués et al. (2015), random effects should not be applied because the values of each spatial unit for the case of the Spanish provinces are not obtained arbitrarily. Consequently, the most suitable model is the SDM with spatial and time-period fixed effects (Elhorst, 2012a, 2012b). Note also that the literature generally does not provide any support for the random spatial effect estimation (Elhorst, 2012b). Here, an advantage of the fixed effects model is that it allows us to control for any omitted variables that correlate with the variables of interest and which do not change over time. In this regard, the fixed effect model only captures the within variation of the data.

Finally, we have to consider the potential bias derived from the simultaneous determination of the manufacturing employment and transport infrastructure variables. The endogeneity problem should not be a concern in the case of surface transportation as investment in these modes in Spain has prioritized passenger rather than freight transport and it has not been guided by demand criteria (Albalate et al., 2012, 2015). Moreover, the endogeneity problem might not exist as the effect of infrastructure investment is not instantaneous (Arbués et al., 2015). More generally, it would be reasonable to argue that the activity in the manufacturing sector is unlikely to drive policy decisions across regions (Cohen and Morrison Paul, 2003).

While the endogeneity bias of the surface transportation variables should not be a concern in the context of this study, the potential endogeneity of the lagged dependent variable and of the port and airport traffic variables needs to be taken more seriously. Thus, to deal with the endogeneity problem, we estimate the parameters of our model using the maximum likelihood method based on the conditional log-likelihood function (Anselin, 1988) and the bias-correction procedures in order to prevent unbiased estimators (Lee and Yu, 2010). The literature includes several examples that adopt this procedure to correct the potential endogeneity bias (Tong et al., 2013; Yu et al., 2013; Arbués et al., 2015).

In order to interpret the parameter estimates, we cannot apply the standard interpretation used in linear regression models, where we assume that the coefficient corresponds to the partial derivative of the dependent variable with respect to the explanatory variables. Indeed, in spatial econometric models, the parameter estimates contain information from the interaction of units that complicate their interpretation (Elhorst, 2014).

Consequently, according to the theoretical description provided by LeSage and Pace (2009), a change in the explanatory variable for a single region can potentially affect the dependent variable in all other regions. Following these authors, the partial derivative of dependent variable (Y) with respect to the X explanatory variables takes the following n x n matrix form:

$$\partial Yi/\partial Xjr=Sr(W)ij$$

This n x n matrix refers to the effect of a one-unit change of a particular explanatory variable in one province on a dependent variable of all the provinces. Thus, these authors suggest to consider not only the own-partial derivatives, i.e. the direct effect that corresponds to the sum of the average of the main diagonal elements of the n x n matrix, but also the cross-partial derivatives, namely, the indirect effects that correspond to the sum of the average of the off-diagonal elements of the n x n matrix. Likewise, the total effects are the result of the sum of direct and indirect effects.

In this regard, in order to interpret all the parameter estimates in our model correctly, we assume that a direct effect is the result of a change in an explanatory variable in province i on the dependent variable of this province. Similarly, the indirect effect occurs when a change in an independent variable in province i has an effect on the dependent variable in all the other provinces.

2.4. Results

Table 2.2 shows the results of the regressions based on the estimation that employs four alternative spatial weight matrices of the bias-corrected fixed effect model, while Table 2.3 shows the computation of the direct, indirect and total effects obtained from these regressions.[12] Their respective fourth columns show the results when using the binary weight matrices with contiguity, a distance of 150 km, a distance of 300 km and a distance of 450 km, respectively.

As can be seen in Table 2.2, in all specifications, the Wald test and the Likelihood Ratio (LR) test indicate that the hypothesis that the SDM could be simplified to the Spatial Lag Model or to the Spatial Error Model must be rejected. Hence, the SDM is considered to be the model that provides the best description of the data (Elhorst, 2012).

[12] Spatial fixed effects and spatial random effects are not shown, but are available on request.

Table 2 2. Results of the Spatial Durbin Model

	W contiguity	W_150	W_300	W_450
Motorways	0.045 (1.116)	0.202*** (4.215)	0.110** (2.900)	0.152*** (3.477)
Railways	0.041 (0.839)	0.074 (1.496)	0.078 (1.601)	0.065 (1.346)
Port	0.361*** (6.475)	0.286*** (5.409)	0.312*** (5.799)	0.325*** (5.918)
Airport	0.027 (0.447)	-0.022 (-0.353)	0.006 (0.101)	-0.025 (-0.403)
Education	0.160*** (3.521)	0.161*** (3.493)	0.200*** (4.436)	0.174*** (3.733)
Density population	0.365** (2.470)	0.382*** (2.705)	0.481*** (3.422)	0.424*** (2.813)
W*Motorways	-0.158** (-1.988)	-0.204*** (-3.826)	-0.0005 (-0.007)	-0.273** (-2.261)
W*Railways	-0.132 (-1.136)	-0.005 (-0.067)	-0.079 (-0.665)	-0.039 (-0.252)
W*Port	0.297*** (2.621)	0.009 (0.123)	0.375* (1.791)	0.467* (1.623)
W*Airport	-0.108 (-0.862)	-0.153 (-1.472)	-0.027 (-0.121)	-0.836** (-2.445)
W*Density population	0.328 (1.172)	0.029 (0.161)	-0.525* (-1.845)	-0.518 (-1.033)
W*Education	-0.016 (-1.507)	0.075 (0.986)	-0.025 (-0.191)	-0.011 (-0.049)
W*Y	-0.007 (-0.121)	-0.217*** (-5.583)	-0.116 (-1.144)	-0.022 (-0.195)
Time specific effects	Yes	Yes	Yes	Yes
Spatial specific effects	Yes	Yes	Yes	Yes
Wald Test Spatial Lag	21.665 (p=0.0014)	17.375 (p=0.0080)	9.538 (p=0.1455)	11.068 (p=0.0863)
LR test spatial Lag	24.223 (p=4.75e-004)	-	10.944 (p=0.0901)	13.068 (p=0.0420)
Wald Test Spatial Error	21.845 (p=0.0013)	20.613 (p=0.0022)	9.285 (p=0.1585)	11.002 (p=0.0883)
LR test spatial Error	24.110 (p=4.98e-004)	-	10.031 (p=0.1234)	13.085 (p=0.0417)
Observations R-squared Corr-squared Log-likelihood	658 0.9894 0.1258 573.590	658 0.9892 0.1353 -	658 0.9891 0.1073 569.122	658 0.9892 0.1097 568.512

Note 1: Standard errors in brackets.
Note 2: Statistical significance at 1% (***), 5% (**), 10% (*)

The coefficients of the port traffic variable and the control variables of education and density of population are positive and statistically significant in all the spatial weight matrices. The coefficient of the motorways variable is positive and statistically significant except in the contiguity weight matrix. Likewise, the coefficient of railways is positive but not statistically significant in any of the regressions, and the coefficient of airports is not statistically significant in any of the regressions.

As for the spatially lagged independent variables, the spillover effect of motorways is negative and statistically significant in all regressions except that in which the spatial weight matrix employs a 300-km radius. The railway coefficient is not statistically significant in any of the regressions, while that of the airports variable is negative but only statistically significant in the regression for the spatial weight matrix that uses a 450-km radius. Finally, the coefficient of the port variable is positive in all the regressions; however, it is not statistically significant in the regression in which the spatial weight matrix uses a 150-km radius.

As for the control variables, the education variable is not statistically significant, while the results for the population density variable are inconclusive, as the sign of the coefficient and the statistical significance vary according to the weight matrix used. Finally, in general, the coefficient associated with the spatially lagged dependent variable is negative, although it is only statistically significant when we use the spatial weight matrix with a 150-km radius.

Table 2 3. Results of the Direct, Indirect and Total effects

	W contiguity	W_150	W_300	W_450
Direct effects				
Motorways	0.041 (0.978)	0.225*** (4.271)	0.112*** (2.946)	0.153*** (3.524)
Railways	0.038 (0.792)	0.076 (1.500)	0.078 (1.577)	0.067 (1.380)
Port	0.361*** (6.592)	0.292*** (5.237)	0.313*** (5.791)	0.323*** (5.992)
Airport	0.032 (0.517)	-0.083 (-0.124)	0.009 (0.150)	-0.024 (-0.384)
Density population	0.353** (2.428)	0.387** (2.609)	0.483*** (3.494)	0.426*** (2.890)
Education	0.163*** (3.668)	0.161*** (3.383)	0.201*** (4.530)	0.170*** (3.615)
Indirect effects				
Motorways	-0.159** (-2.001)	-0.225*** (-4.025)	-0.012 (-0.193)	-0.273** (-2.189)
Railways	-0.133 (-1.106)	-0.018 (-0.270)	-0.081 (-0.720)	-0.040 (-0.252)
Port	0.294** (2.617)	-0.050 (-0.730)	0.306* (1.655)	0.433 (1.525)
Airport	-0.114 (-0.921)	-0.141 (-1.478)	-0.031 (-0.154)	-0.819** (-2.488)
Density population	0.339 (1.173)	-0.047 (-0.267)	-0.524* (-1.983)	-0.519 (-1.032)
Education	-0.161 (-1.568)	0.033 (0.461)	-0.044 (-0.369)	-0.019 (-0.091)
Total effects				
Motorways	-0.117 (-1.260)	-0.0004 (-0.011)	0.100 (1.457)	-0.120 (-1.066)
Railways	-0.094 (-0.679)	0.057 (0.909)	-0.003 (-0.022)	0.027 (0.168)
Port	0.656*** (5.021)	0.242*** (3.339)	0.619*** (3.197)	0.755** (2.501)
Airport	-0.082 (-0.589)	-0.149 (-1.525)	-0.021 (-0.101)	-0.844** (-2.438)
Density population	0.692** (2.563)	0.338** (2.175)	-0.041 (-0.163)	-0.093 (-0.194)
Education	0.002 (0.017)	0.194** (2.670)	0.156 (1.270)	0.151 (0.676)

Note 1: Standard errors in brackets.
Note 2: Statistical significance at 1% (***), 5% (**), 10% (*)

Thus, we find evidence of a positive direct effect of motorways and ports, and no effects of airports and railways, on industrial employment. Our analysis shows that the level of employment in the manufacturing sector is higher in regions with larger ports and with a better endowment of motorways. In terms of magnitudes, a 1% increase in port traffic in a region increases the level of employment in manufacturing industry in the same region by 0.29-0.36%. Additionally, the level of employment in the manufacturing sector is higher in regions with more kilometers of motorways. The elasticities for this variable are around 0.05-0.22%.

The results of our analysis for ports are in line with Bottasso et al. (2013) and Ferrari et al. (2010) while the results for motorways are in line with those obtained by Duranton and Turner (2012). Likewise, Tong et al. (2013) reported positive effects of road expenditure on agricultural activities; while Yu et al. (2013) reported positive effects of surface transportation modes.

A possible explanation for the lack of impact of the airport and railway variables is that in Spain passengers have priority over goods in air and rail transportation policies. However, although there is a high concentration of goods being moved by Madrid and Barcelona airports, industrial employment in these provinces may be better explained by other variables, including density of population, motorways (Madrid) or port traffic (Barcelona) variables. Furthermore, investment in transport infrastructure in Spain since the 1990s has focused on the high-speed rail network, which is not designed to be truly compatible with freight. Indeed, Spain's freight rail transport represents one of the lowest shares in Europe (Albalate et al., 2015).

In the case of the indirect effects, we obtain negative values of the motorway variable in almost all the weight matrices employed. As a result, an increase in a province's motorway infrastructure would yield negative effects on the employment of its neighbors with a magnitude that ranges from 16 to 27%. Hence, a good endowment of motorways in one region negatively affects employment in the manufacturing sector in other nearby regions. Note here that our analysis may be limited by the fact that the dependent variable is provided at the NUTS-3 level (in Spain, that of the provinces), while the surface transportation variables are at the NUTS-2 level (in Spain, that of the regions). This may distort the magnitude of the indirect effect obtained for network modes; yet, we do not expect this data limitation to affect the direction and statistical significance of the spillover effects.

As for motorways, we find evidence that the negative effect associated with the migration of employees to more productive regions is stronger than the positive effect associated with the improved connectivity of less productive regions. This finding is in line with Holl (2004), who analyzes the impact of road transport infrastructure on the location of manufacturing establishments using micro-level data for Spain. The author finds that the benefits from road improvements are concentrated near the new infrastructure.

Note also that several studies of spatial spillovers focus specifically on road transport infrastructure. This may be because the literature usually examines the relationship between output and investments, and because the investment in roads accounts for a large share of the sector's total investment in transportation. In this regard, our results are in line with Boarnet (1998), Chandra and Thomson (2000) and Ozbay et al. (2007), who find clear evidence of negative spatial spillovers from investments in motorways, and with Holtz-Eakin and Schwartz (1995), who also reject the existence of positive spillovers in motorways.

In general, we find positive indirect effects associated with port traffic, although they are only clearly significant in the case of the contiguity matrix. Hence, the positive spillovers associated with large ports seem to concentrate in the immediate neighboring regions. In line with this result, Arbués et al. (2015) found that seaport investment in Spain can have positive effects, spilling over into neighboring regions. Similarly, Shan et al. (2014) reported a positive relation between per capita GDP and port traffic in China.

Results for the spatially lagged independent variables suggest that the gains that a region obtains (in terms of attracting industrial activities) from a better endowment of motorways may harm other nearby regions. In contrast, the positive indirect effects of port traffic reinforce the positive outcomes discussed above.

Finally, it is not surprising that we do not find strong indirect effects for the airport and railway variables. Indeed, such infrastructures do not even seem to have a large impact on their own neighbors, which may explain why the spillovers generated in other regions (either positive or negative) are modest.

Overall, therefore, the results of our analysis suggest that the total effects are only positive and statistically significant for ports. The increase in industrial employment generated by a region with more kilometers of roads is associated with less employment for other regions. In contrast, regions that reap the benefits of having a large port and the regions located nearest to them generate more employment in manufacturing activities without harming employment levels in the other regions.

2.5. Conclusions

In this study we have analyzed the effects of transportation infrastructure on employment levels in manufacturing industry for 47 Spanish provinces between 1995 and 2008. We show that some types of transport infrastructure significantly influence employment in the manufacturing sector. Motorway infrastructures and the level of port traffic have a positive and statistically significant impact, while railways and the amount of airport traffic have no clearly observable effects. Proximity to large markets (measured in terms of population density) and the availability of skilled labor also have marked direct effects.

Our empirical analysis shows that there are significant negative spatial spillovers in the case of motorways. In contrast, we observe that a region with a large port is able to generate positive effects on neighboring regions.

In short, we provide evidence that the expansion of industrial activity in a country is mainly dependent on the infrastructure that enhances its international connectivity. The effects of this infrastructure on industrial employment seem to be related to growth. In contrast, the effects of the infrastructure that improve the connectivity of the regions within a country seem to be related to the reorganization of industrial activity in that country.

In Spain, ports are the mode of transport infrastructure that appear to have promoted this international connectivity. However, the movement of goods by air is concentrated in the two largest cities, while investment in rail has focused on high-speed rail lines that are not compatible with freight and serve only to improve connectivity within the country. While the movement of goods by road is sizeable both at the national and (to a lesser extent) international levels, our analysis suggests that motorways tend to reorganize a country's employment in the industrial sector more than they generate additional activity.

Hence, we infer from our empirical analysis that the promotion of a country's industrial activity requires a focus on the infrastructure that supports its international connectivity, as is the case of ports. In Spain, the promotion of cargo at smaller airports might also be advisable given that the regions in which the main passenger airports are located are already attractive to industrial firms because of the size of their markets. Furthermore, investment in roads that cross national borders (such as those that constitute the international E-road network) and the development of international rail services dedicated to freight may help make a country more attractive to industrial firms.

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Chapter 3

What drives European port traffic? The role of competition[1]

3.1. Introduction

In recent years, international maritime transportation has played a critical role in the strengthening of the relationship between trade and economic development, with such factors as the container revolution and burgeoning trade flows ensuring that ports have become a vital element in economic growth. Several empirical studies have examined the economic impact of port traffic on the European (Bottasso et al., 2013), Italian (Ferrari et al., 2010) and Spanish regions (Fageda and Gonzalez-Aregall, 2015), concluding that port throughput has a positive effect on employment. Similarly, Shan et al. (2014) reported a positive relationship between per capita GDP and port traffic in China. In addition, Arbués et al. (2015) found that seaport investment in Spain can have positive effects spilling over into neighboring regions.

Europe, because of its highly developed economy and large population, is one of the world's main trading regions (Stopford, 2009), as illustrated by the volume of cargo flows handled on its trade routes. Thus, the transatlantic route between America and Europe shifts a stable traffic of six million full TEUs[2] per year and the Asia and Europe route moves 20 million full TEUs per year (UNCTAD, 2013). Against this backdrop of globalized markets, the world's ports are subject to increasingly intense competition as they seek to attract more traffic from global competitors as well as from local ports in overlapping hinterlands (Xiao et al., 2012). A number of studies claim that this increased competition is closely related to processes of containerization and port devolution[3] (Yuen et al, 2012; Zhang, 2008). For example, in the gateway

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[1] *Chapter written with Xavier Fageda. I thank Jose Ignacio Castillo-Manzano,Stephan Joseph for helpful comments. Working paper version available at IREA-UB working papers publication.*

[2] TEUs: Twenty-foot Equivalent Units.

[3] The OECD (2008) report explains that containerization allows ports in the same region to become substitutes, exposing them to more competition from other ports, and that the devolution of port management results in ports adopting a more commercial approach, which intensifies competition.

region of the Rhine-Scheldt Delta, Notteboom (2009) observed that the region's largest ports were substitutes for each other and that its smaller ports were complements of these large load centers.

In this chapter, we examine the factors that account for the volume of traffic handled by Europe's ports by drawing on data for 2010. Controlling for the economic and geographic attributes of the regions in which the ports are located, we analyze the influence of the competition scenarios that port authorities face. Indeed, greater competition may enhance efficiency (Garcia-Alonso and Martin-Bofarull, 2007), promote a port's attractiveness (Ng, 2006) and influence investments and prices (Van Reeven, 2010, Xiao et al., 2012). In short, a more competitive scenario can have the effect of boosting port traffic. In contrast, competition might mean some ports suffer reductions in traffic at the expense of other, more efficient, ports. Thus, traffic may well be diverted from small to large ports that are connected to extensive hinterland networks (Notteboom, 2010). Additionally, such factors as the level of connectivity with surface transportation modes and the degree of inland congestion can shift traffic to more efficient ports (Zhang, 2008).

The primary objective of this article is to determine whether a more competitive scenario benefits port traffic in the European Union. The study focuses on total container traffic as opposed to total traffic, since in this way we can take into account competition not only from the local market but also from other regions. Moreover, the availability of data for all port authorities and the homogeneous characteristics of containers allow us to compare port traffic records.

This chapter contributes to the literature by reporting an analysis of the determinants of European port traffic using a multivariate equation. Previous studies have analyzed the impact of a range of specific factors on port efficiency. For example, Garcia-Alonso and Martin-Bofarull, (2007) examined the effect of improvements in efficiency in attracting more traffic, while Cheon (2010) analyzed the impact of privatization. Other studies have examined the effect of competition on port traffic but have tended to focus on one port region and to undertake analyses of variance (Anova and t-test) or of reveled preference indicators (Ng, 2006; Notteboom, 2009). This chapter uses econometric techniques to estimate a multivariate equation that simultaneously considers port attributes, surface transport connectivity and governance variables of a large sample of European ports. Although previous studies have evaluated Europe's port system (Notteboom, 2010), none have examined the influence of such a broad range of factors on port traffic.

We find evidence that a more intense competition between ports may boost traffic as suggest the results for the variables that identify the traffic of nearby ports and the governance model. Furthermore, we do not find clear evidence that competition within the port increases traffic as ports with a terminal managed by a shipping line have more traffic. In this regard, we also find that ports with a greater share of transshipment traffic have more traffic. Hub ports may be subject to a more intense competition from other ports but they tend to be dominated by one shipping line. Finally, we also find that those ports connected with rail facilities that can move trains of more than 700 meters length are able to generate more traffic.

The rest of the chapter is organized as follows: Section 2 outlines the main features of the European port authorities included in our sample focusing especially on those factors that may determine the competition scenario in which they operate; Section 3 describes the empirical model used and provides a justification of the explanatory variables selected. Section 4 addresses some econometric issues and explains the results of the estimates. Finally, the last section is devoted to summarizing the main findings and discussing the policy implications.

3.2. Sample of European Ports

This section provides an exploratory analysis of the factors explaining the intensity of port competition among European port authorities considered in our analysis. Our database draws on the Containerization Yearbook for 2012. From the World Container Port Traffic League (totaling 365 port authorities), we consider 92 European Port authorities. Our sample permits us to analyze all the largest European port authorities and most medium and small port authorities. This sample represents a high percentage of total port traffic in Europe.[4]

An increase in maritime freight traffic has led to a rise in long-distance containerized trade. A difficulty in establishing direct shipping connections induced the emergence of intermediate transshipment ports (ITF, 2009). According to Portopia (2012), large hub ports are those with more than 2

[4] See table A1 in the Annex for a list of all port authorities contained in our database, with data about traffic and governance characteristics.

million TEUs and with a transshipment incidence of greater than 50 % of their total TEU throughput.[5] Note that one terminal (at least) of these large hub ports is usually controlled by a single shipping company.

Consequently, we observed that these transshipment ports are subject to more competition with other ports but not within the port itself. To illustrate, Bremen is a transshipment port located in the North of Europe and has a terminal controlled by MSC and Maersk. Furthermore, the transshipment port of Marsaxlokk is located in the Island of Malta and it has a terminal managed by CMA-CGM. Note here that the aim of this analysis is to measure the dominance of pure shipping lines. For example, APM Terminal is a subsidiary of Maersk but in our analysis it is considered a Terminal Operator according to the classification of Notteboom and Rodrigue (2012).[6]

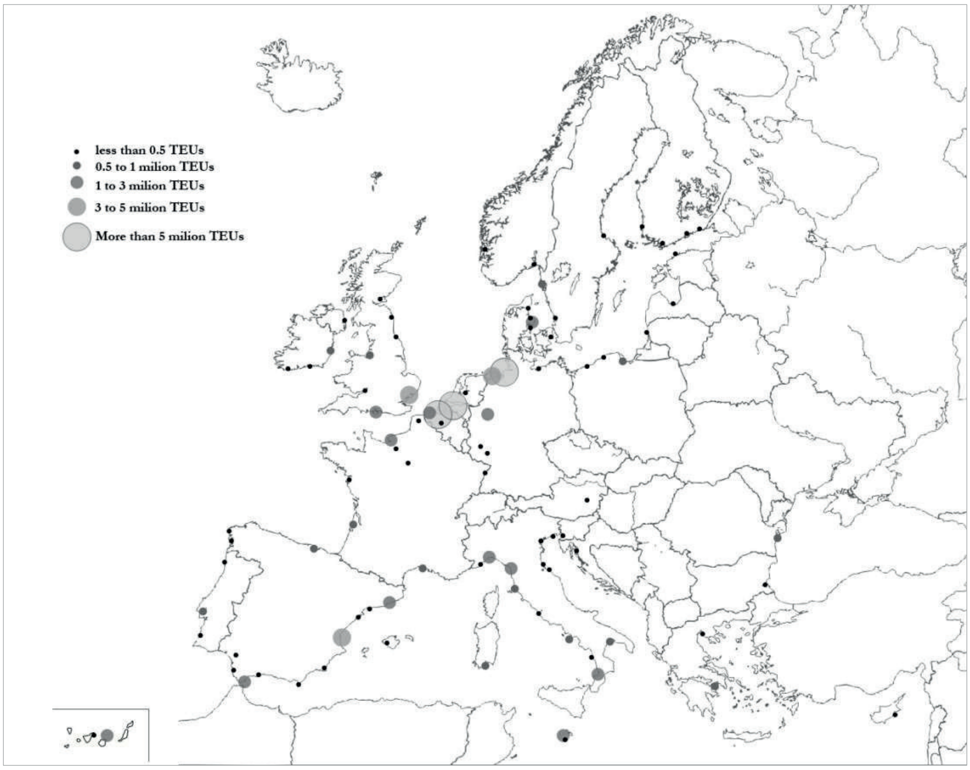
Undoubtedly, this increase in maritime freight traffic has affected local port competition and hinterland connections. In this regard, the potential hinterland of a port can be defined as the area that can be reached in the least amount of time while incurring the lowest cost (Wilmsmeier et al., 2011). While overlapping hinterlands can occur in contiguous port market areas (Van Klink and Van den Berg, 1998), this area is essential for port competition (Wan et al., 2013) and has an impact on port growth (Zhang, 2008). Thus, ports with rail facilities within a terminal may expand their hinterland. In this regard, port terminals with suitable rail facilities are fundamentally located in the North compared to a lack of availability of rail facilitates in the Southern ports of Europe.[7] In this regard, Castillo-Manzano et al (2013) found that the poor intermodal port-to-rail connections in Spain have damaged the competitiveness of ports.

Similarly, the amount of port traffic that is operated in the same region can affect the degree of competition with nearby ports. As can be seen in Figure 1, the three major ports move more than 5 million TEUs and are located in Northern Europe. Port authorities in the range of 1 to 5 million TEUs are

[5] In our analysis ports with these characteristics are Bremen (Germany), Gioia Tauro (Italy), Algeciras (Spain) and Marsaxlokk (Malta). We do not have available data on transshipment traffic for all ports in our sample to identify smaller hubs.
[6] According to the authors, almost 75 % of the total European Container throughput in 2008 was handled by the top five terminal operators: PSA, APM Terminals, HPH, DP World and Eurogate.
[7] Rotterdam (Netherlands), Antwerp (Belgium), Hamburg (Germany), Bremen (Germany), Zeebrugge (Belgium), Le Havre (France), Genoa (Italy), Duisburg (Germany), Marseilles (France), Strasbourg (France), Gavle (Sweden), Bristol (UK) and Amsterdam (Netherlands).

primarily located in Germany, France, UK, Spain and Belgium. Finally, the majority of port authorities are smaller, containing less than 0.5 Million TEUs. From Figure 3.1, it can be concluded that the majority of regions in the Southern Europe have smaller, local ports while the most concentrated traffic throughput and the largest ports are based in the North of Europe regardless of its size and population.

Figure 3 1 Traffic in European ports



Source: Own elaboration based on Containerization International Yearbook 2012

The complexity and diversity of Europe's port authorities has had a marked influence on competition. Notteboom and Verhoeven (2010) and Notteboom et al. (2012) perceive the diversity of the port authorities in terms of the involvement of private operators. Likewise, Wang and Cullinane (2006) indicate that different systems of port governance in Europe might be a key determinant of container terminal efficiency.[8]

The development of the European Union has seen the establishment of a single market place typified by economic integration and intense competition.[9]

[8] Trujillo and Tovar (2007) examined the economic efficiency of the European port industry.
[9] For an analysis of organization and regulation theory and port industry in Europe see Tovar et al. (2004).

However, while the European Commission has taken steps to set up a common European port policy (Verhoeven, 2009), the decision-making process of the port agents has yet to be harmonized (Pallis, 2007).

Since the eighties, almost all port authorities have undergone a process of devolution with greater private involvement (Brooks, 2004) and different governance strategies.[10] So as to analyze the effect of port governance models on port traffic competition, we based on three different viewpoints: regulation, finance and ownership.

First, few studies have evaluated regulation needs in relation to port traffic. According to Trujillo and Tovar (2012), competition is an economic factor that has an influence on port regulation, which in turn affects port traffic. Likewise, some studies have taken into account the effect of port pricing regulation. Thus, theoretical studies tend to associate investment in port capacity and hinterland congestion with port prices (De Borger et al., 2008) and a shipping line's choice of port (Bae et al., 2013). Whereas, the empirical analysis conducted by Fageda and Gonzalez-Aregall (2014) concluded that the strict regulation of port charges in Spain influenced the volume of port traffic and mitigated price competition.

Secondly, an analysis of port finance systems[11] shows that typically governments use public resources to subsidize basic port infrastructure. Yet, the growth of the private sector has led to a debate regarding the introduction of limits on port investments (World Bank, 2007). However, no previous study has examined the relationship between port financial management and port traffic.

Finally, the majority of port ownership studies have examined the effect of public-private ownership on port efficiency with inconclusive results. Privatization may have a positive effect on port efficiency and national welfare (Czerny et al., 2014); while, Tongzon and Heng (2005) conclude that the best option for port efficiency is to limit private sector participation. However, to the best of our knowledge, no previous studies have analyzed the relationship between port governance systems and port traffic.

Drawing on a number of research studies (the Espo Fact Finding Report, 2010; Verhoeven and Vanoutride, 2012; ISL report, 2006 and OECD Policy

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[10] For a port governance model (Service Port, Tool Port, Landlord Port, Private Port) see World Bank (2007).

[11] For a detailed analysis of port finance systems see World Bank (2007).

Round Tables, 2011; World Bank, 2007), with the goal of determining a simple homogeneous structure for Europe's port system, we classify them in three categories: market, hybrid and bureaucratic.[12]

The first category – market port systems – includes those port authorities with their own management body operated by a private firm, with its own financial resources and a regulatory framework based on free market prices. Port authorities with these characteristics can be found above all in the United Kingdom.

The second category – hybrid port systems – includes all port authorities with an autonomous individual management run by the regional or local government. These port authorities may be recipients of public aid, including subsidies financing their infrastructure, while their regulatory framework is based on free market prices or regulation imposed by the local government. Examples of the hybrid port system can be found in Amsterdam, Antwerp and Rotterdam.

The third category – bureaucratic port systems – includes port authorities with individual management run by the central government and public financial resources (public subsidies). These port authorities operate strict regulatory frameworks where prices are established by the central government. Examples can be found in France, Spain and Italy. Figure 3.2 shows the location of the different European port systems in our analysis.

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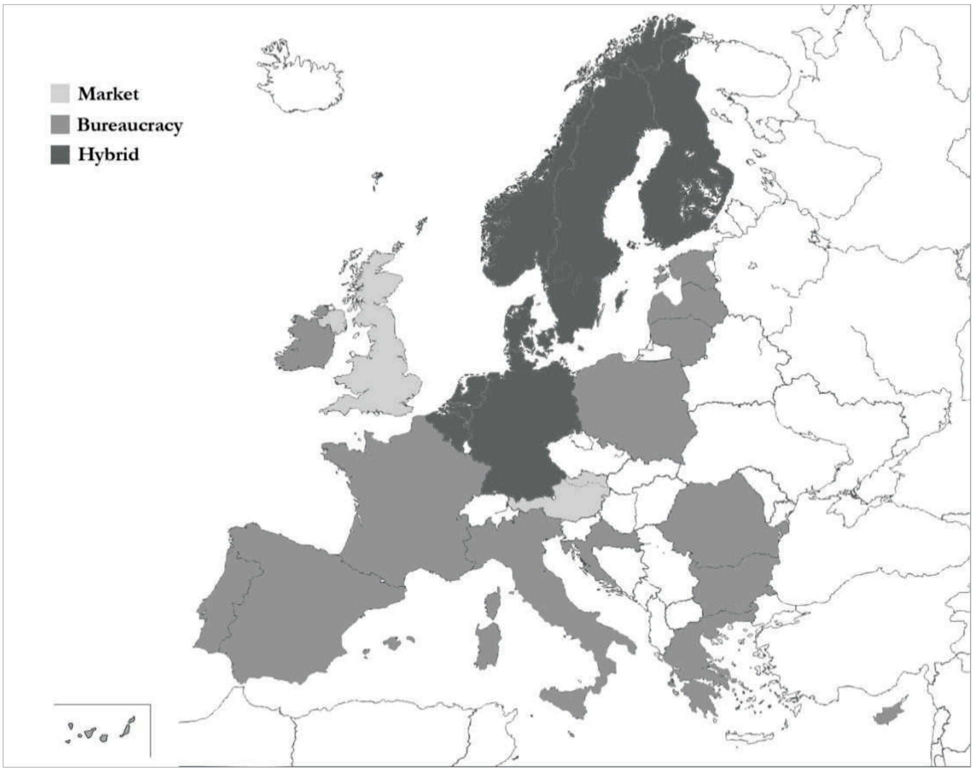
[12] Espo Fact Finding Report (2010) and Verhoeven and Vanoutride (2012) classify port authorities in three regions: Hanse (North), Latin (South) and Anglo-Saxon (United Kingdom). They conclude that differences exist in terms of ownership and financial autonomy (port authorities being more limited in the south) and between small and large ports, with the latter presenting more transparent systems of management.

Figure 3 2. Map of the European port system classification



Source: Own elaboration based on our port regulation and information from Containerization International Yearbook 2012 and annual reports of port authorities.

As can be seen, the dominant port system in Southern Europe (grey color) is the bureaucratic model, characterized by a strict regulation and less price flexibility. In case that competition between ports spur traffic, we may expect that ports under this system absorb less traffic than ports located in Northern Europe (black color) dominated by the hybrid model. Likewise, we expect greater traffic volumes in ports operating a market system (light grey) which are the ports located in the United Kingdom and Austria.

3.3. The Empirical Model

In this section we develop an empirical model to estimate the factors that influenced container traffic in European ports during 2010. First, we consider a number of control factors, including, the economic and geographic attributes of the region in which the port authorities are located. Second, we consider such port attributes as the share of transshipment traffic, competition within terminals and the volume of traffic at neighboring ports. Third, we include variables related to surface transportation modes. Finally, we take into account the different port governance models operated by the port authorities. In short, these factors can affect port competition between other ports but also within the own port authority.

We estimate a cross-sectional equation in which the dependent variable is the amount of container port traffic handled by the European port authority *i* during 2010. The equation to be estimated is as follows:

$$\begin{aligned} \text{Traffic}_i = {} & \beta_0 + \beta_0 \text{GDP}_{it-1} + \beta_2 \text{long}_i + \beta_3 \text{latit}_i + \beta_4 \text{Indland}_i + \beta_5 \text{Island}_i \\ & + \beta_6 \text{hub}_i + \beta_7 \text{no\_multiuser}_i + \beta_8 \text{traffic\_nearby\_ports}_i \\ & + \beta_9 \text{motorways}_i + \beta_{10} \text{railfacility}_i + \beta_{11} \text{hybrid}_i \\ & + \beta_{12} \text{bureaucracy}_i + \varepsilon_i \end{aligned}$$

Table 3.1 shows the variables used in the empirical analysis, the sources of information and the descriptive statistics. We group the variables into four categories: Economic and geographic attributes of the region, port attributes, surface transportation and port governance models.

Table 3 1 Descriptive statistics of the variables

	Variable	Description	Source	Mean	Std. Dev.	Min. Value	Max. value
Dependent Variable	TRAFFIC	Total amount of container traffic in 2010	Containerization International (CI) Yearbook 2012	898844.2	1792942	41500	1.11e+07
Economic and geographic attributes of the region	GDP_{t-1}	Gross domestic product in 2009 (current market prices/euro per inhabitant at NUTS 2)	Eurostat database	70257.53	69235.69	3703	558579
	LONGITUDE	In the East (higher values) or in the West (lower values)	Google maps	7.16	10.71	-16	33
	LATITUTE	In the North (higher values) or in the South (lower values)	Google maps	47.36	8.07	28.13	61.12
	INLAND	Dummy variable that takes value 1 if a port authority is located in a navigable channel	CI Yearbook 2012/ UNECE Inland waterway Map (2012)	0.07	0.27	0	1
	ISLAND	Dummy variable that takes a value of 1 for ports located in islands	CI Yearbook 2012	0.12	0.33	0	1

Port attributes	HUB	Dummy variable that takes a value of 1 for large hub ports	CI Yearbook 2012 / Portopia Report 2014	0.04	0.20	0	1
	NO_MULTIUSER	Dummy variable that takes value 1 if at least one terminal is controlled by Shipping Company	Annual reports and port authorities' websites	0.15	0.36	0	1
	TRAFFIC NEARBY PORTS	Sum of the volume of container traffic of neighbor ports (up to 400 miles)	CI Yearbook 2012 and port distance miles measured by google maps	7845447	1.10e+07	0	4.41e+07
Surface Transportation	MOTORWAYS	Density of motorways (Length in km divided by area of country)	Eurostat database	0.03	0.04	0	0.29
	RAILFACILITY	Dummy variable: value 1 for terminals with trains with more than 700 m. of length	CI Yearbook 2012	0.14	0.35	0	1
Governance Model	MARKET	Dummy variable that takes value 1 if PA is owned by a private firm and set free market prices	Freire Seoane and Gonzalez-Laxe (2003), ESPO report (2010), ISL report	0.11	0.31	0	1

			(2006), annual reports				
	BUREAUCRACY	Dummy variable that takes value 1 if PA is a public entity, subject to reg. of prices, receives public subsidies	Freire Seoane and Gonzalez-Laxe (2003), ESPO finding report (2010), ISL report (2006) and annual reports	0.64	0.48	0	1
	HYBRID	Dummy variable that takes value 1 if PA with local/regional management, set free prices, receive public subsidy	Freire Seoane and Gonzalez-Laxe (2003), ESPO finding report (2010), ISL report (2006) and annual reports.	0.25	0.43	0	1

Source: Own elaboration based on different sources of information.

First, as economic and geographic attributes of the region, we include Gross Domestic Product (GDP), location variables, and dummies for inland navigation channels and islands. The expected sign of the GDP variable is positive, since wealthier regions should generate more container traffic due to more demand from maritime transport services. In contrast, the expected sign for the location variables is unclear. On the one hand, the largest ports are located in the North-West of Europe but, on the other, ports located in the Mediterranean Sea (South-East) absorb part of the international trade that originates in Asia and passes through the Suez Canal. We also consider inland port authorities for which the expected sign is negative reflecting smaller regions and smaller local demand.[13] Finally, the expected sign of the island variable is not clear as the traffic to these peripheral locations is captive so that it is totally dependent on the size of local demand[14].

Second, in the case of port attributes, we consider a dummy variable for ports that act as large hubs. Here, we include ports that can hold more than 2 million TEUs and which have a higher than 50% share of transshipment. The expected sign of the variable is positive since these ports should handle more traffic than is predicted by local demand. According to Heaver et al. (2000), shipping line alliances in hubs will have a greater presence and a greater market influence on the decision-making of port authorities in the future.

We also consider a 'no multiuser' variable that takes a value of one in the case of those ports in which at least one terminal is managed and monopolized by a single shipping line. The expected sign of this variable is a priori unclear. On the one hand, such a scenario could weaken competition as one of the port's terminals would be free from any competitive pressure; on the other, a positive sign might be expected as the shipping line would guarantee a certain volume of port traffic.

In addition, we consider a variable for the volume of traffic in neighboring ports, taking into account the number of nearby ports located in a radius of between one hundred and five hundred miles. We then sum the total amount of port traffic for each traffic threshold. The expected sign of this variable is a priori unclear. In the literature, Yap and Lam (2006) reported that port competition only benefits the largest seaports in East Asia that are located in the same hinterland. Likewise, Notteboom (2009), in a study of shipping-line decisions, observed a tendency towards concentration in the Rhine-Scheldt

[13] See table in the Annex for a list of all inland port authorities in our database.
[14] Because of its size, we do not consider the United Kingdom as an island.

Delta region. In that case, the largest ports acted as substitutes for each other while smaller ports were complements of the large load centers. Hence, in our analysis, the sign should be negative if competition has a substitution effect between major ports in the same region. However, a positive sign might be expected if a complementary effect is dominant. Indeed, the traffic handled by the port could grow due to an increase in the total amount of traffic in the nearby ports as more shipping lines may include it in their routes.

Plainly, transporting goods by inland requires an efficient network infrastructure. So, an increase in corridor capacity increases a port's output and profit and reduces the profit of a rival port (Zhang, 2008). Thus, De Langen (2008) stressed the importance of the port authority as a coordinator capable of enhancing the efficiency of the transport chain and competitive clusters. So as to measure the effect of surface transport modes, we also include explanatory variables related to the endowment of motorways in the country and the endowment of rail facilities within a terminal. In the first case, the endowment of motorways is measured at the country level that could distort our results but data at a more disaggregated level is not available. The expected sign for the motorway variable is unclear since, on the one hand, it might be positive as it could promote greater efficiency in the logistics chain (a complementary effect); yet, on the other hand, it might be negative with maritime traffic losing out to road traffic (substitution effect). Finally, the rail facilities variable is expected to present a positive sign since it should serve to attract more container traffic and to transport it to other regions.

Finally, in the case of the models of port governance we consider three characteristics: regulation, finance and ownership. Specifically, we consider hybrid and bureaucratic system variables, where the reference variable is the market system. The expected sign of these variables is unclear, as there is a dearth of studies explicitly examining the influence of the models of governance on port traffic and so it is difficult to identify a clear relationship between the two. However, we can expect a positive sign of the hybrid model variable as the more intense competition that allows the free pricing could allow attracting more traffic. In contrast, the bureaucratic variable model is expected to have a negative sign as it put barriers to competition between ports of the same country subjected to this governance model.

3.4. Estimation and Results

In this section we show the results of the estimation of the port traffic equation considering various econometric techniques.

An initial analysis of the distribution of the dependent variable (Figure 3.3) shows a range of values from extreme to values close to zero, indicating that it is severely positively skewed with a non-normal distribution. A log normalization of the dependent variable was therefore conducted to reduce the skewness (see Figure 3.4). Note also the importance of considering the non-normal distribution given the small number of observations.

Figure 3 3. Traffic distribution

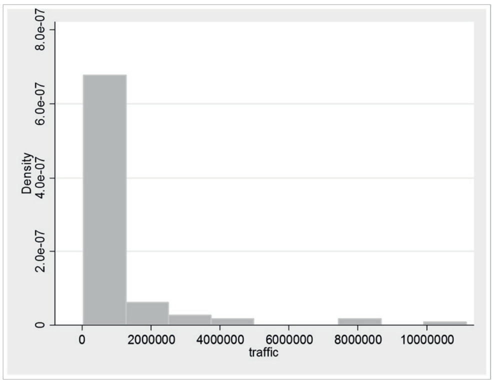
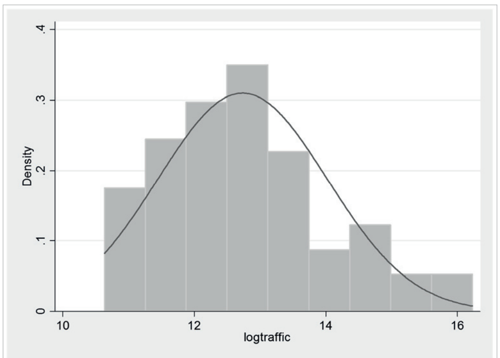


Figure 3 4. Log Traffic distribution and Normal density plot



Source: Total of container traffic of 92 European port authorities and based on information obtained from Containerization International Yearbook 2012.

The resulting model of log normality of the dependent variable appeared to resemble the basic normal distribution, indicating the possibility of estimating an OLS model. However, as Table 3.2 shows, the Doornik-Hansen test for multivariate normality and the skewness and kurtosis normality test showed that the log-transformed dependent variable continued to follow a non-normal distribution.

Table 3 2. Econometric normality tests and summary statistics

	Results of tests
N	92
Mean	12.723
Standard Deviation	1.287
Skewness and kurtosis normality test (dependent variable)	71.28***
Skewness and kurtosis normality test (log transformation dependent variable)	6.30**
Doornik Hansen test for multivariate normality	2931.008***

Note 1: Standard errors in brackets.
Note 2: Statistical significance at 1% (***), 5% (**), 10% (*)

Several studies in the fields of insurance, health and transportation (Manning and Mullhay, 2001; de Jong and Heller, 2008; Hill and Miller, 2010 and Tyworth and Zeng, 1998) have used dependent variables with a positively skewed distribution. These analyses indicate, however, that distributional problems can occur, resulting in substantial bias in the OLS regression. We, therefore, considered different classes of regression models based on the Generalized Linear Model (GLM) in which the log-link function could be implemented without imposing a transformation of the dependent variable. In addition, our estimations may present a problem of heteroscedasticity in the error term. To correct this, we applied robust standard errors in all our analyses. Indeed, Cameron and Trivedi (2009) recommend using robust standard errors for parameter estimates in some count-data models.

An alternative to the OLS regression is a Poisson model. Statistical theory considers that in a Poisson distribution the conditional variance is equal to the conditional mean. In order to determine whether our model satisfied this assumption, we calculated the Pearson dispersion statistic. This goodness-of-fit test is defined as the Pearson statistic divided by the model's degrees of freedom (DF) which should give a value of around one (Hilbe, 2007). A result greater than one, however, might indicate over-dispersion, while a result lower than one would indicate under-dispersion. Such a situation could lead to the incorrect estimation of the standard errors. In our case, the ratio of the Pearson statistic to the DF was equal to 1062245, clearly indicative of an over-dispersion problem, and as a consequence, the Poisson distribution is not a good choice in our estimation process.

Given the problem of over-dispersion, we had to consider alternative models. Alternatives include a negative binomial distribution (Cameron and Trivedi, 2009; Hilbe, 2007) or a gamma distribution model. In the first case, the ratio of the Pearson statistic to the DF was equal to 1.02, i.e., almost 1, close to the goodness-of-fit statistic. In the second case, the ratio of the Pearson statistic to the DF is also equal to 1.02, i.e., almost 1, close to the goodness-of-fit statistic too.

The gamma distribution assumes that the standard deviation is proportional to the mean and can be used when the dependent variable is continuous and does not present a normal distribution. In our analysis, the dependent variable presents positive integer values but the number of counts is so high that it resembles a continuous variable. Consequently, the gamma distribution is a better alternative than the negative binomial model.

Moreover, we need to consider the possibility that some endogenous explanatory variables might bias the estimation results. In particular, there may be a simultaneous determination of traffic and the Gross Domestic Product (GDP), so that the GDP variable may be endogenous; thus, in our estimation we considered the lag of GDP variable as explanatory variable as it is hard to assume that the GDP in 2009 is dependent upon traffic in 2010. Note that the use of additional lags of the GDP variable does not change the results of the empirical analysis.

Finally, we need to take into account the potential problem of multicollinearity due to the high correlation between the explanatory variables. Table 3.3 shows that the results of the variance inflation factor are lower than 4 in the equation considered, so we can conclude that there is no problem of multicollinearity.

Table 3 3. Variance Inflation Factor

	VIF
Log Traffic	1.66
GDP 2009	1.26
Longitude	1.70
Latitude	3.04
Island	1.49
Inland	1.16
Hub	1.44
Traffic200	1.43
No_multiuser	1.49
Motorways	1.75
Rail facility	1.57
Hybrid	2.94
Bureaucracy	3.90
MEAN VIF	**1.91**

We estimated the GLM with a gamma distribution for different distances of nearby ports in order to select which is most appropriate for our analysis[15]. In order to select one nearby port distance threshold as explanatory variable, we used different information criteria using goodness-of-fit statistics. Generally, there are two standard measures for a selection test for different estimations, namely, Akaike's information criterion (AIC) and Schwarz's Bayesian information criterion (BIC), where a smaller AIC and BIC are preferred (Cameron and Trivedi, 2009). However, and according to Hilbe (2007), most statisticians today prefer to use the AIC, BIC, or other model-specific fit statistics to the deviance. For this reason, we do not consider deviance goodness-of-fit statistics here. As a result, in the gamma distribution model using all thresholds for nearby port distances, the variable of port traffic in a 400-mile radius presents the lowest AIC and BIC values and so we have opted to consider this distance threshold in our preferred regressions. In any case, only the GDP and traffic in the nearby port variables are affected by the consideration of one or other of the measures of traffic handled in nearby ports.

[15] The details of the gamma distribution model using all thresholds for nearby port distances are available from the authors.

Table 3.4 reports the results of the equation of traffic in European ports using three estimation methods. The first column shows the results for the OLS regression, while the second and third columns show the results for the GLM using a negative binomial distribution and a gamma distribution, respectively. As can be observed, the estimation results when using the negative binomial and the gamma distribution techniques do not change. Recall that the results obtained with these two techniques should be more accurate in our context than those obtained with OLS. In any case, the result in table 4 suggests that the estimation is less precise when using OSL as some variables loss statistical significance when using this method.

Table 3 4. Results of the Traffic equation comparing different model techniques

	Log Traffic (OLS)	Log Traffic (NB)	Log Traffic (Gamma)
GDP 2009	1.24e-06 (1.42e-06)	2.22e-06 (1.59e-06)	2.22e-06 (1.59e-06)
Longitude	0.0114 (0.0125)	0.00805 (0.0109)	0.00805 (0.0109)
Latitude	-0.0338 (0.0204)	-0.0428** (0.0192)	-0.0428** (0.0192)
Island	0.0822 (0.426)	-0.0387 (0.334)	-0.0387 (0.334)
Inland	-0.466* (0.245)	-0.949*** (0.272)	-0.949*** (0.272)
Traffic_Nearby_Ports	1.46e-08 (1.93e-08)	2.60e-08* (1.52e-08)	2.60e-08* (1.52e-08)
Hub	1.574*** (0.431)	1.254*** (0.480)	1.254*** (0.480)
No_Multiuser	1.007** (0.439)	0.902** (0.364)	0.902** (0.364)
Motorways	-3.899 (2.610)	-3.217 (2.851)	-3.217 (2.851)
Rail Facility	0.992* (0.533)	1.268*** (0.456)	1.268*** (0.456)
Hybrid	-0.429 (0.510)	-0.455 (0.410)	-0.455 (0.410)
Bureaucracy	-0.511 (0.477)	-0.673* (0.398)	-0.673* (0.398)
Constant	14.26*** (1.172)	15.13*** (1.065)	15.13*** (1.065)
Number observations	86	86	86
R^2	0.401	-	-
Joint significance test	8.597	-	-
AIC	-	28.73	28.73
BIC	-	-246.4	-246.4
Pearson /DF	-	1.044	1.044

Note 1: Robust Standard errors in brackets.
Note 2: Statistical significance at 1 %(***), 5 %(**), 10% (*)

Table 3.5 shows the results of the estimation of the traffic equation using the GLM with a gamma distribution. As mentioned above, although the results of the negative binomial and gamma distribution are similar, we opted to use the gamma distribution as our preferred method because our dependent variable resembles a continuous variable. The first column shows the results when considering the geographic attributes, the second when adding port competition variables, the third when adding surface transportation variables, and the fourth when considering all explanatory variables.

Table 3 5. Results of the Traffic equation

	Log Traffic (Gamma)	**Log Traffic (Gamma)**	**Log Traffic (Gamma)**	**Log Traffic (Gamma)**
GDP 2009	1.70e-06 (2.45e-06)	9.45e-07 (1.77e-06)	1.30e-06 (1.55e-06)	2.22e-06 (1.59e-06)
Longitude	-0.0185 (0.0137)	0.00162 (0.00802)	0.000591 (0.0107)	0.00805 (0.0109)
Latitude	0.00126 (0.0255)	-0.0218 (0.0133)	-0.0266* (0.0149)	-0.0428** (0.0192)
Island	-0.563 (0.546)	-0.225 (0.292)	-0.0942 (0.335)	-0.0387 (0.334)
Inland	-1.397*** (0.353)	-0.714** (0.341)	-0.805*** (0.310)	-0.949*** (0.272)
Traffic_Nearby_Ports	-	5.22e-08*** (1.42e-08)	3.48e-08** (1.37e-08)	2.60e-08* (1.52e-08)
Hub	-	0.996** (0.391)	1.310*** (0.481)	1.254*** (0.480)
No_Multiuser	-	1.031*** (0.339)	0.855** (0.367)	0.902** (0.364)
Motorways	-	-	-2.937 (2.870)	-3.217 (2.851)
Rail Facility	-	-	1.074** (0.417)	1.268*** (0.456)
Hybrid	-	-	-	-0.455 (0.410)
Bureaucracy	-	-	-	-0.673* (0.398)
Constant	13.77*** (1.222)	13.67*** (0.670)	13.90*** (0.706)	15.13*** (1.065)
Number Observations	91	91	86	86
AIC	29.41	28.70	28.71	28.73
BIC	-221.9	-278.9	-253.3	-246.4

Note 1: Robust standard errors in brackets.
Note 2: Statistical significance at 1 %(***), 5 %(**), 10% (*)

Note that because of a lack of data for some explanatory variables, our sample is reduced from 91 to 86 observations. The following conclusions can be drawn from the results of our regressions.

The coefficient associated with the GDP variable (column 1) is positive and not statistically significant (although it is statistically significant when the construction of the variable capturing the traffic in nearby ports is calculated at the 100-, 200- and 300-mile radius). Thus, it would seem that the economic activity of the region in which the port authority is located may have a positive influence on container traffic, although the effect is not strong from a statistical point of view. A possible explanation of this result is that the hinterland of the port extends beyond the local region in which the port is located.

In the case of the location variables, the coefficient associated with the longitude variable is negative but not statistically significant, while the coefficient associated with the latitude variable is positive and not statically significant. This seems to indicate that ports located in the North-West have more traffic. The island coefficient is also negative and does not reach statistically significant levels. This result can be explained by the peripheral characteristics of these ports, which means the existence of a large captive traffic making the ports totally dependent on local demand. Finally, the coefficient associated with the inland port variable is negative and statistically significant, indicating that ports located in a navigable channel manage lower volumes of container traffic given that their traffic is related exclusively to their (small) local hinterlands.

If we only consider a region's economic and geographic attributes, almost all the variables are not statistically significant. This means it is essential to include additional variables to explain the determinants of port traffic.

The coefficient associated with the number of ports located within a 400-mile radius (column 2), when also controlling for economic and geographic attributes, is positive and statistically significant. Thus, we find evidence of a complementary effect whereby the traffic handled by a port might grow due to an increase in traffic in a nearby port. This can be explained by the strategies adopted by shipping lines that operate regular lines and which stop at several ports that are located close to each other.

Importantly, the coefficient of the large hub port variable is also positive and statistically significant. This, as discussed, can be attributed to the fact that ports with a greater share of transshipment traffic are able to generate more traffic than is otherwise predicted by their regional attributes. This result is in line with that obtained for the variable of the 'no multiuser' terminal. The coefficient of this variable is positive and statistically significant. Thus, a terminal managed by a shipping line company would seem to guarantee the movement of more container traffic given the values of the other control variables.

The above results do not change significantly when considering the surface transportation variables (column 3), while continuing to control for the economic and geographic variables and the port attributes. Only the coefficient associated with the latitude variable becomes negative and statistically significant. Thus, the coefficient associated with the endowment of motorways is negative but not statistically significant, suggesting that the complementary effect between ports and motorways is offset by the substitution effect, with the greater volume of freight transport by road reducing port traffic. Note here that according to Eurostat, in 2012 the percentage of inland freight transport by road in Europe was 75.1%, compared to 18.2% by rail and 6.7% by inland waterways (Eurostat, 2012. Units: % of total inland tkm). In contrast, the coefficient associated with the rail facility variable is positive and statistically significant. This means that if a railroad track is operated within the terminal (being able to move trains with more than 700 meters of length), this intermodal infrastructure may help the port to attract more traffic.

Finally, when controlling for all the above explanatory variables, the coefficient associated with the hybrid variable is negative and not significant, while the coefficient associated with the bureaucratic variable is negative and statistically significant (column 4). Thus, we find evidence that ports with fixed-price regulation, central government ownership and public finance, negatively affect the attraction of port traffic. Consequently, a more market-oriented governance model seems to be positive for port traffic. As such, we would expect ports located in the North to have more competitive advantages than the ports located in the South that are subject to a bureaucratic system of port governance.

3.5. Conclusions

Competition between European port authorities can be associated with the effects of distant large transshipment ports as well as with local nearby ports. A more competitive scenario can increase a port's traffic due to incentives to be more efficient; yet, at the same time, this competition might also reduce the volume of traffic handled by less efficient ports. Here, controlling for several factors, we have examined whether ports benefit from a more competitive scenario.

Overall, we can infer from our results that competition between ports may boost traffic. Indeed, ports may benefit from being located near to other large ports and from a more market-oriented governance model. In contrast, we do not find clear evidence that competition within the port spur traffic. Controlling for other factors, hub ports are able to generate more traffic. Hub ports are typically subject to an intense rivalry with other ports but they tend to be dominated by one shipping line. In this regard, traffic tend to be higher in ports that have a terminal managed by a shipping line. Finally, we also find that the connectivity with rail facilities is a major determinant of the ability of a port to attract traffic.

As such, our results indicate that Southern European port authorities present specific characteristics that may undermine their competitive position. The Mediterranean port authorities are generally managed in accordance with the bureaucratic model of governance and operate few rail facilities within the port terminals. Although Mediterranean ports enjoy global connectivity in international shipping networks, it is difficult for them to extend their rail services in their own hinterlands (Notteboom, 2010). The OECD (2008) also observes an imbalance in geographical traffic flows between the North and South and concludes that the Northern region is likely to enjoy greater growth due to better hinterland transport conditions.

In conclusion, Southern European port authorities need to consider adopting more flexible systems of governance in order to attract more traffic and to ensure greater efficiency. Furthermore, they should also consider the possibility of experimenting with different port governance models within the same region. In this way, the largest ports could be managed with more flexible systems so that they can increase their financial resources and invest in the port authority's facilities, including better railway links. Likewise, ports in Southern Europe should be not so concerned by nearby ports and they could put the attention on their competitiveness in relation to port authorities in North of Europe.

A limitation of this analysis has been the lack of data preventing us from extending the analysis beyond a period of one year. Further research could usefully examine the influence of additional factors including the economic crisis or situations of over-investment. Similarly, future studies should examine in greater depth the dynamic relationship between competition, efficiency and traffic.

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Annex

Table A.3.1: Port Authorities list

Million of TEUs	Port	Country codes	traffic	tax	funds	PA'sproperty	market	bureaucracy	hybrid
More than 5	Rotterdam	NL	11145804	free	own	municipality	0	0	1
	Antwerp	BE	8468475	free	external	municipality	0	0	1
	Hamburg	DE	7900000	free	external	municipality	0	0	1
From 3 to 5	Bremen/Bremerhaven	DE	4871297	free	external	municipality	0	0	1
	Valencia	ES	4206937	law	external	state	0	1	0
	Felixtowe	UK	3400000	free	own	private	1	0	0
From 1 to 3	GioiaTauro	IT	2851261	law	external	state	0	1	0
	Algeciras	ES	2810242	law	external	state	0	1	0
	Zeebrugge	BE	2389879	free	external	municipality	0	0	1
	Marsaxlokk	MT	2370729	law	external	state	0	1	0
	Le Havre	FR	2358077	law	external	state	0	1	0
	Barcelona	ES	1945735	law	external	state	0	1	0
	Genoa	IT	1758858	law	external	state	0	1	0
	Southampton	UK	1540000	free	own	private	1	0	0
	La Spezia	IT	1285455	law	external	state	0	1	0
	Duisburg	DE	1181000	free	external	municipality	0	0	1
	Las Palmas	ES	1113262	law	external	state	0	1	0
From 0.5 to 1	Marseilles	FR	953435	law	external	state	0	1	0
	Gothenburg	SE	796000	free	own	municipality	0	0	1
	Liverpool	UK	681414	free	own	private	1	0	0
	Leghorn	IT	635270	law	external	state	0	1	0
	Bordeaux	FR	632407	law	external	state	0	1	0
	Taranto	IT	581936	law	external	state	0	1	0
	Cagliari	IT	576092	law	external	state	0	1	0
	Constrantza	RO	556694	law	external	state	0	1	0
	Dublin	IE	554260	law	external	state	0	1	0
	Naples	IT	532432	law	external	state	0	1	0
	Bilbao	ES	531457	law	external	state	0	1	0
	Pireaus	EL	513319	law	own	state	0	1	0
	Lisbon	PT	512789	law	external	state	0	1	0
	Gdansk	PL	508587	law	external	municipality	0	1	0
Less than 0.5	Leixoes	PT	481784	law	external	state	0	1	0
	Gdynia	PL	480142	law	external	municipality	0	1	0
	Koper	SI	476731	law	external	state	0	1	0
	Teesport	UK	469096	free	own	private	1	0	0
	Aarhus	DK	447000	free	own	municipality	0	0	1
	Helsinki	FI	399903	free	own	municipality	0	0	1
	Kotka	FI	397286	free	own	municipality	0	0	1
	Venice	IT	393913	law	external	state	0	1	0
	Sines	PT	382089	law	external	state	0	1	0
	Strasbourg	FR	360938	law	external	state	0	1	0
	Tenerife	ES	357472	law	external	state	0	1	0
	Limassol	CY	348861	law	external	state	0	1	0
	Paris	FR	345000	law	external	state	0	1	0
	Helsingborg	SE	320000	free	own	state	1	0	0
	Vienna	AT	318000	free	own	private	1	0	0
	Malaga	ES	298401	law	external	state	0	1	0

	Klaipeda	LT	294954	law	external	state	0	1	0
	Trieste	IT	281689	law	external	state	0	1	0
	Salerno	IT	274940	law	external	state	0	1	0
	Thessaloniki	EL	273282	law	own	state	0	1	0
	Tarragona	ES	255407	law	external	state	0	1	0
	Riga	LV	182980	law	external	state	0	1	0
	Savona	IT	220000	law	external	state	0	1	0
	Belfast	UK	217896	free	own	private	1	0	0
	Grangemouth	UK	215783	free	own	private	1	0	0
	Vigo	ES	213123	law	external	state	0	1	0
	Oslo	NO	201893	law	external	municipality	0	0	1
	Dunkirk	FR	200858	law	external	state	0	1	0
	Ravenna	IT	183041	law	external	state	0	1	0
	Rauma	FI	166460	free	own	municipality	0	0	1
	Nantes	FR	166266	law	external	state	0	1	0
	Copenhagen-Malmo	DK	153000	free	own	municipality	0	0	1
	Seville	ES	152612	law	external	state	0	1	0
	Tallinn	EE	151969	law	external	municipality	0	1	0
	Gavle	SE	147998	free	own	municipality	0	0	1
	Cork	IE	147534	law	external	state	0	1	0
	Alicante	ES	147308	law	external	state	0	1	0
	Rijeka	HR	137048	law	external	state	0	1	0
	Mannheim	DE	120568	free	external	municipality	0	0	1
	Varna	BG	118702	law	external	state	0	1	0
	Hamina	FI	115388	free	external	municipality	0	0	1
	Ancona	IT	110395	law	external	state	0	1	0
	Cadiz	ES	109187	law	external	state	0	1	0
	Castellon de la Plana	ES	103956	law	external	state	0	1	0
	Ghent	BE	102128	free	external	municipality	0	0	1
	Rouen	FR	101328	law	external	state	0	1	0
	Bergen	NO	93238	law	external	municipality	0	0	1
	Ludwigshafen	DE	84762	free	external	state	0	0	1
	Lubeck	DE	83939	free	external	municipality	0	0	1
	Bristol	UK	80000	free	own	private	1	0	0
	Valletta	MT	79936	law	external	state	0	1	0
	Waterford	IE	71084	law	external	state	0	1	0
	Cartagena	ES	64657	law	external	state	0	1	0
	Amsterdam	NL	60043	free	own	municipality	0	0	1
	Tyne	UK	57950	free	own	private	1	0	0
	Szczecin-Swinoujscie	PL	56503	law	external	state	0	1	0
	Fredericia	DK	55000	free	own	municipality	0	0	1
	Palma de Mallorca	ES	54811	law	external	state	0	1	0
	Aalborg	DK	54147	free	own	municipality	0	0	1
	Marin	ES	48685	law	external	state	0	1	0
	Civitavecchia	IT	41500	law	external	state	0	1	0

Chapter 4

Port Charges in Spain: The role of regulation and market forces[1]

4.1. Introduction

Globalization and containerization have led to an increase in maritime freight traffic with shipping companies tending to operate out of just a few ports that serve as their logistic platforms. This has resulted in fierce competition among the world's ports as they seek to attract the traffic of the shipping companies.

In this context of fierce competition, and taking into account that port users are often multinational companies operating at the global scale, the study of charges of port authorities to terminal operators and shipping companies takes on considerable relevance. Firstly, port charges are generally subject to strong regulation, but in a context of global competition the market power of port authorities is not altogether clear. Secondly, port charges are one of the factors that influence the port selection of shipping companies and shippers (Steven and Corsi, 2012; Tongzon and Sawant, 2007). Finally, port charges are also significant since they determine the revenues that the Port Authority has available to finance its investments and current operations and they may also serve to alleviate problems of congestion.

Several empirical studies have examined the cost and efficiency indicators of ports (for a review, see Gonzalez and Trujillo, 2009)[2], while others have focused on the pricing strategies of shipping companies (Fung et al., 2003;

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[1] *Chapter written with Xavier Fageda. Comments from Germà Bel, Jose Ignacio Castillo-Manzano, Ancor Suárez-Alemán and Thierry Vanelslander really contributed to improve this paper. I thank as well participants to the WCTRS 2012, Antwerp; XV World Economic Meeting 2012, Santander and IAME 2013, Marseille, for helpful comments. Paper published at International Journal of Shipping and Transport Logistics. Reference: Fageda, X., Gonzalez-Aregall, M. (2014) "Port charges in Spain: The roles of regulation and market forces", International Journal of Shipping and Transport Logistics, 6 (2), 152–171.*

[2] Liu and Medda (2009) provide a recent analysis applied to the Europe-Mediterranean Area. In general, the main factors assessed in these articles are related to the size and ownership of the port authority's (see, for example, Cheon et al., 2010; Tongzon, 1995; Tongzon and Heng, 2005).

Stojstrom, 1989). However, no previous empirical study has examined the determination of port charges in any detail[3].

In this chapter, we undertake an empirical examination of relationships that influence traffic and revenue per tonne of Spain's port authorities by estimating a simultaneous equation system using data from 2004 to 2010.

Although the analysis focuses specifically on Spain, it is of relevance to other countries as it is quite usual that port charges are subject to strict regulation. The Spanish case is of particular interest because of the heterogeneity of the 28 port authorities. Here, we find ports that just serve the local hinterland while other ports, typically the largest, are involved in global markets. Furthermore, we find some terminals that are managed by private (multinational or national) firms and others managed by public firms or the Port Authority itself. However, all port authorities are subject to a common regulation.

Our objectives are, on the one hand, to determine whether port charges have a direct impact on traffic volumes; and, on the other hand, to examine whether the current legal system in Spain offers any scope for price competition despite the high degree of regulation of port charges. We study the relationship of regulation and of different types of competition (i.e., global or local) with the revenue a port authority is able to generate. The study also offers evidence as to which actor in the port system (i.e., the port authorities, terminal operators or shipping companies) wields the effective market power.

The rest of the chapter is organized as follows: Section 2 outlines the main features of the regulation of ports in Spain; Section 3 describes the empirical model used, including the sources of data and a justification of the explanatory variables selected. Section 4 provides an analysis of data describing Spanish ports. Section 5 explains the results of our regression analysis and the last section is devoted to summarizing the main findings and discussing the policy implications.

[3] Several theoretical papers have, however, examined different issues related to port charges and competition (see, for example, De Borger et al., 2008; Van Reeven, 2010). Note also that Vanden Bossche and Gujar (2010) analyze port pricing and competition for dry ports.

4.2. Regulation of port charges in Spain

The two main agencies managing the ports of Spain are "Puertos del Estado" and port authorities[4]. "Puertos del Estado" is a public company under the auspices of the Ministry of Transport. Its main objectives are to coordinate operations, and to approve the port authorities' investment plans. Additionally, it is the agency that regulates the prices that the firms managing the terminals charge to shipping companies. It is financed by a share (four per cent) of the total revenues of each port authority located on the mainland and a share (two per cent) of the revenues of ports situated in Spain's islands and in Ceuta and Melilla.[5]

The port authorities (PAs), on the other hand, are public institutions with their own legal structure and a president/CEO of the organization appointed by the regional Government. The president's role is to propose investment plans and establish concession contracts with the companies that operate at the terminal. All the port authorities are financed by property income, port charges and contributions from the inter-port solidarity fund.[6]

Our analysis is of port charges between 2004, the first full year following the introduction of Law 48/2003, and 2010.[7] The structure of port charges is set by the central agency, Puertos del Estado, rather than by port authorities.

Terminal operators have to pay two charges to the port authorities: a fee for the private occupation of a public area and a fee for the use of a public domain. The former is fixed according to the area occupied, and the charge is updated on an annual basis in line with the consumer price index. By contrast, the second fee is fixed according to the type and volume of activity and the degree of utility of the service obtained. Both fees depend on the land value of

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[4] For details about the reform of port management in Spain, see Castillo-Manzano, J.I. (2010); Castillo-Manzano et al. (2008) and González and Trujillo (2008).

[5] This kind of tax seems a very high price that port authorities must pay to the central agency. The analysis of the benefits that could come from a more de-centralized management system is out of the scope of this study.

[6] The inter-port solidarity fund is a financial tool managed by Puertos del Estado to redistribute resources among the different port authorities. For financing this fund, each port authority has to provide up to 12 percent of their revenues. The redistribution of resources is made according to criteria of co-investment in infrastructures for port authorities in difficult situations (due to hinterland limitations, to be located in an island, etc.), environmental actions and improve road and rail accessibility.

[7] A new regulation introduced in 2010 provided greater incentives to manage the environmental sustainability of the port and to attract new sources of private investment.

the port area and they are paid directly from the concessionaire to the port authority.

Shipping companies also have to pay a fee for the special use of port facilities. This is determined by three separate charges. Firstly, a good's rate is based on a classification of different types of goods.[8] This classification is the same for all the port authorities and is, in theory, determined by port infrastructure costs. The regulation provides various parameters depending on the particular group of merchandise. In general, the parameter related to the rate of bulk goods is the lowest, while it is less clear as to whether containerized or general cargo pay higher prices. In general, however, the rate charged to the different goods is not related to any specific economic criteria; goods with a higher economic value are not necessarily charged a higher fee. Secondly, the vessel rate is determined by the size of the vessel. Finally, the passenger rate is determined by the units of transport (passengers, vehicles, etc.). These rates are paid directly by the shipping companies to the Port Authority.

The regulation provides some scope for price competition through the application of two tools: a correction coefficient and discounts. The correction coefficient is the percentage that each port authority can apply in order to modify the fee paid by the shipping companies. *A priori*, these correction coefficient rates are established according to criteria such as the needs of investment, the debt level or the expected demand for each port authority. However, the most important feature of the correction coefficient is that it implies a *"regulation of maximum profit"*. Indeed, a port authority with higher profit levels than the national mean has to decrease its prices by up to 15%, while a port authority with lower profit levels has to increase its prices by up to 15%. This regulation of maximum profits may generate an economic distortion, since the price setting is not necessarily related to the costs of each port authority.

The second tool to promote competition comprises the discounts that port authorities can apply under certain conditions. In the case of terminal operators, discounts may be applied to public entities or firms that have a substantial investment in the port. Numerically, the discounts on terminal operators vary within a range from 10 to 50% of the terminal operator's fee.

[8] In relation to this rate, Núñez-Sánchez et al. (2011) examine the relationship between price levels and marginal costs. They find that prices are generally slightly higher than marginal costs.

In the case of shipping companies, discounts depend on the type of rate. As regards the vessel rate, the port authority may apply discounts if a shipping company is an intensive user of the port facilities, if it has regular lines in that port, if it ships goods to the Spanish islands or to Ceuta and Melilla, and if it contributes to an improvement in the port's environmental practices. As for the good's rate, discounts depend on the country of origin and the type and amount of traffic. It is not clearly established in the regulation which type of traffic is entitled to most discounts; it is left to the discretion of the port authority. Finally, discounts can be applied to passengers who live on an island.

The regulation fixes for each port authority an upper limit on the maximum amount that the discounts can represent as a share of its total revenue. Specifically, the sum of all discounts cannot exceed ten per cent of the mean total revenue for the last five-year period. However, a shipping company may enjoy specific discounts that represent a substantial discount on the fees that they should pay to the port authority. Specifically, these discounts may range from 10 to 70% of one of the three rates (goods, passengers and vessel).

In short, shipping companies that use a port as a hub can benefit from higher discounts. Furthermore, terminal operators that invest substantially in a port may also benefit from higher discounts. The amount of discounts that a shipping company or terminal operator can receive from the port authority may depend on their relative market power. A shipping company with a substantial share of traffic in the port may wield considerable negotiating power because the port depends on its activity and the shipping company might transfer its ships to another endpoint. By contrast, the negotiating power of the terminal operator could be weaker because it has to invest in what are largely sunk assets, including cranes or the rights to use the public domain.

4.3. The Empirical model

In this section we develop an empirical model of traffic in Spanish ports and their revenues per tonne, drawing on data for the period 2004-2010. In identifying the determinants of demand, we have considered those used in typical demand models for transport infrastructure as we are not aware of previous empirical studies of port charges and traffic. In general, the use of transport infrastructure depends on the demographic size and the wealth of the region in which the infrastructure is located, its geographical location, the prices charged for using the infrastructure and, in the case of ports, the extent of industrial activity and the degree of internationalization of the port activity itself.

Port charges are considered related to the volume and type of traffic, the competition and the relative market power of the users of the infrastructure. Unlike ports, several empirical studies have examined revenues or charges in airports (Bel and Fageda, 2010; Bilotkach et al., 2012; Van Dender, 2007). Our pricing equation, therefore, follows the same line of reasoning as that adopted in these papers focused on airports, but we incorporate the particular characteristics of ports and the price regulation framework that prevails in Spain.

We estimate a demand equation in which the dependent variable is the amount of traffic handled by the port authority and a pricing equation in which the dependent variable is the revenue per tonne generated by the port authority. The equations to be estimated are as follows:

The demand equation (1)

$$\begin{aligned}\text{Traffic}_{it} = {} & \beta_0 + \beta_0 \log(\text{revenue\_per\_tonne}_{it}) + \beta_2 \text{GDP}_{it} + \beta_3 \text{pop}_{it} \\ & + \beta_4 \text{indus}_{it} + \beta_5 \text{long}_{it} + \beta_6 \text{latit}_{it} + \beta_7 \text{perc\_interna}_{it} \\ & + \beta_8 \text{car}_{it} + \beta_9 \text{year05} + \beta_{10} \text{year06} + \beta_{11} \text{year07} \\ & + \beta_{12} \text{year08} + \beta_{13} \text{year09} + \beta_{14} \text{year10} + \varepsilon_t\end{aligned}$$

The pricing equation (2)

$$\begin{aligned}\text{Revenue\_per\_tonne}_{it} = {} & \alpha_0 + \alpha_1 \log(\text{traffic}_{it}) + \alpha_2 \text{pax}_{it} \\ & + \alpha_3 \text{number\_nearby\_ports}_{it} + \alpha_4 \text{HHI}_{it} \\ & + \alpha_5 \text{multinational}_{it} + \alpha_6 \text{perc\_interna}_{it} \\ & + \alpha_7 \text{bulk}_{it} + \alpha_8 \text{conten}_{it} + \alpha_9 \text{island}_{it} \\ & + \alpha_{10} \text{ceumel}_{it} + \alpha_{11} \text{year05} + \alpha_{12} \text{year06} \\ & + \alpha_{13} \text{year07} + \alpha_{14} \text{year08} + \alpha_{15} \text{year09} \\ & + \alpha_{16} \text{year10} + \xi_t\end{aligned}$$

- *Demand Equation*

In the demand equation, the dependent variable (TRAFFIC) is the sum of traffic through the port authorities i during year t expressed in tonnes. Data on port traffic were taken from the historical series provided by the Ministry of Transport. We consider the following variables when explaining the traffic in a port authority i during year t:

1) LOG (REVENUE PER TONNE). We consider all revenue per tonne for all the port authorities. To calculate this we take into account the total revenues of each port authority and we divide this by the total amount of traffic. Total revenue data were taken from the annual reports of each port authority and port traffic data were taken from the Ministry of Transport's historical series. The main interest of our traffic equation lies in this variable. We expect ports that charge lower prices have more traffic, i.e., we are interested in determining the relationship of prices with the volume of traffic generated by the port. While it seems clear that a port's traffic depends on the fundamental attributes of its hinterland, including its population, GDP and geographical location, we seek to test whether these charges might also influence traffic after controlling for these attributes. Other key factors such as land accessibility by train or road cannot be taken into consideration due to a lack of data. This variable is expressed in logs because the relationship between traffic and revenue per tonne is not linear.

2) Gross domestic product per capita in region i during year t (GDP). The information for this variable was obtained from Spain's Institute of Statistics (INE). These data are available at the regional level (NUTS 2). We expect the coefficient of this variable to present a positive sign since wealthier regions should generate more demand for maritime transport services.

3) Population in region i during year t (POPULATION). These data are available at the provincial level (NUTS 3) and again are provided by the INE. We expect the coefficient of this variable to present a positive sign since the demand for maritime transport services should be higher in more highly populated cities.

4) We capture the industrial activity (INDUSTRIAL) as the total number of employees in the industry sector (data from the INE) at the autonomous region level (NUTS 2). The demand for maritime transport services should be higher in industrial areas with a more intense import/export activity, so we expect to find a positive relation between industrial activity and the amount of traffic.

5) Due to its geography, namely a Peninsula jutting out into the Mediterranean and the Atlantic Seas, Spain makes an interesting case study. We, therefore, employ two variables of location. On the one hand, the (LONGITUDE) variable indicates whether the port is situated in the East (positive sign) or the West (negative sign); and, on the other hand, the (LATITUDE) variable is positive when the port is in the North and negative when located in the South. Spain's largest ports lie in the Mediterranean Sea and absorb part of the international trade originating from Asia since the shipping companies use the Suez Canal. As such, we expect a positive sign for the longitude variable and a negative sign for the latitude variable.

6) CAR: We also construct a dummy variable to account for a particularly important industrial sector in Spain.[9] We consider a dummy variable that takes a value of 1 for a region with an automobile production plant and 0 otherwise. In assigning this variable we consider if the production plant is located within a specific provincial level (NUTS 3). Here, we expect a positive sign, on the understanding that if an automobile production plant is located in the region, then the port should benefit from more traffic because of the increased amount of imports and exports in that region.

7) PERCINTERNA: The percentage of international regular lines among the total number of regular lines. Ports that have a higher number of international regular lines should generate more traffic than is generated by national lines; so, we expect the coefficient of this variable to be positive.

[9] According to the Bank of Spain (Banco de España, Boletin Economico May 2011), the exports of the automotive industry accounted for 22.2% of total exports (in terms of medium value) for the period 1999-2009.

8) Finally, we consider six dummy variables, one for each year in the study, in order to take into account the time effect. We estimate this time effect from 2005 to 2010 with 2004 serving as the year of reference.

- Pricing Equation

The dependent variable is the total revenue per tonne that the port authority charges to its concessionaires and to the shipping companies (REVENUES PER TONNE). The explanatory variables are the following:

A) LOG (TRAFFIC): We consider the total amount of traffic handled by each port authority. As above, we use logs because the relationship between traffic and revenue per tonne is not linear. We expect the coefficient of this variable to present a negative sign as some components of the port charges are fixed and the regulations establish that ports generating higher profits (i.e., handling more traffic) have to reduce their prices (regulation of maximum profit).

B) Some ports move a substantial number of passengers. Thus, we construct a dummy variable (PAX) that takes a value of 1 for ports handling more than a million passengers during 2009.[10] The information is available from the "Puertos del Estado". While the variable may capture the fact that a higher number of passengers will generate more income, the number of tonnes transported will not be affected. Thus, in consequence we expect the coefficient of this variable to present a positive sign.

C) Spain has 28 port authorities that manage 44 ports of general interest. Given this number, several ports may be located very close to each other; in some instances we even find more than one port in the same province (NUTS 3). Thus, we consider the intensity of local competition by including a variable that measures the number of ports within a one-hundred mile (NUMBER NEARBY PORTS). The information is available from the "Puertos del Estado". We expect the intensity of competition for a port authority to increase with the number of nearby ports. Hence, we expect this variable to present a negative sign as the port authority may have more incentives to apply discounts due to more intense local competition.

[10] The ports are Almeria, Bahía de Algeciras, Baleares, Barcelona, Ceuta, Las Palmas and Santa Cruz de Tenerife.

D) We consider the market power of the shipping companies by including a variable of concentration at the port level.[11] To do this, we count all the regular lines that the shipping companies provide in each port. Note that, especially in the largest ports, some regular services are operated by more than one regular shipping line. We construct a Herfindahl-Hirschman Index (HHI) based on the sum of the square shares enjoyed by the shipping companies operating in the port.[12] To calculate the HHI we take the total number of companies that operate a regular line and their respective shares among the total regular lines. We create our own database from the annual reports of all the port authorities.

We expect shipping companies with a larger share in the port's traffic to have a higher bargaining power in negotiations with the port authority since the port's total traffic will be more dependent on the decisions of those specific shipping lines. Thus, port authorities may have more incentives to offer discounts if just a few shipping lines concentrate the supply of regular lines. Thus, we expect this coefficient to present a negative sign associated with the HHI variable. In ports in which the shipping lines present low levels of concentration, shippers may also play a key role in choosing the port to handle their goods.

The most accurate measure of the shipping companies' share of traffic would be the total cargo loaded and unloaded, but unfortunately this information is not available. Furthermore, data have had to be collected manually using the annual reports or websites of each port authority. Thus, we only have data for 2010.

E) As an indicator of the level of operation of the terminal operator, we create a dummy variable (MULTINATIONAL) that takes a value of 1 if the terminal operator is a multinational company and 0 otherwise. This variable seeks to measure the presence of multinational companies among terminal operators. The port authority could have incentives to apply discounts to firms that operate at the global level because these firms may offer greater potential for investment than public firms or private firms that operate at a local level. In this regard, the bargaining power of the terminal operators could be weakened by the fact that they have already incurred major investments with

[11] The liner shipping industry is dominated by few large operators. However, Lun and Marlow (2011) show that non-mega operators can be very efficiently too.

[12] Some values are missing for Aviles, Huelva, Las Palmas, Motril and Santa Cruz de Tenerife.

high sunk costs.[13] By contrast, multinational operators tend to manage specialized container terminals that may well be associated with higher costs than other terminals (due, for example, to more expensive cranes). Thus, a priori, the sign of the coefficient associated with this variable is unclear. Note that the higher costs associated with facilities required to handle containers could also be captured by a variable that accounts for the percentage of total traffic transported by containers.

F) The percentage of international regular lines among the total number of regular lines (PERCINTERNA). Port authorities may have incentives to apply more discounts when traffic is restricted to a higher percentage of international regular lines, which may be subject to global competition. However, international regular lines are less subject to intermodal competition from rail and road to serve shippers than national lines. Thus, a priori, the sign of the coefficient associated with this variable is unclear.

G) Charges to shipping companies according to the category of the good. A (BULK) good is charged as a "cheaper" good, so this should have a direct impact on revenue per tonne. Thus, we expect the coefficient associated with this variable to present a negative sign.

H) At the same time, we can consider the degree of containerization (CONTE) of a port though the percentage of containerized traffic over total traffic. The classification of goods in terms of the level of charges does not clearly distinguish between containerized and general traffic. However, container traffic may be associated with capital costs due to a need for more specialized assets but yielding heightened productivity. In any case, a priori, the sign of the coefficient associated with this variable is unclear because it might be the case that goods belonging to the general traffic category (such as cars) are more expensive than container traffic.

I) The regulation grants peripheral or isolated regions some specific advantages. To take this into account, we construct two dummy variables. (ISLAND) takes a value of 1 for ports located in Spanish Islands (Balearics and Canaries). We also include a variable (CEUMEL) that takes a value of 1 if the ports are located in the two Spanish cities in North Africa: Ceuta and

[13] For example, in Barcelona the multinational company Hutchison Port Holdings Group opened a new container terminal in September 2012. The new terminal occupies a 100-hectare site, boasts a quay that is 1,500 meters long and has the capacity to handle 2.65 million TEUs each year. The total investment in the new terminal amounts to about 500 million Euros.

Melilla. Traffic to these peripheral locations is not subject to intermodal competition from road and rail but at the same time the current regulation fixes lower charges for ports located in islands. Thus, the sign of the coefficient associated with this variable is unclear.

J) Finally, we consider six dummy variables, one for each year in the study, in order to take into account the time effect. We estimate this time effect from 2005 to 2010 with 2004 serving as the year of reference.

4.4. Data on Spanish ports

The Spanish port system comprises 28 authorities and a total of 44 general interest ports. The data used have been taken from the Ministry of Transport, "Puertos Del Estado" and the annual reports published by the Port Authorities for the period 2004-2010.

As Table 4.1 shows, Algeciras, Valencia and Barcelona are the ports handling most traffic and with most containers. The table also shows that only nine of the 28 port authorities have specialized container terminals. In general, the largest ports have terminal operators that are managed by some of the world's leading companies. They include the Hutchison Port Holdings Group in Barcelona and DP World in Tarragona. Terminal de Contenidors de Barcelona (TCB) is a national firm that operates around the world and has a presence in several Spanish ports. Other terminals are managed directly by shipping companies. This is the case of Mediterranean Shipping Company (MSC) in Valencia and Hanjin in Algeciras.

Table 4 1. Main characteristics of Spanish ports

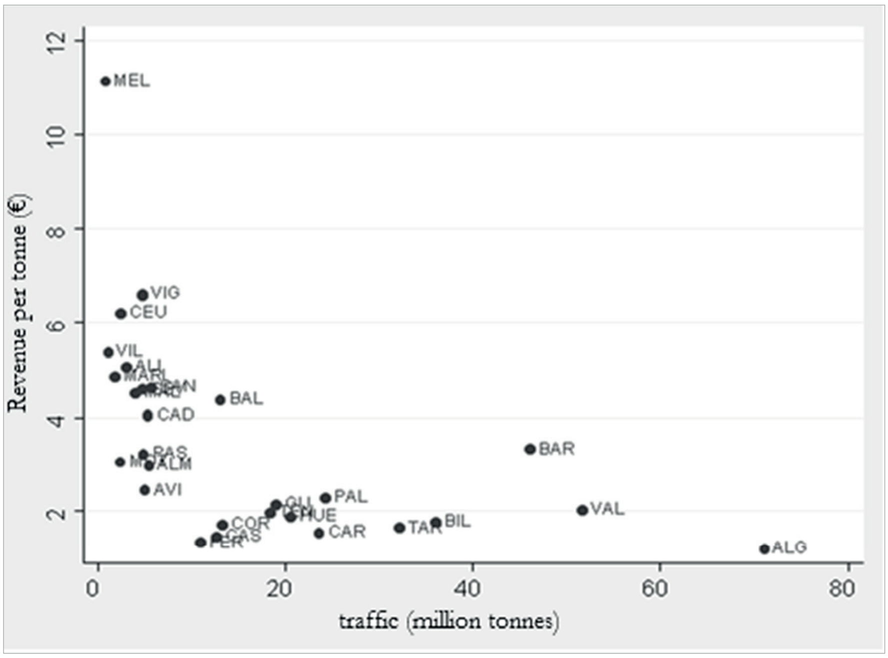
PORT AUTHORITIES (Abbreviation)	TOTAL TRAFFIC (TONNES)	CONTAINERS (TEU)	Nº OF SPECIALIZED TERMINALS (FIRMS)	TOTAL Nº REGULAR LINES	% INTERNATIONAL REGULAR LINES	DOMINANT SHIPPING COMPANY	HHI
B.ALGECIRAS (ALG)	71048280	3138092	2 (APM / HANJIN)	67	92.54 %	Maersk	0.609
VALENCIA (VAL)	51662952	3099570	3 (NOATUM/MSC/TCB)	80	96.25 %	MSC	0.015
BARCELONA (BAR)	46098736	2171957	2 (TCB / TerCat-Hutchison	95	81.05 %	MSC	0.008
BILBAO (BIL)	36023316	508930	1 (NOATUM)	104	93.27 %	MacAndrews	0.002
TARRAGONA (TAR)	32111253	79767	1 (DP WORLD)	21	85.71 %	ZIM integrated Shipping Services	0.016
LAS PALMAS (PAL)	24271682	1196118	-	n.a.	n.a	n.a.	n.a
CARTAGENA (CAR)	23587996	43903	-	31	100 %	Maersk	0.111
HUELVA (HUE)	20544759	0	-	n.a.	n.a.	n.a	n.a
GIJÓN (GIJ)	18991113	17166	1 (TCB)	7	85.71 %	WEC LINES	0.183
S.C.TENERIFE (TEN)	18352238	419823	1 (TCB)	86	83.72 %	n.a	n.a.
A CORUÑA (COR)	13281465	4447	-	1	100 %	OPDR Hamburg	1
BALEARS (BAL)	13054753	170444	-	12	0 %	Eurolineas Marítimas	0.206
CASTELLÓN (CAS)	12644303	73100	-	23	100 %	Línea Messina	0.085
FERROL-S.CIBRAO (FER)	10948753	1550	-	3	100 %	-	-
SANTANDER (SAN)	5688419	651	-	21	100 %	Wallenius Wilhemsen Lines	0.036

ALMERIA (ALM)	5445873	985	-	6	83.33 %	Acciona Transmediterranea	0.13
B.CÁDIZ (CAD)	5294482	127623	1 (CONCASA)	12	50 %	-	-
AVILES (AVI)	5032211	6926	-	1	0 %	Guixar	1
PASAIA/PASAJES (PAS)	4846814	3	-	6	83.33 %	UECC Norway	0.183
VIGO (VIG)	4777592	216229	-	65	87.69 %	MITSUI 0.S.K. LINES	0.008
SEVILLA (SEV)	4681031	128032	-	14	92.86 %	ZIM Lines	0.140
MÁLAGA (MAL)	3952267	321975	1 (NOATUM)	10	70 %	Terminales del Sudeste- Grupo NOATUM	0.528
ALICANTE (ALI)	3112125	155921	-	21	52.38 %	-	-
CEUTA (CEU)	2439006	11628	-	4	25 %	-	-
MOTRIL (MOT)	2385934	787	-	n.a.	n.a.	n.a.	n.a.
MARÍN. PONTEVEDRA (MARI)	1817693	36106	-	4	75 %	Seatrade	0.25
VILAGARCIA DE AROUSA (VIL)	1081373	4775	-	3	66.66 %	P. & J. CARRASCO. SL	1
MELILLA (MEL)	798395	21031	-	4	50 %	Cia Trasmediterránea	0.16

Note: Traffic data refer to the mean values for the period 2004-2010, while data on regular lines are for 2010. Source: Based on information obtained from the Ministry of Transport and the annual reports of all the Port Authorities.

In the case of shipping companies, the dominant company is generally a multinational firm operating globally. The concentration index, indicative of the share of the total regular lines that each shipping company is operating in the port, shows that in most ports there is a diversification of shipping operations. As such, there are very few ports that function as a hub for one specific shipping company. Thus, the largest ports, including Barcelona, Valencia and Tarragona, are used by a highly diversified range of shipping companies. The main exception here, however, is the port of Algeciras (which handles the most traffic in Spain). In this port, one shipping company (Maersk) handles around 60% of total traffic. Although to a lesser degree, some concentration is also apparent in Malaga, the Balearics and Melilla where local shipping companies tend to dominate the domestic regular lines. The concentration levels are also higher than the mean sample in some northern ports (Gijón and Pontevedra, for example) with international shipping companies dominating a large number of regular lines. Note that, except in the Aviles, Balearics and Ceuta, traffic is mainly centered on international regular lines.

Figure 4 1. Scatter plot between traffic and port revenues per tonne



Source: Based on information obtained from the Ministry of Transport and the annual reports of all the Port Authorities.

Figure 4.1 shows a scatter plot describing the relationship between traffic and port revenues per tonne. The largest ports (Algeciras or Valencia) have more traffic but lower revenues per tonne than most of the other ports.[14] However, revenues per tonne are higher in Barcelona than in several smaller ports. It is clear, therefore, that the charges in operation in Algeciras (which serves as a hub) are lower than those in Barcelona and Valencia (which operates as a gateway). In addition, revenues per tonne are especially low in a group of large ports that specialize in bulk traffic (namely, Bilbao, Cartagena and Tarragona).

It seems that below certain traffic limit (around 10 million tonnes), revenues per tonne become higher. A possible explanation for this might be that some components of port charges are fixed regardless of the level of traffic. Furthermore, the correction coefficient (which imposes a regulation of maximum profit) might also account for the lower charges made by the large ports.

4.5. Estimation and Results

The data used for estimating the equations considered herein have a time-series, cross-sectional structure (data panel). Various techniques and estimation models are available for estimating equations with data panels of this nature.

The random effects model, however, is not a suitable alternative in our context because the random effects may be correlated with some of the explanatory variables. Likewise, the Hausman test is not useful for testing the suitability of the random effects because several explanatory variables are time-invariant, which means that results for the random and fixed effects models will differ. Here, the use of the fixed effects means that we may fail to identify the effect of the time-invariant variables, such as a port with an island location. This shortcoming of the fixed effects model is particularly grave in the case of the pricing equation because our variables designed to capture competition do not vary over time. This is the case of the dummy variable for multinationals that operate at least one terminal in the port, the number of nearby ports and the concentration index based on the shares of shipping companies operating regular lines in the port. Thus, here we have opted to present the results of the demand equation using the pooled model and the fixed effects model, but in the case of the latter we have excluded the time-invariant variables. The results of the pricing equation are based on the pooled model, taking into account

[14] Note that only four of the 28 ports reported losses in the period under review.

that our analysis focuses primarily on the between rather than the within variation of the data.

Furthermore, our estimates might present heteroscedasticity, non-stationarity and temporal autocorrelation problems in the error term. Here, the Wooldridge test for autocorrelation in panel data shows that we may have a problem of serial autocorrelation which we correct through clusters of time. The Levin-Lin-Chu test of unit roots indicates that the dependent variables (traffic, revenues per tonne) do not contain a unit root and, hence, we can confirm that there is no long-term co-integration relationship. Furthermore, the standard errors are robust to any problem of heteroscedasticity after applying White standard errors.

We also take into account the possibility that some endogenous explanatory variables might bias the estimations. In the case of the demand equation, the revenues per tonne variable may be endogenous. In the case of the pricing equation, we do not consider the multinational variable to be endogenous because the investment plans of the multinational terminal operators represent specific, one-off decisions. By contrast, we do consider two endogenous variables in the pricing equation, namely, traffic and the HHI.

Thus, the estimation is made using the two-stage least squares estimator. The instruments of the traffic and concentration index variables in the pricing equation are: GDP, Population, Longitude, Latitude, Industry and Car (see descriptions in section three above). The instruments of the revenues per tonne variable in the demand equation are: Passengers, Number of nearby ports, Multinational, Bulk, Containerization, Island and Ceumel (see descriptions in section three above). The partial R^2 in the first step of the estimation shows that the instruments are strong.

Table 4 2 Results of the Demand equation

	(1) Traffic	(2) Traffic	FE (with temporal effects)	FE (without temporal effects)
L(revenues per tonne)	-1.81e+07*** (512,847.4)	-1.57e+07*** (675,427)	-1.08e+07*** (3874881)	-1.15e+07*** (3497284)
GDP	1,063*** (109.7)	1,048*** (96.92)	121.2 (392.8)	841.7*** (242.6)
Population	5.065*** (0.174)	5.679*** (0.298)	12.23 (7.773)	21.96*** (6.141)
Longitude	462,285*** (69,141)	482,875*** (73,672)	-	-
Latitude	-137,047*** (63,513)	-1,406,105*** (75,459)	-	-
Industrial	2,402* (988.5)	591.2 (983.9)	-3,429 (13,427)	-4,613 (14,305)
Perceninterna	-	5,449,036*** (1101141)	-	-
Car	9525619*** (1027756)	6,988,020*** (1258756)	-	-
year05	567,005*** (134,191)	512,828** (139,018)	886,104 (891,459)	-
year06	-967,688*** (230,457)	-654,064** (254,886)	16,325,876 (1381009)	-
year07	-653,291* (336,125)	-478,639 (375,430)	2,600,079 (1838656)	-
year08	2,101,162*** (338,839)	1,728,708** (501,398)	4,136,835* (2390560)	-
year09	3,056,310*** (242,316)	2,384,515*** (509,219)	3,120,380 (2522385)	-
year10	2,741,688*** (243,741)	1,968,283*** (510,284)	31,551,344 (2450749)	-
Constant	5.91e+07*** (3291372)	5.51e+07*** (5196879)	9,193,976 (1.56e+07)	-1.40e+07* (8321118)
Observations	189	170	190	190
F	49.14 ***	48.15***	8902.91***	8499.12***
R^2	0.60	0.60	0.44	0.37

Note 1: Standard errors in brackets.
Note 2: Statistical significance at 1%(***), 5%(**), 10% (*)

Finally, we also take into account a potential problem of multicollinearity due to the correlation of some of the explanatory variables. The variance inflation factor is lower than 2 in the demand equation and lower than 3 in the pricing equation so we can conclude that there is no problem of multicollinearity.

Table 4.2 shows the results of the estimation of the demand equation of traffic in Spanish ports. Recall that data for certain variables, including the HHI and percentage of international regular lines, are not available for all port authorities. Thus, the first column shows the results for all port authorities but not for all variables, while the second column shows the results for all variables but not for all port authorities. The last two columns show the results with fixed and temporal effects (third column) and with fixed effects but without temporal effects (fourth column).

The explanatory capacity of the estimated models based on the R^2 is quite satisfactory. The following conclusions can be drawn from our findings. First, as expected, the variables of GDP per capita, population, industrial activity and the dummy for the car industry are all statistically significant. Similarly, and as expected, all the variables related to the economic activity of the region in which the port is located have a substantial influence on traffic.

In addition, the location variable reveals that there is more traffic in the East (the longitude coefficient being positive) and in the South (the latitude coefficient being negative), reflecting that the Mediterranean Sea ports handle more traffic. This, as discussed, is attributable to the use of the Suez Canal route which leads to a concentration of the traffic linking Asia with Europe.

This result is in line with that obtained for the variable of the percentage of international regular lines. The coefficient associated with this variable is positive and statistically significant. Thus, we find evidence that ports with more international regular lines have a greater capacity to generate traffic beyond that directly related with the local hinterland.

Importantly, the coefficient associated with the revenues per tonne variable is negative and statistically significant in all the regressions. Thus, we find that higher port charges are associated with lower volumes of traffic and that not only the demographic size, geographical location and economic activity of the hinterland influence the amount of traffic that a port is able to generate. Controlling for all these variables, traffic seems to be affected by the price levels. Together with the level of investment, port managers may also influence the decisions of shipping companies and shippers. In terms of elasticities, a 10% increase in revenues per tonne is associated with an 11% decrease in traffic.

Overall, from our results, we can infer that the regulation of port charges is important as a competitiveness factor. Of course, there are other elements including the costs of transporting goods to and from the port over land that we are unable to capture and which must have an influence on the competitiveness of ports.

Table 4.3 shows the results of the estimation of the pricing equation and explains the determinants of the revenues per tonne for the Spanish ports. The first column shows the results for all port authorities but not for all variables, while the second column shows the results for all variables but not for all port authorities.

Table 4 3 Results of the Pricing equation

	(1) Revenues per tonne	(2) Revenues per tonne
ltraffic	-1.326*** (0.219)	-1.728*** (0.202)
pax	-0.191 (0.182)	0.0996 (0.208)
n100	-0.310** (0.0912)	-0.342*** (0.0642)
multinational	0.651** (0.193)	1.122*** (0.216)
perceninterna	-	1.444** (0.419)
bulk	-3.933*** (0.252)	-2.756*** (0.470)
conte	-1.200*** (0.293)	0.0857 (0.593)
island	-0.874*** (0.202)	1.622** (0.544)
ceumel	2.004** (0.585)	2.389** (0.810)
hhi	-	-0.873*** (0.176)
year05	0.142*** (0.0167)	0.177*** (0.0164)
year06	0.274*** (0.0310)	0.346*** (0.0296)
year07	0.433*** (0.0358)	0.522*** (0.0340)
year08	1.200*** (0.0176)	1.328*** (0.0166)
year09	1.540*** (0.0184)	1.626*** (0.0182)
year10	1.236*** (0.0100)	1.246*** (0.0162)
Constant	26.97*** (3.620)	31.34*** (2.955)
Observations	189	163
F	33.09***	40.32***
R^2	0.78	0.81

Note 1: Standard errors in brackets.
Note 2: Statistical significance at 1%(***), 5%(**), 10% (*).

We find that more traffic is associated with lower revenues per tonne. Indeed, the coefficient associated with the traffic variable is negative and statistically significant. This result can be justified in terms of scale economies (i.e., costs per tonne fall as traffic volume rises) provided some charges remain fixed. Moreover, the regulations governing port charges place a limit on the maximum amount of profits. So, the ports with most traffic have a greater probability of making more extraordinary profits and this regulation imposes a reduction in their prices.

In addition, the coefficient associated with the island variable is negative and statistically significant. This result can also be explained by the regulations governing port charges whereby ports located on islands issue lower charges, even though their traffic is largely captive. By contrast, the coefficient associated with the variables of Ceuta and Melilla is positive. In these port cities, higher prices may well reflect the higher amount of captive traffic.

The coefficient of the number of nearby ports variable is negative and statistically significant. This finding has two possible interpretations. First, it seems that the discount system functions in the case of local competition. Second, the existence of a higher number of nearby ports would seem to have a detrimental impact on each port authority's income per tonne.

The coefficients associated with the containerization and bulk variables are negative and statistically significant, but while the passenger variable is also negative it does not reach statistically significant levels. In this sense, and based on Spanish legislation and the good's rate, bulk traffic is cheaper than the containerized merchandise. Here, it would seem that non-containerized general merchandise, such as cars, is more expensive to ship than containerized merchandise. The containerization variable, therefore, does not seem to capture the possible higher costs associated with the specific assets required to handle containers. It could be also that the efficiency of container systems in supply chains explains the negative sign of the containerization variable[15].

The coefficient associated with the variable of multinational companies serving as the terminal operator presents a positive sign and is statistically significant. Thus, we find that terminal operators do not benefit from discounts. Here, we can conclude that such a situation negatively affects the

[15] See Quaresma Dias et al. (2009) for a study of the efficiency of container terminals applied to the Iberian seaports.

competition between ports that are subject to global competition, and that these ports are unable to improve their competitive position via price changes. A further key aspect related to this positive correlation is the importance of the increased costs associated with the investment in a specialized container terminal that influence on the bargaining power of the terminal operator in front of the port authority. On the one hand, the specific investment implies considerable sunk costs that weaken the operator's bargaining power with the port authority because the terminal operator will have less incentives to move its activity to another port in case of an increase in port charges. On the other hand, the traffic of the port authority could be more dependent on decisions made by the specialized terminal operator. In our analysis, the first effect seems to be more relevant.

In the case of the shipping companies, the coefficient associated with the HHI variable has a negative sign and is statistically significant. We find that the discount system works only in ports with many regular lines, such as the hub ports. From our results we can infer that the shipping companies with a high market share enjoy stronger negotiating powers when seeking discounts from the port authorities. Thus, our results seem to indicate that the market power of the shipping companies is greater than that of the terminal operators.

The coefficient associated with the percentage of regular international lines is positive and statistically significant. We find that ports with greater volumes of international traffic report higher revenues per tonne, while the national shipping lines pay less than international shipping lines. This might be because the international lines require larger ships and, as such, the charges associated with these ships will be higher. In addition, ports with a multinational terminal operator have more international regular container lines. Furthermore, the national regular lines must compete with alternative modes of transport, e.g. road or railway transport. Yet, ports linked to international regular lines and which are thus subject to global competition do not seem to be able to apply charges that are any lower than those applied by ports subject solely to local competition.

4.6. Conclusions

In this chapter, we have found that higher port charges are associated with lower volumes of traffic, so that the former are important as a competitiveness factor of Spain's ports. Our results also show that ports set lower charges where a number of shipping companies operate many regular lines. In contrast, ports do not set lower charges where the terminals are managed by multinational companies or where the international traffic is higher. Such a situation has a negative impact on the competition between ports that are subject to global competition and raises the costs of terminal operators when they make an investment. By contrast, we have found evidence that if there is a significant number of nearby ports the revenues per tonne decrease. Thus, we find evidence of local price competition.

In Spain, the 28 port authorities operate under common regulations but they differ markedly in terms of their size, the functions of their terminal operators and shipping companies and the type of traffic they handle. More specifically, the main specialized container ports do not compete with other national ports but rather with the other major ports of Europe. Most of Spain's large ports need to improve their accessibility by land, but in a context of severe budgetary constraints affecting public administration. These investments will presumably have to be made by private companies. Such investments can then either be financed by tolls paid by users or by a deferred payment from the public administration. The current regulations are quite strict and may prevent port authorities from compensating port users for higher land costs by implementing a pricing system.

There are large multinational companies operating terminals that have invested large sums of money in several Spanish ports. These investments (with their associated sunk costs) create strong links between the port authority and the company. For this reason, the negotiating position of the terminal operator can be weakened. In fact, we have found that they sometimes pay higher prices than public firms (even the port authority) or national firms. However, it seems that the bargaining power of shipping companies is stronger, especially when they enjoy a high market share. In this sense, it seems that the regulation of prices in Spain favors lower prices in hub ports, such as Algeciras, but this is not the case in gateway ports, such as Barcelona or Valencia, which have a much more diversified traffic.

Port authorities have to consider the following trade-offs when setting charges: lower prices can contribute to higher volumes of traffic while high prices can serve to fund investment. Hence, pricing regulations affect not only a port's competitive position, but also its ability to finance investments. In a context of global competition, ports should have some flexibility in defining their business strategy without overlooking any potential mechanisms of solidarity. This put into question the role of the central agency, Puertos del Estado, as Spanish ports could be better off freeing the individual port authorities to manage their businesses as independent local port authorities.

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Chapter 5

Conclusions and Policy Implications

This present dissertation deals with the analysis of seaport infrastructure through three unique essays on port economics. Particularly, this study has focused on quantify seaport influence and evaluating its effects and its consequences in a general dimension of European port authorities and also, in the Spanish framework. In a context of container influence, Chapter 2 focuses on the effects of transport infrastructure and its international connectivity on employment industry. Chapter 3 analyzes whether a more competitive scenario affect the amount of traffic that a port is able to generate. Chapter 4 aims to identify the effect of price regulation on port activities. Finally, this current chapter presents the main findings of each study as well as some policy implications that may be derived from these results.

Generally, it is accepted that better transport infrastructure implies a positive effect on economic growth. In order to evaluate the economic impact of port infrastructure, Chapter 2 is focusing on measure how transport infrastructures that improve its international connectivity have an impact on industrial employment. For the specific analysis of Spanish regions, the results show that regions with large ports and the regions nearest to port regions get more employment in manufacturing activities without harming the other regions. Moreover, regions with road infrastructure are able to attract more industrial employment but this is at the expenses of nearby regions. While rail infrastructure and the amount of air freight traffic have any observable effects on employment in the manufacturing sector. This study contributes to the literature by providing evidence that the expansion of the industrial activity in a country is mainly dependent upon the infrastructures that improve its international connectivity. Thus, the effects of these infrastructures on industrial employment seem to be related with growth; while, the effects of the infrastructures that improve the connectivity of the regions within a country seem to be related with the reorganization of the industrial activity.

In the specific case of Spain, port infrastructures have been able to support such international connectivity, while airport traffic is localized in the two largest cities. Rail transportation has focused on high-speed rail lines that are not compatible with freight and that just improve the connectivity within the country. Although the relevance of road infrastructure is based on national and international level, this study suggests that this kind of infrastructure tends to reorganize the employment in the industrial sector within the country more than generating additional activity. Thereby, as policy implication, this research suggests that develop industrial activity in a country imply to consider those infrastructures that encourage its international connectivity, as it is the case of ports. In the case of air freight transport, it could be important to consider the promotion of movement of goods in regions with smaller airports that lead the movements of passengers are already attractive for industrial firms due to the size of their markets. Finally, promote international freight rail services and investment in road that cross national boarders may help a country to improve its attractiveness for industrial firms.

This international connectivity character of port infrastructure faced with a globalization markets induced to ports become to be subject to intense competition as they seek to attract more traffic from global competitors as well as from local ports in overlapping hinterlands. Related to this situation, Chapter 3 aims to measure the impact of different competition scenarios on traffic demand in Europe port authority framework. The main hypothesis of this study is to identify whether ports benefit from a more competitive scenario due to incentives to be more efficient; yet, at the same time, this competition might also reduce the volume of traffic handled by less efficient ports. Controlling for several factors, the main findings obtained suggest that competition between ports may increase traffic. In depth, traffic of neighboring ports and governance model oriented on market system benefits port traffic demand. In contrast, this study does not find evidence that competition within a port spur traffic. In this line, hub ports whose terminals are generally managed by a shipping line, present higher traffic. Moreover, ports with rail facilities in a terminal can attract more traffic.

In short, this research indicates that Southern European port authorities present specific characteristics that may undermine their competitive position. The Mediterranean port authorities are generally managed in accordance with the bureaucratic model of governance and operate few rail facilities within the port terminals. Following this, as policy implications, regions with rigid systems of governance, such as ports located in the South of Europe, need to consider adopting more flexible systems so as to attract more traffic and to ensure greater efficiency. Alternatively, these port authorities should also consider the possibility of combine different port governance models within the same region. Thus, the largest ports could be managed with more flexible systems so that they can increase their financial resources and invest in the port authority's facilities, including better railway links. Likewise, ports in Southern Europe should be not so concerned by nearby ports and they could pay attention on their competitiveness in relation to port authorities located in Northern Europe.

Additionally, ports authorities are aimed to attract investments of companies specialized on the management of terminals and also promote shipping regular lines in order to generate more traffic. In this complex context, the study of port charges becomes relevant as a competitiveness factor of ports. Chapter 4 of this dissertation evaluates port management and finance through an analysis of port charges in Spain. The hypothesis of this research is based on determinate whether port charges have a direct impact on volumes of traffic and also, to examine whether the Spanish port regulation offers any chance of price competition even with the high degree of regulation of port charges. This research finds empirical evidence that higher port charges are associated with lover volumes of traffic. Moreover, this study suggests that ports with many regular lines operated by shipping companies set lower charges, in contrast with ports managed by multinational companies or high international traffic where do not set lower charges. Likewise, it appears local price competition as ports with nearby ports decrease its revenues per tonne. Taking into account the lack of empirical analysis about port charges, the relevance of this research relies on finding a negative impact of the competition between ports that are subject to global competition as the costs of terminal operators raise when they make an investment. Thus, there are large multinational companies operating terminals that have invested large sums of money in several Spanish ports. These investments (with their associated sunk costs) create strong links between the port authority and the company. For this reason, the negotiating position of the terminal operator can be weakened. In fact, it seems that terminal operators sometimes pay higher prices than public firms (even the port authority) or national firms. However, it seems that the bargaining power of shipping companies is stronger, especially when they enjoy a high market share. In this sense, it seems that the regulation of prices in Spain favors lower prices in hub ports, such as Algeciras, but this is not the case for gateway ports, such as Barcelona or Valencia, which have a much more diversified traffic.

The results of this chapter have several policy implications. First, the main specialized container ports do not compete with other national ports but rather with the other major ports of Europe. Most of Spain's large ports need to improve their accessibility by land, but in a context of severe budgetary constraints affecting public administration. These investments will presumably have to be made by private companies. Such investments can then either be financed by tolls paid by users or by a deferred payment from the public administration. The current regulations are quite strict and may prevent PAs from compensating port users for higher land costs by implementing a new pricing system. Secondly, Port Authorities have to consider the following trade-offs when setting charges: lower prices can contribute to higher volumes of traffic while high prices can serve to fund investment. Hence, pricing regulations affect not only a port's competitive position, but also its ability to finance investments. In a context of global competition, ports should have some flexibility in defining their business strategy without overlooking any potential mechanisms of solidarity. This put into question the role of the central agency, Puertos del Estado, as Spanish ports could be better off freeing the individual PAs to manage their businesses as independent local PAs.

To summarize, the results obtained in this dissertation provide a better understanding of port infrastructure behavior. This thesis suggests that ports have a direct impact on industrial activity as they support the international connectivity of the regions where are located. Thus, in a context of global port competition it is important to consider a more flexible regulation and management system in order to increase their financial resources and invest in the port authority's facilities. Consequently, although lower prices can contribute to higher volumes of port traffic, this thesis proposes that a more adjustable regulation can serve to increase their financial resources and investment in port's facilities. In this way, better freight terminal facilities can allow to attract more port traffic.

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