Analysis of the spatial development of the hinterland of ports: a case study

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Abstract: There is a growing interest concerning the inland side of port traffic. According to this trend, this paper analyse the spatial development of the ports' hinterland through the simultaneous use of two indices. The aim is to assess two relevant and complementary questions in the port hinterland configuration: its relative geographical extent and its spatial homogeneity in the generation of traffic. The interest of the combined use of the proposed indices is shown by means of a case study: the analysis of the spatial development of the hinterland of the main Spanish ports. To conduct the study it was necessary to identify the location of the Spanish firms generating the flows of cargo, as well as their volume and distribution among the ports analysed. The main finding is that the port of Valencia has reinforced its leadership among the Spanish ports over the past decade also in the inland side.

Keywords: hinterland; inland traffic distribution; port regionalisation; Spanish ports.

Reference to this paper should be made as follows: Garcia-Alonso, L., Martinez-Pardo, A. and Vallejo-Pinto, J.A. (2016) 'Analysis of the spatial development of the hinterland of ports: a case study', *Int. J. Shipping and Transport Logistics*, Vol. 8, No. 2, pp.111–128.

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This paper is a revised and expanded version of a paper entitled 'Analysis of the spatial development of the hinterland of ports: a case study' presented at IAME 2014 Conference, Norfolk, VA, USA, 15–18 July 2014.

1 Introduction

The evolution of the research in the seaport field has been reviewed in some recent papers (see for instance Paixao Casaca et al., 2010; Pallis et al., 2010; Woo et al., 2011, 2012). From them it can be concluded that the issue of the geographical evolution of the ports' hinterland has been less studied than other topics regarding the port activity, despite the fact that both the origin and the destination of the maritime flows are on the inland side. As Cullinane and Wilmsmeier (2011) state, the analysis of the spatial development of the ports' hinterland 'has received considerably less attention' (see also Monios, 2011; Guerrero, 2014).

Notteboom and Rodrigue (2007) state that in the late 80s the interest in the issue of the hinterland development waned. They highlight the process of containerisation and the development of logistic networks as the most likely main reasons. The broad consensus achieved about the fact that the focus of the competition for the traffic is taking place among logistical chains (Robinson, 2002) could explain why the empirical papers analysing the port traffic distribution from the inland perspective were not usual. In addition, data are lacking to perform a proper analysis (Guerrero, 2014).

In spite of the stated above, there are authors defending that each port belongs to a system and, consequently their activity is related to their economic, social and political environment (Bichou and Gray, 2005; Yap and Lam, 2006), particularly when there are large centres either of production or consumption in the surroundings of the port facilities (Notteboom, 2010). Fleming and Hayuth (1994) were pioneers in recognising the relevance of the hinterland in the port activity despite the process of containerisation. But the interest on the ports' hinterland had a scarce presence in the literature until the second half of the previous decade. Thereafter, the hinterlands and the inland traffic distribution are issues with an increasing presence in several papers. For instance, authors such as Notteboom (2006a) highlight the relevance of the inland distribution of cargo in the maritime transport service and even in the process of globalisation; Rodrigue and Notteboom (2006) point out that the activity of a port is directly related to the dynamics of the consumption and production centres to which it is linked; Nottebboom and Rodrigue (2007) state that nowadays one of the biggest challenges in maritime transportation lies in the ports' hinterlands and how they fit within the supply chain. Besides, they suggest that the hinterland of the ports must be seen as a dynamic place where macro-economic, physical and logistical elements evolve (see also Ferrari et al., 2011). Likewise, Rodrigue and Guan (2009) observe that the reinforcement of the competition for the traffic on the landside is putting the focus on the capacity of land corridors and the establishment of inland terminals. Within this context, van den Berg and de Langen (2011) and Wilmsmeier et al. (2011) consider that the way each port faces the competition for the traffic on the landside can be a determinant for their competitive position and their choice.

This renewed interest regarding what is happening with the traffic in the landside has been reinforced by Notteboom and Rodrigue, who have introduced a new concept: *regionalisation*. This is a new phase in port system development; a step further from the previous spatial models (see Notteboom and Rodrigue, 2005; Rodrigue and Notteboom, 2006) and more recently Ferrari et al. (2011), for a proper revision of the theoretical models of port development). This proposal has not been without certain controversy (Rodrigue and Notteboom, 2010; Monios and Wilmsmeier, 2012). However, it has served to clearly state that it is necessary to take into account both the landside and the maritime side for a better understanding of the port activity evolution, as other authors also stated (for instance Garcia-Alonso and Sanchez-Soriano, 2009; Roso et al., 2009).

Therefore, as Gouvernal et al. (2012) highlight, "the hinterland continues to play the determining role in container port development". But the concept of *hinterland* must now be understood in a dynamic manner: as "the area that can be reached at a cheaper cost or shorter time than from another port" (Wilmsmeier et al., 2011). The improvement achieved in transport services favours the mobility of cargo in such a way that the concept of hinterland has evolved deeply. Nowadays, many ports compete over the same market areas and their hinterlands can overlap. Consequently, the traditional boundaries are blurring and the hinterlands are becoming discontinuous because of the formation of islands beyond the immediate surroundings of the ports' facilities (see Ferrari et al., 2011).

In that new context, the improvement of the port-hinterland links is key for the success of the ports. One of the main elements for this improvement are the inland terminals/inland ports because of the role they can play into the supply chains: they can act as linkages for global cargo transport, favouring the emergence of transport corridors and expanding the traditional hinterland of the ports. Some papers dealing with this topic have been published recently (see for instance Rodrigue et al., 2010; Roso, 2010; Monios, 2011; van den Berg and de Langen, 2011; Wilmsmeier et al., 2011; Monios and

Wilmsmeier, 2012, 2013; Witte et al., 2014). Nevertheless, there is a lack of empirical research regarding the evolution of the spatial configuration of the ports' hinterland. This kind of analysis is necessary to assess the impact of any strategy, such as the construction of a new inland terminal, on the distribution of the traffic among the ports.

To contribute to fill this gap, this paper proposes the combined use of two indices as a tool for assessing and comparing the spatial development of the hinterland of a set of ports. The paper is structured as follows. Section 2 is a methodological description of the proposal. Section 3 presents the data used to delimit and analyse the hinterland of the ports included in the case study: Algeciras, Barcelona, Bilbao and Valencia. Section 4 shows the main results obtained. The conclusions drawn are highlighted in Section 5.

2 Methodological framework for the analysis of the spatial configuration of the hinterland of ports

The design of efficient regionalisation strategies is hardly possible without proper information of how the cargo flows are evolving. This information should include the identification of the 'inland islands' where the traffic is generated, their relevance for the whole of the port activity and the hinterland to which they belong.

The assessment of the spatial development of the hinterland of ports requires all that information, but also a tool able to synthesise it and make comparisons between ports. What we propose is to combine two very simple indices to analyse the spatial configuration of the inland distribution of the port traffic.

One of the most popular tools used to explain the spatial distribution of any economic variable has been the Gini coefficient. It is a purely descriptive index, thus it does not explain interactions between the independent variables. But it is useful as it reveals the existence of concentration (Leal et al., 2011). In the framework of the port activity research, Notteboom (2006b) has applied a Gini decomposition analysis for the study of the European and North American container port systems. In this paper, the focus shifts to the analysis of the spatial scope and the geographical dependency of the hinterland of ports. The aim is to assess and compare the evolution of the hinterland of a set of ports from a spatial perspective, but not to explain it or identify its key variables. Specifically, the proposal is:

- to evaluate to what extent the geographical configuration of a hinterland differs from the area where the whole traffic of its port range is generated (called *expansion index, E*)
- to evaluate to what extent the traffic generation is homogenously distributed from the spatial perspective within a port's hinterland (with a common *Herfindahl index, H*).

To address these evaluations two spatial references are used: the unit and the subunit. Both references must enclose the whole territory under analysis without overlapping (the subunits must satisfy that same condition regarding the units). The spatial unit can be the province, the region or any other alternative territorial demarcation. The spatial subunits can be municipalities, postal codes, local labour systems or any other spatial reference defined within the units. Accordingly, the indices E and H are respectively defined for each port p as (1) and (2):

$$E_p = \frac{\sum_i (S_i - x_i)^2}{\sum_i z_i^2} \quad (1)$$

$$H_p = \sum_i z_i^2 \quad (2)$$

where

s_i share of the spatial subunits of the unit *i* tied in with the port *p*. Specifically, it is the number of the spatial subunits of unit *i* linked to port *p* divided by the total number of spatial subunits that manage their flows through this port *p*.

x_i number of the spatial subunits of the unit *i* that generate maritime flows divided by the total number of the spatial subunits responsible of the generation of the maritime traffic (regardless of the port).

z_i share of the volume of traffic generated in unit *i* in the activity of port *p*.

Indices *E* and *H* take values in the (0, 1) interval. In both cases, values close to 1 reflect a higher level of concentration (namely a spatial concentration of the subunits linked to port *p* – index *E* – or a high level of dependence of port *p* on the traffic generated in some spatial units – index *H* –) and vice versa. That is, the larger the value of *E*, the smaller the extent of the ports' hinterlandin regard to its potential borders. Likewise, the larger the value of *H,* the greater the spatial concentration of the traffic generation within each hinterland. In such a case, if *E* is close to 0 the port is able to attract traffic from practically all the points where it is generated, but a significant amount of its traffic is generated in a reduced area within the borders of the hinterland. Then, the question to be answered is whether this is because some territories generate a small amount of traffic or because the port has not yet been able to strengthen its leadership there. Finally, when both *E* and *H* tend to 0, the port hinterland is as wide as possible and its traffic is homogeneously generated (from the spatial point of view) within its borders.

Therefore, by combining both indices it is possible to assess two complementary issues concerning the port activity distribution at the inland side:

1 the relative geographical extent of each port's hinterland (*E*)

2 the homogeneity of the traffic generation within them (*H*).

That is, firstly, it is possible to delimit and compare the area of each port hinterland taking into account the spatial units/subunits where their traffic is generated. And secondly, it is possible to know if that area corresponds to their relevant hinterland (the area where the largest amount of the port traffic is generated).

3 The Spanish case as a case study

To show the usefulness of the methodological tool proposed, we present a case study. This paper analyses the evolution of the hinterland of the main Spanish peninsular container ports during the previous decade. These ports are Algeciras, Barcelona, Bilbao and Valencia. Together they managed more than three quarters of the national container traffic, both at the beginning and at the end of the period analysed (77% in 2000; 80% in 2010).

The container traffic grew in Spain by 107% during the previous decade, but this dramatic growth was unevenly distributed among those four ports: 30% in Bilbao, 247% in Valencia. Consequently, the share of this last port in the container traffic jumped from 21% in 2000 to 35.4% in 2010, while the share of Bilbao decreased from 6.5% to 4%. Between both extremes, the container traffic in Barcelona and Algeciras went up by 48% and 77%, respectively. As a result, the ports of Barcelona and Bilbao maintained the same positions over the whole period (third and fourth, respectively); but Valencia surpassed Algeciras at the end of the period to reach the first position.

These traffic figures (provided by Ente Público Puertos del Estado, 2014) refer to the whole container traffic managed by the Spanish port system. Hence they include both national and overseas flows. The location of the ports contributes to explain the nature of their traffic regarding its origin. As Monios (2011) points out, the traffic of Bilbao is mainly short sea or feeder from northern European facilities and in Algeciras is mostly transhipment. The ports of Barcelona and Valencia are located in the geographical area where the Spanish foreign trade activity is stronger. Consequently, they add national flows to the transhipment traffic in a higher share than the rest (Garcia-Alonso and Sanchez-Soriano, 2010). Additionally, they are located closely and on the same coastline, thus they compete more directly with each other and their hinterlands can overlap more easily.

In order to analyse the evolution of the hinterland configuration of all of them, two different national sources of data have been used: the databases of the Spanish Customs Statistics and the Directory of exporting-importing firms of the chambers of commerce.

The flows of traffic analysed are exclusively those generated within each of the 47 Spanish peninsular provinces. That means that the traffic generated outside Spanish borders was ignored, despite being aware that the ports' hinterland can transcend the national borders. The main reason is the lack of traffic data from France and Portugal. Nevertheless, this fact does not affect the conclusions drawn. The final goal of the analysis is to serve as a starting point for future works on, for example, the effectiveness of the inland infrastructure investment on traffic distribution, the success of the logistical support services to the external activity of domestic firms, or even the role of the ports in such activity. Therefore, the results of this analysis remain valid even though the ports may also attract traffic from other countries.

The database of the Spanish Customs Statistics provides information about the volume, composition and provincial origin/destination of the foreign trade flows over time. Thus, the province becomes the unit of spatial reference for this analysis. It constitutes our first proxy of the boundaries of the ports' hinterland, already applied in other papers (Garcia-Alonso and Sanchez-Soriano, 2009, 2010). This information is combined with data from the Directory of exporting-importing companies of the Chambers of Commerce, which allows us to identify and to locate, within each province, the firms that generate the export/import flows of cargo every year. This data source offers information about the municipality and the postal code where each firm is located. Any of those spatial demarcations can serve as subunits.

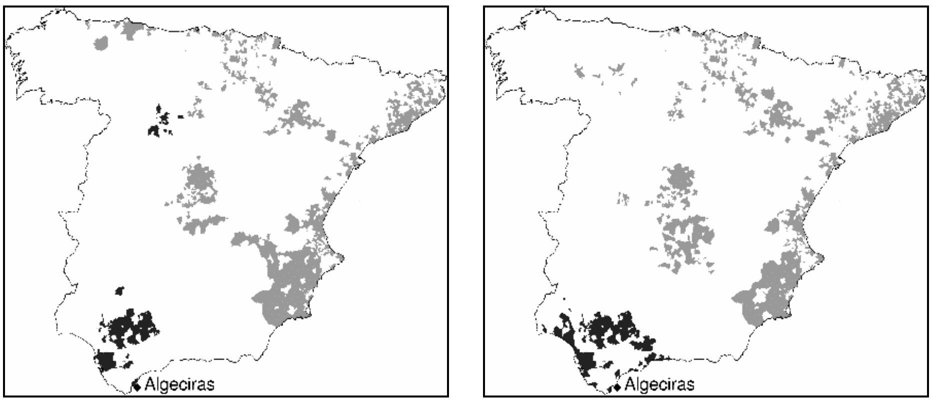
A drawback of the Directory of Spanish exporting-importing companies is that it does not include information about the value/volume of the cargo generated by each firm. Consequently, it is not possible to calculate the share of each company in the global port flows. Therefore, it is necessary to combine this source of data with the customs statistic database in order to quantify the magnitude of the flows of the inland islands that define the hinterland of ports. This new approach allows us to delimit the ports' hinterland much more accurately: now the origin of traffic generation within each province is known. Consequently, it is possible to better compare the atomisation of the hinterland of different ports, from the geographical perspective.

This paper focuses the analysis on the companies whose foreign trade is linked to the American continent or the Asian countries. The reason is that the Directory of the Chambers of Commerce does not include information on the transport mode employed, thus only those companies that guarantee the use of maritime transport are taken into account. In spite of this restriction, a large part of the exporting/importing firms is analysed. For instance, for the last year of the period studied (2000–2010), almost 70% of the firms involved in foreign trade had exchanges with some American or Asian country.

4 Obtained results

Figure 1 shows, superimposed, the actual and the potential hinterlands of each port for 2000 and 2010. In each map the origin of the traffic of the corresponding port (in black) is compared with the whole area where the national maritime traffic is generated (in grey). Therefore, the potential hinterland is the same for all four ports in both 2000 and 2010, but changes over time. Looking at Figure 1 by columns, it can be observed that in 2000 Algeciras had the smallest hinterland, Valencia had the biggest one and the hinterlands of Barcelona and Bilbao were similar to each other. However, a question arises: how much smaller, bigger or similar were they? And the same could be asked for 2010 (second column). Looking by rows, the evolution of the hinterland of each port can also be observed over time. Apparently, the hinterland of Algeciras has increased whereas that of Bilbao has decreased, but it is difficult to conclude anything about the evolution of the hinterlands of Barcelona or Valencia during this period because the potential hinterland has changed over the decade.

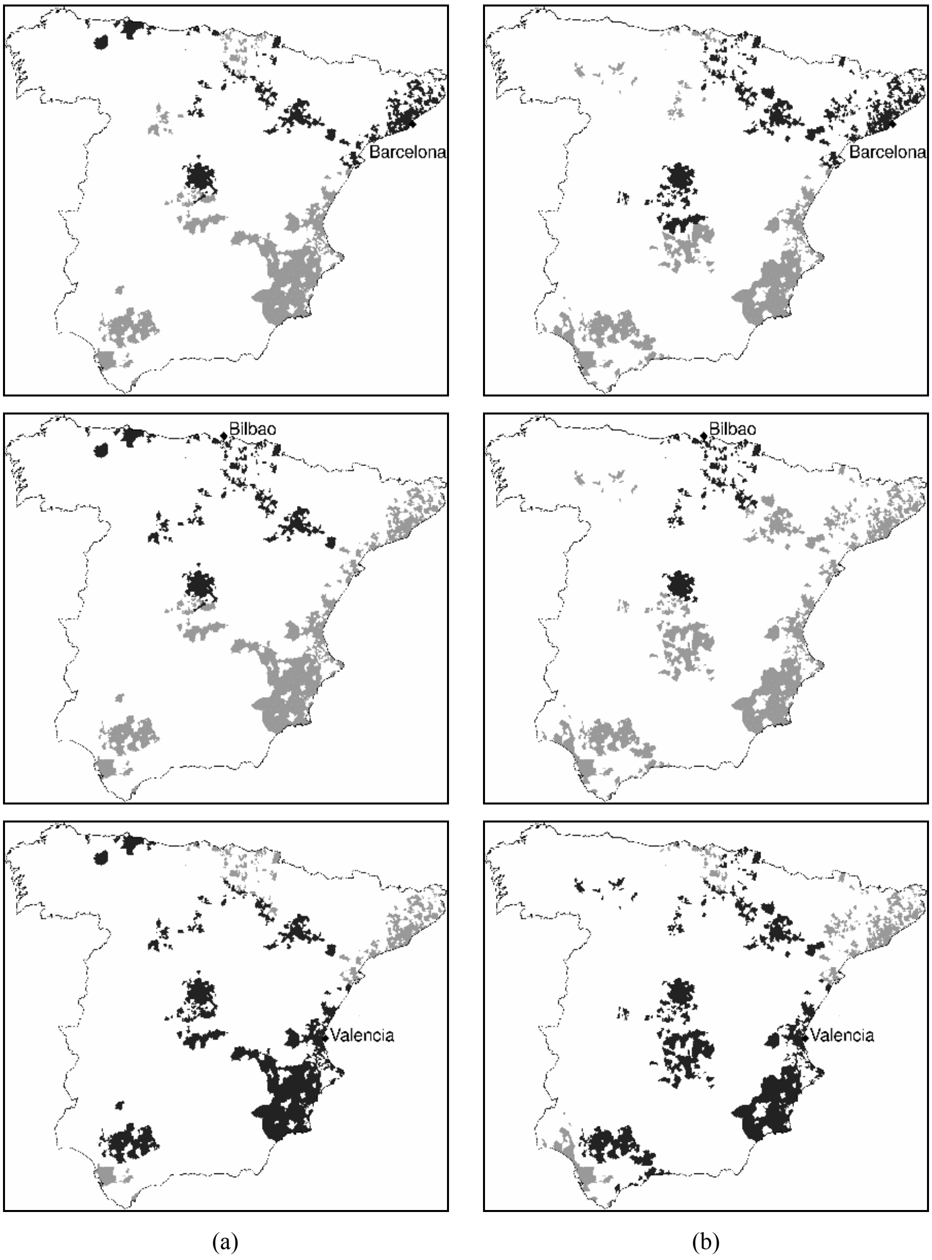
Figure 1 Geographical configuration of the ports' hinterland, (a) 2000 (b) 2010)



(a) (b)

Source: Spanish Customs Statistics (Agencia Tributaria, 2014) and Directory of Exporting-Importing Companies of the Chambers of Commerce (Consejo Superior de Cámaras de Comercio, 2014)

Figure 1 Geographical configuration of the ports' hinterland, (a) 2000 (b) 2010) (continued)

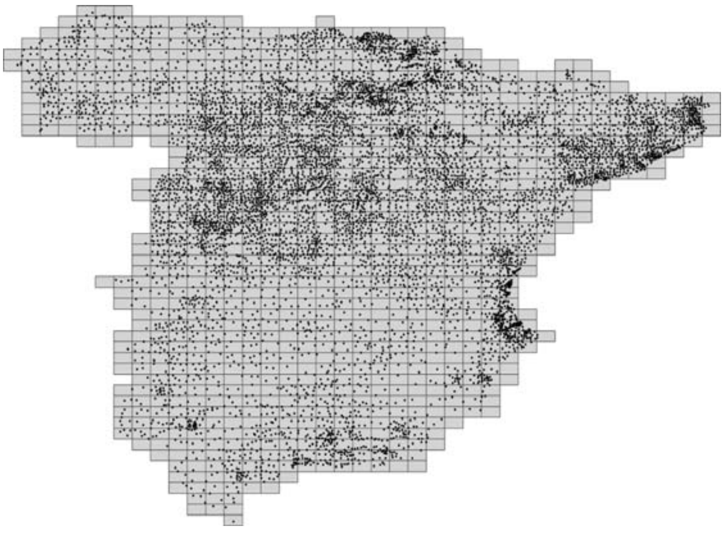


Source: Spanish Customs Statistics (Agencia Tributaria, 2014) and Directory of Exporting-Importing Companies of the Chambers of Commerce (Consejo Superior de Cámaras de Comercio, 2014)

This is why a tool able to quantify the relative scope of the hinterland of the ports is needed, both to make comparisons among them and to assess their own evolution. The index E is proposed to be such a tool. Consequently, as all these maps compare the spatial scope of each hinterland with the whole geographical area where the traffic is generated, they can be seen as a graphical representation of index *E*.

To draw Figure 1,we took into account the municipalities where the firms are located, but to calculate the index we need a different approach. The accuracy of the Expansion index is related to the homogeneity of the spatial size of the subunits. The municipalities are defined from an administrative perspective, thus their size can be very heterogeneous and distort the value of *E*. This is the Spanish case. In Figure 2, where the points represent the location of the municipal centroids, the imbalance in the size of the municipalities is clearly shown: they are particularly disperse in the north-western and the half southern areas, whereas they are strongly concentrated in other areas (for instance, in the North Mediterranean coast). That means that their relative size is quite different and consequently, using them as spatial sub-units could distort the value of the index *E*. To solve this problem, grid cells were used instead of municipalities. These cells are the ones defined by the National Topographic Map of the National Geographic Institute of Spain at 1:50,000 scale (known as MTN50). The mapping between municipalities (7,969) and cells (1,050) was made through the location of the municipal centroid.

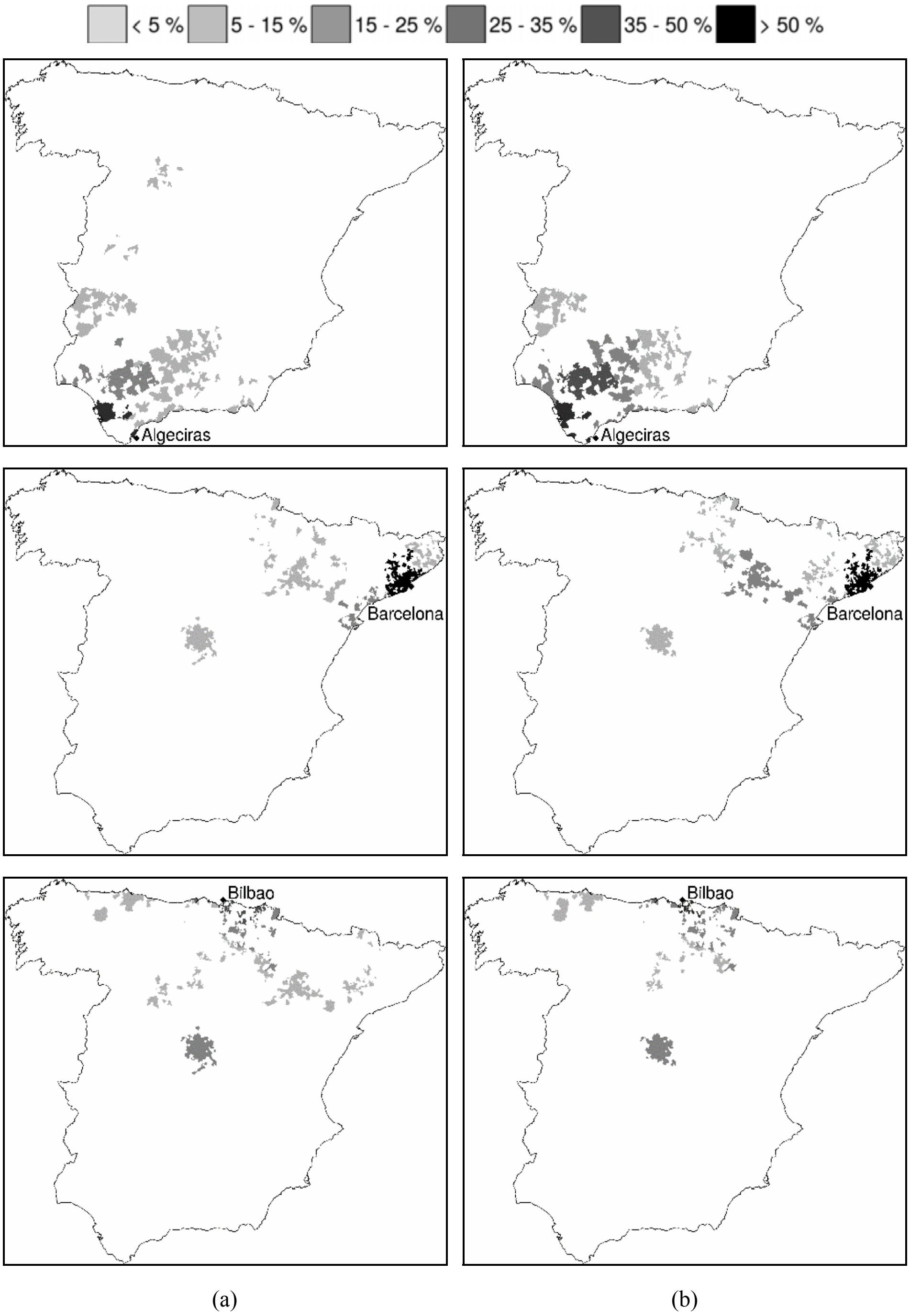
Figure 2 Mapping between municipalities and grid cells



Source: National Geographic Institute of Spain (Ministerio de Fomento del Gobierno de España, 2014)

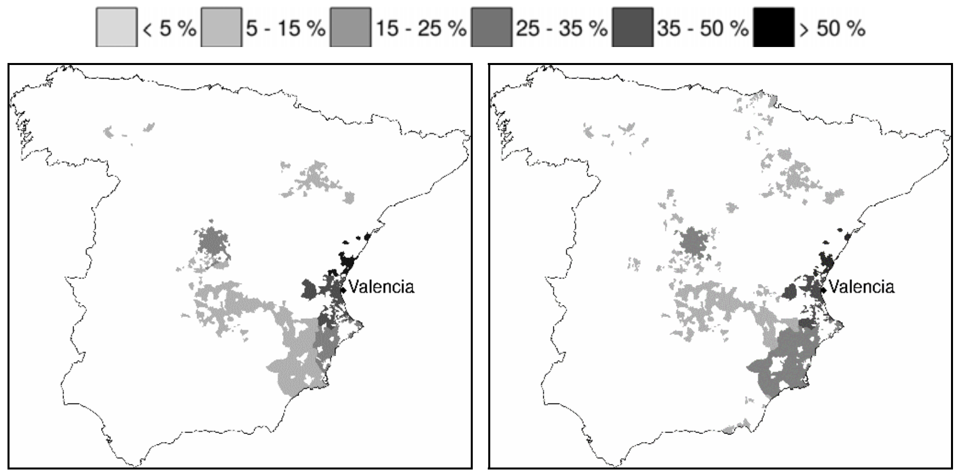
The borders of each port's hinterland can be extracted from Figure 1, but from these maps it is not possible to observe if there is spatial concentration in the generation of the traffic of each port. This fact can be appreciated in Figure 3: their maps highlight the share of each inland island in the traffic generation of the corresponding hinterland (the darker the inland island, the greater the amount of traffic generated). At this point, two new questions arise: what is the ranking of the ports according to their spatial dependence? How has the spatial dependence of a specific port evolved? Once again, a statistical tool is needed to solve these questions. The proposed tool is the index *H* and as the maps of Figure 3 show the spatial heterogeneity in the generation of flows (by volume), they can be seen as a graphical representation of this index.

Figure 3 Geographical dependency of the hinterland of the ports, (a) 2000 (b) 2010



Source: Spanish Customs Statistics (Agencia Tributaria, 2014) and Directory of Exporting-Importing Companies of the Chambers of Commerce (Consejo Superior de Cámaras de Comercio, 2014)

Figure 3 Geographical dependency of the hinterland of the ports, (a) 2000 (b) 2010 (continued)



(a) (b)

Source: Spanish Customs Statistics (Agencia Tributaria, 2014) and Directory of Exporting-Importing Companies of the Chambers of Commerce (Consejo Superior de Cámaras de Comercio, 2014)

Slight differences can appear in the borders of the hinterlands between both sets of maps (Figure 1 vs. Figure 3). This is because different perspectives were adopted to draw them. In order to obtain a cleaner picture, the provinces generating flows whose share is less than 0.5% of the total are not represented in the first set of maps. As a result, what can be seen is the area that generates at least 95% of the whole flow, but not 100%. Nevertheless, the second set of maps is seen from the perspective of the port. That is, they represent the area needed to reach the lower limit of 95%, taking only their own traffic into account.

Figure 3 shows a fact that was to be expected: the larger amount of traffic for each port comes from its geographical surroundings. But they also show another important fact: the degree of dependence on the closest surroundings varies;

1 depending of the port (Barcelona *vs* Bilbao)

2 also over time (Valencia).

Besides, the traffic not always chooses the nearest facilities (as Ferrari et al., 2011; Wilmsmeier et al., 2011 highlight). Figure 1 shows that this is the case for most of the flows, but there are clear exceptions (the north-western of Spain in 2000 or the southern in 2010). These exceptions may also change over time, modifying the borders of the ports' hinterland (as Ferrari et al., 2011 state). For instance, from all these figures it can be seen that the geographical area where the traffic is generated around Zaragoza (top-right corner) has expanded and its share in the flows has been reinforced. That is precisely the place where the biggest Spanish inland terminal is located (see Monios and Wilmsmeier, 2012 for more information about that issue). The hinterlands of the ports of Barcelona, Bilbao and Valencia overlapped here in 2000. Ten years later, the entire area was captured by only the ports of Barcelona and Valencia.

The analysis of these phenomena is the goal of the papers focused on the issue of the port choice (see Sánchez et al., 2011 for a synthesis of the literature regarding its keys). Nevertheless, the aim of this paper is to describe, in an accurate manner, how the evolution of the spatial configuration of the hinterland of a set of ports takes place. It is expected that the immediate surroundings of each port belong to their hinterland, but the relevance of these surroundings in the total port traffic and the extent of the area where the port is strong enough to attract traffic varies regarding both the port itself and over time. The simultaneous use of the proposed indices allows us to measure and to compare the evolution of both circumstances on a set of ports taking into account:

1 the geographical extent of their hinterland

2 the degree of spatial concentration in the traffic generation within each one.

Table 1 Values for indices *E* and *H* for 2000 and 2010

	Algeciras	*Barcelona*	*Bilbao*	*Valencia*
2000	E = 0.651	E = 0.394	E = 0.477	E = 0.160
	H = 0.238	H = 0.562	H = 0.135	H = 0.267
2010	E = 0.638	E = 0.418	E = 0.596	E = 0.123
	H = 0.161	H = 0.460	H = 0.144	H = 0.163

Source: Spanish Customs Statistics (Agencia Tributaria, 2014) and Directory of Exporting-Importing Companies of the Chambers of Commerce (Consejo Superior de Cámaras de Comercio, 2014)

Table 1 shows the results obtained for the indices *E* and *H* for the case study performed (years 2000 and 2010). It can be seen that the geographical scope of the hinterland of the port of Algeciras remains practically the same from the beginning of the period (E_{2000} = 0.651; E_{2010} = 0.638), while it has gained homogeneity with respect to the spatial origin of its traffic (that is, the traffic generation is less spatially concentrated: H_{2000} = 0.238; H_{2010} = 0.161). The port of Barcelona has also reduced its level of spatial dependence (H_{2000} = 0.562; H_{2010} = 0.460), but it has experienced a slight reduction in the scope of its hinterland relative to the other ports (E_{2000} = 0.394; E_{2010} = 0.418). The same has happened to the port of Bilbao, whose relative inland scope has been reduced (E_{2000} = 0.477; E_{2010} = 0.596) and whose level of spatial dependence has increased. Nevertheless, its hinterland has a much greater level of homogeneity in the generation of traffic: it is the most compact in this sense, both at the beginning and at the end of the period (H_{2000} = 0.135; H_{2010} = 0.144). Finally, the spatial scope of the hinterland of the port of Valencia is larger at the end of the decade (E_{2000} = 0.160; E_{2010} = 0.123). Aside from this, it has increased its homogeneity in the generation of traffic (H_{2000} = 0.267; H_{2010} = 0.163).

These results allow us to conclude that the port of Valencia has evolved in the right direction. At the end of the decade, this port was the most advanced in terms of the diversification of its hinterland: it was more compact (lower value of *H*); it extended its hinterland in relative terms (lower value of *E*); and it reached the greatest geographical extent of the ports analysed (lowest value of *E* by far). Thus it can be concluded that the hinterland of the port of Valencia has experienced a broader and better balanced inland development than the rest of ports analysed from 2000 to 2010.

From the maps it could also be concluded that there is a certain relationship between the geographical origin of the flows and the location of the port chosen for channelling them. Therefore, a direct link could be expected between the traffic channelled through a port and the nature of the flows generated within the nearest provinces. That could confirm the hypothesis about the influence of the economic environment on the activity of the ports (Bichou and Gray, 2005; Yap and Lam, 2006). To confirm the existence of this relationship a deeper statistical analysis is needed but this is not the objective of this paper.

4.1 Analysis of the inland distribution of port traffic by type of flow

The previous results were obtained from the analysis of the whole maritime traffic channelled by container and derived from the foreign trade of the firms located within the peninsular Spain. It is known that the hinterland of the ports can vary according to the type of traffic because the impact of the distance differs depending on the nature of the cargo (Guerrero, 2014). As a first approach to this matter, in this paper we repeat the analysis separating the exports and the imports for 2000 and 2010. The obtained results are shown in Tables 2 and 3.

Table 2 Values of indices *E* and *H* for 2000 and 2010 for the export flows

	Algeciras	*Barcelona*	*Bilbao*	*Valencia*
2000	E = 0.666	E = 0.426	E = 0.401	E = 0.199
	H = 0.343	H = 0.472	H = 0.115	H = 0.430
2010	E = 0.666	E = 0.421	E = 0.582	E = 0.161
	H = 0.214	H = 0.415	H = 0.126	H = 0.204

Source: Spanish Customs Statistics (Agencia Tributaria, 2014) and Directory of Exporting-Importing Companies of the Chambers of Commerce (Consejo Superior de Cámaras de Comercio, 2014)

Table 3 Values of indices *E* and *H* for 2000 and 2010 for the import flows

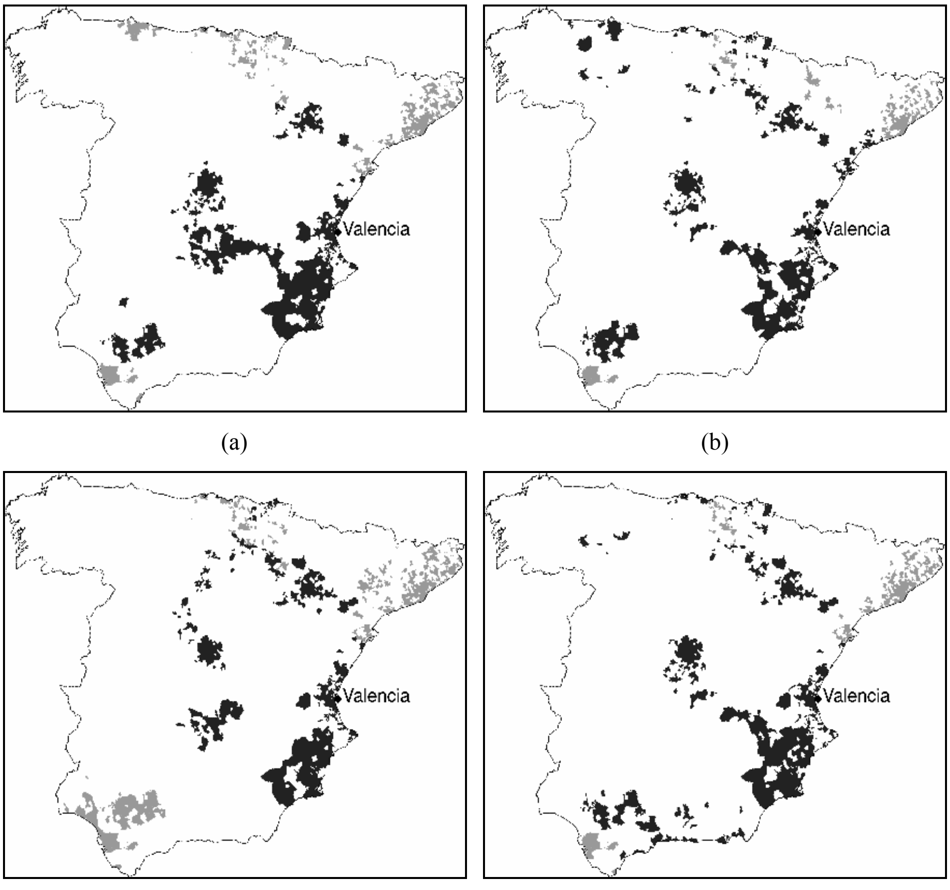
	Algeciras	*Barcelona*	*Bilbao*	*Valencia*
2000	E = 0.568	E = 0.351	E = 0.543	E = 0.107
	H = 0.123	H = 0.671	H = 0.195	H = 0.215
2010	E = 0.598	E = 0.350	E = 0.677	E = 0.126
	H = 0.128	H = 0.520	H = 0.210	H = 0.191

Source: Spanish Customs Statistics (Agencia Tributaria, 2014) and Directory of Exporting-Importing Companies of the Chambers of Commerce (Consejo Superior de Cámaras de Comercio, 2014)

In general terms, the evolution of both indices (*E* and *H*) when applied to each type of flow remains very similar to that previously observed for the whole traffic: the hinterland of the port of Valencia has experienced the best development, whereas the hinterland of the port of Bilbao has simultaneously decreased its scope and its homogeneity in the traffic generation inside its borders. It can also be appreciated that the hinterlands of the ports of Algeciras and Barcelona are relatively wider for imports than for exports.

The spatial scope of the hinterland of the port of Valencia has experienced a very slight decrease when considering the import flows. Nevertheless, Table 1 shows that it has actually expanded. This is because the potential hinterland (the area where the maritime traffic is generated, regardless of the port that manages the flows of cargo) is different for exports and imports. Therefore, the evolution of their corresponding index *E* can also be different. Besides this, the share of the flows within the total traffic is also different. Consequently, one of them can be high enough to compensate a shift in the opposite direction in the other. In this particular case, the export flows represent 62% of the total traffic. In addition, the potential hinterland for this flow has reduced whereas that of the imports has remained similar (see Figure 4).

Figure 4 Geographical configuration of the hinterland of Valencia port by type of flow, (a) export flows (2000) (b) import flows (2000) (c) export flows (2010) (d) import flows (2010)



Source: Spanish Customs Statistics (Agencia Tributaria, 2014) and Directory of Exporting-Importing Companies of the Chambers of Commerce (Consejo Superior de Cámaras de Comercio, 2014)

Focusing on index *H*, Table 1 shows that the geographical dependence of the ports' hinterland has been reduced during the period (with the only exception of the port of Bilbao, whose index *H* was the lowest during the period and has hardly changed). The same has been found for exports. The spatial homogeneity in traffic generation inside the hinterland has been reinforced, particularly in the port of Valencia, whereas the geographical dependence of the hinterland of the port of Bilbao remains the lowest despite a little increase. With respect to the import flows, the port of Barcelona is still the more dependent on the traffic generated in its surroundings. Nevertheless, the more balanced hinterland for these flows, regarding its homogeneity in traffic generation, corresponds to the port of Algeciras.

5 Concluding remarks and discussion

The empirical analysis of the inland distribution of the maritime flows of cargo is not usual in the literature. Nevertheless, these flows have a relevant role to play in the port development process. Beyond the direct activity of the ports, they also influence the configuration of corridors and, therefore, the use of the inland transport infrastructure because the ports are main pieces in the logistic chains. On the other hand, the economy, either at local, regional or national level, is also influenced by how the ports manage their relationships with their hinterlands. Consequently, it is convenient to go further in the knowledge both of the inland distribution of maritime traffic and of the evolution of the spatial configuration of the ports' hinterland.

The performance of the logistics and the transport system depends on the interactions among the agents involved. How these interactions take place depends on the confluence of private decisions and institutional arrangements. The more reliable and processed the information about needs and tendencies is, the greater the effectiveness of the policies and the success of the choices will be and consequently the greater the efficiency and growth of the system.

This paper makes a proposal to advance in the knowledge on the spatial development of the hinterland of the ports. The proposed indices do not explain why the observed hinterland development takes place, but how. They synthesise the available information on the inland distribution of the maritime traffic. Specifically, they measure two aspects of the hinterland evolution: its geographical scope and its spatial dependence. This knowledge not only allows us to assess the evolution of the spatial development of a specific port over time, but also to compare the evolution of the leadership of a range of competing ports in the inland side. The simultaneous use of the proposed indices can help when evaluating both the impact of the port authorities' strategies and the influence of factors beyond their control, such as the improvement of the road/rail infrastructure or the evolution of the economic activity of the port surroundings.

Besides the interest of the information obtained from its use, this methodological proposition has two additional advantages: its simplicity and its flexibility. Both indices have a simple specification and their components can be redefined depending on the framework and the nature of the spatial data available, thus they can be employed in different geographical contexts and on different port ranges. The only requirement is to have information spatially disaggregated about the inland origin of flows within the geographical area of interest.

Regarding the case study, the analysis conducted allows us to confirm that the port of Valencia has reinforced its leadership also in the inland side among the Spanish ports over the previous decade. It also allows us to observe a certain relationship between the configuration of the ports' hinterland and the economic activity of the surrounding provinces. In parallel, the territory that generates the traffic flows varied during the period analysed: some of the farthest inlands from the ports disappeared from their potential hinterland, while others closest to them began to generate flows.

The results obtained encourage us to dig deeper in this line of research. There are some very interesting questions to solve in future works. One of them is the identification of the determining factors of the observed evolution of the ports' hinterland. Regarding this, the analysis of the role played by factors such as the accessibility, the road and rail infrastructure available, the existence of inland ports or intermodal terminals or even the location of the large centres of production/consumption will be very pertinent. Another deals with analysing to what extent the development of the port hinterland is conditioned by the economic activity of its geographical environment and vice versa; that is, to what extent the economic activity of a territory is influenced by the nearest port infrastructure and the corridors linked to its hinterland.

From the methodological point of view, it would be desirable to go further and to combine both indices in a more global one. Nevertheless, the definition of that synthetic index would require a deeper discussion about what is more desirable for a port (to extend its geographical scope or to reduce its geographical dependence) when both goals cannot be achieved simultaneously. In the case study conducted, it was easy to conclude that the hinterland of Valencia has experienced the best spatial evolution. However, what conclusion should be drawn if indices E and H evolve in an opposite direction for the same port? And when comparing two ports, if the only improvement of one of them lies in the index E whereas the other is in the index H?

Acknowledgements

Authors acknowledge the financial support provided by the Government of Spain under the project MTM2011-23205 and would also like to thank Simme Veldman for their useful and constructive comments.

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