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Analysis of the inland port regionalization process in Spain

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Abstract

The aim of this paper is to analyse and compare the ability of the main Spanish containers ports to penetrate into their inland territory along the last decade. To achieve this goal we firstly identify the inland origin of the container cargo by considering the location of the Spanish companies generating those flows in the peninsula. Then we determine the distribution of flows among the considered ports from 2000 to 2010, setting the boundaries of their hinterlands along that period. Finally we use two indexes to assess the evolution of these hinterlands in a complementary way: by their scope and their homogeneity.

Furthermore, considering that the inter-port distribution of the traffic can change according to their composition, we repeat the analysis in a disaggregate way; that is, separately for each one of the main flows (by volume) of the Spanish foreign trade on the basis of the Combined Nomenclature Clasification.

The main results show that the port of Valencia is the one whose hinterland has better evolved: by increasing its scope and by reducing its dependency both geographical as by type of flow. They also highlight that the main centres generating the maritime container flows are closer to this port than to the rest. Also these results allow us to conclude that this port regionalization process has not been oblivious to its economic environment but positively influenced by it.

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Keywords: hinterland; port competition; port regionalization; Spanish ports.

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1. Introduction

The interest of researchers in the topic of port choice has increased in the last decade (see (Paixao Casaca, Carvalho, & Oliveira, 2010), (Pallis, Vitsounis, & De Langen, 2010), (Woo, Pettit, Kwak, & Beresford, 2011) or (Woo, Pettit, Beresford, & Kwak, 2012)). From a revision of the literature, we can conclude that a wide majority of the papers on that topic have been focused on the sea side, while the process of geographical evolution of the ports' hinterland has been much less studied (Cullinane & Wilmsmeier, 2011). Actually, the analysis of the scope, boundaries and development of port hinterlands is not a very common topic in the literature about the ports. As a result, most of the papers published about the activity of the port sector ignore what is happening in the inland side despite the inflows/outflows having an inland origin/destination.

Nowadays there is a broad consensus about the fact that the focus of the competition for the traffic is taking place among logistics chains ((Magala & Sammons, 2008), (Robinson, 2002)). Consequently, the improvement of the intermodal transport would have made that the traffic generated in the space surrounding the ports was not determinant for the success of those ports ((De & Park, 2003), (Malchow & Kanafani, 2004)), and this could explain the lack of interest for the inland traffic distribution. Nevertheless, despite the generalised agreement about the shift of the degree of dependence of the ports on their own spatial environment, some authors defend that each port belongs to a system and that their activity is closely linked to their economic, social and political environment ((Bichou & Gray, 2005), (Yap & Lam, 2006)), particularly when in the port hinterland there are large centres either of production or consumption ((Notteboom, 2010)).

Thus it can be concluded that a proper approach for understanding the evolution of the activity of a port requires taking into account both perspectives, namely the maritime side and the inland side (Roso, Woxenius, & Lumsden, 2009). Given the lack of studies focusing on this second perspective, this paper aims to fill part of the gap in the literature regarding the analysis of the inland distribution of the port traffic. With this task in mind, we were inspired by the concept of *port regionalization* (Notteboom & Rodrigue, 2005) as a starting point for the analysis of the evolution of the port's hinterland.

The paper is structured as follows. In section 2 we propose two simple indexes to analyse both the configuration and evolution of the hinterland of ports. In section 3 we explain the databases used to delimit the hinterlands of the ports considered for the proposed case study: Ports of Algeciras, Barcelona, Bilbao and Valencia. In section 4 we show the mains results, and our conclusions are highlighted in section 5.

2. Proposal for the analysis of the inland traffic of the ports

Notteboom and Rodrigue (Notteboom & Rodrigue, 2005) emphasized the need to include a proper analysis of the inland distribution of the cargos in port development models. They proposed a new phase for port development taking into account the port's links with its hinterland in addition to its foreland. This phase is called *port regionalization*.

Nowadays, logistical integration makes it possible to attract a huge volume of traffic from minor and discontinuous hinterlands through inland distribution centres (see, for instance, (Monios & Wilmsmeier, 2012), (Notteboom, 2010), (Rodrigue, Debrie, Fremont, & Gouvernal, 2010), (Roso, 2010) or (Veenstra, Zuidwijs, & van Asperen, 2012) for clear insights into the issue). In this sense, Notteboom and Rodrigue point out that the port regionalization phase is characterized by increasing interdependence relationships between some loading centres and logistic platforms located in the port hinterland, with this interdependence favouring the port's expansion, reducing its costs and delays. Thus, we can conclude that a port's success in the competition for traffic also depends on its own ability to integrate into the inland traffic corridors.

The design of efficient regionalization strategies is hardly possible without a proper knowledge of the inland sea traffic corridors, including the role of the "inland islands" that belong to the port hinterland but are not spatially contiguous to the area surrounding the port. Consequently, it is advisable to analyse its hinterland and its evolution along time both for the design of its strategy and for a better understanding of a port's regionalization process. With this task in mind, we propose an index to analyse how the hinterland of the main Spanish ports has evolved over the last decade.

Our aim is to analyse the evolution of the spatial configuration of the ports' hinterland taking into account two relevant issues in this regard: their spatial scope and their geographical dependency. We suggest:

- To evaluate the degree to which the geographical configuration of the port's hinterland differs from that expected in the case that all the spatial sub-units that contribute to traffic generation were linked to the port (*Expansion index, E*); and
- To evaluate the degree to which the traffic generated in the port's hinterland is homogenously distributed from the spatial perspective (*Herfindhal index, H*).

The indexes *E* and *H* are respectively defined for each port *p* as (1) and (2):

$$E_p = \frac{\sum_i (s_i - x_i)^2}{\sum_i s_i^2 + \sum_i x_i^2} \tag{1}$$

$$H_p = \sum_i z_i^2 \tag{2}$$

Where:

- s_i is the share of the spatial sub-units from province *i* tied in with the port *p*, expressed as the number of these spatial sub-units divided by the total number of spatial sub-units where we can find companies that manage their flows through port *p*. The spatial sub-units might be municipalities, zip codes or even the Local Labour Systems of the spatial unit (province) *i* where the companies generating the flows are located, and they comprise the inland islands of the hinterland of the ports in each province *i.*
- x_i is the share of the spatial sub-units from province *i* that host companies generating maritime flows over the total number of the spatial sub-units where maritime traffic is generated.
- z_i is the share of a port's traffic generated in province *i.*

Indexes *E* and *H* take values in the interval (0, 1). In both cases values close to 1 reflect a higher level of concentration, namely a geographical concentration of the companies that channel their traffic through port *p* (index *E*) or a high level of dependence of port *p* on the traffic generated in some provinces (index *H*). That is, the larger the value of *H*, the greater the geographical concentration of the generation of traffic within the hinterland, and the smaller the relevant hinterland of the port. In such a case, if *E* was close to 0 would be facing an installation capable of attracting traffic from practically all the points where it is generated but whose relevant hinterland is much smaller. Then, the question to be solved is whether this is due to some territories generating a small amount of traffic or to the port not yet been able to strengthen there its leadership. Finally, when both *E* and *H* tend to 0, we would be facing ports with hinterlands with a large geographical reach and a homogeneous traffic generation.

3. Databases

We used the database of the Spanish Customs Statistics, which provides information on the provincial origin of foreign trade flows. It constitutes our first proxy of the boundaries of the ports' hinterland, already applied in previous papers (see for example (Garcia-Alonso & Sanchez-Soriano, 2009) or (Garcia-Alonso & Sanchez-Soriano, 2010)). This information was combined with data contained in another source, the Directory of exporting-importing companies of the Chambers of Commerce, which allowed us to identify the companies that are generating those export/import transactions by year.

As the directory of the Chambers of Commerce does not include information on the transport mode employed, selecting only those companies that have commercial flows with the American continent and Asian countries guarantees the use of maritime transport. Moreover, we only take into account the exporting companies. Eventually, and for instance, 3,821 out of the 5,491 Spanish exporting companies registered in 2010 (the last year considered for this study), necessarily dispatch their cargo through a port (69.59% of the total).

A drawback is that the Directory of Spanish exporting-importing companies does not include information on the value/volume of the cargo exported by each company. Consequently, it is impossible to determine the share of each company in the total port export flows. Thus, in order to quantify the intensity of the transactions of the inland islands it is necessary to combine these with the customs provincial database. This new approach allows us to delimit the hinterland of the ports much more accurately than in previous papers because now we know where exactly the traffic is generated within the province and we can consequently compare the atomization of the hinterland of different ports from the geographical perspective.

4. Results

The results obtained for the indexes *E* and *H* for the set of the analysed ports both at the beginning and at the end of the last decade are shown in Table 1. In the Appendix it is shown in Figure 1 their corresponding hinterlands in 2000 and 2010.

Table 1. Values for indexes *E* and *H* for 2000 and 2010.

	Algeciras	Barcelona	Bilbao	Valencia
2000	E= 0.783	E= 0.200	E= 0.548	E= 0.320
	H= 0.238	H= 0.474	H= 0.116	H= 0.438
2010	E= 0.752	E= 0.232	E= 0.678	E= 0.059
	H= 0.198	H= 0.409	H= 0.124	H= 0.206

We can see that the geographical scope of the hinterland of the port of Algeciras remains practically the same from the beginning to the end of the period (E2000 = 0.783; E2010 = 0.752), while it has gained homogeneity with respect to the spatial origin of its traffic. The port of Barcelona has reduced its level of dependence on the traffic generated in its geographical surroundings (H_{2000} = 0.474; H_{2010} = 0.409), and it has also experienced a reduction in the scope of its relative hinterland respect to the other ports (E_{2000} = 0.200; E_{2010} = 0.232). The same has happened to the port of Bilbao, whose relative geographical scope has been reduced (E_{2000} = 0.548; E_{2010} = 0.678). Nevertheless, compared to the hinterland of the port of Barcelona, the one of Bilbao has a much greater level of homogeneity in its ability to generate traffic, and is the most compact of all ports in this sense, both at the beginning and at the end of the period (H_{2000} = 0.116; H_{2010} = 0.124). Finally, the scope of the hinterland of the port of Valencia is larger at the end of the decade. Aside from this, we can see that this hinterland has evolved in a positive direction: it extended its scope (E_{2000} = 0.320; E_{2010} = 0.059) and simultaneously increased the homogeneity in its geographical ability to generate traffic (H_{2000} = 0.438; H_{2010} = 0.206).

Our results allow us to conclude that the port of Valencia is the most advanced in terms of the diversification of its hinterland: it is more compact at the end of the period than it was at the beginning (lower value of *H*), it is the only port that has significantly expanded its hinterland compared to the other ports (the *E* index has fallen), and it has the greatest geographical scope of the ports analysed (lowest value of *E*). Thus we could conclude that the process of *regionalization* of the port of Valencia is the most advanced.

4.1. Analysis by composition of flows

The previous results were obtained from the analysis of the whole of the Spanish exports channelled by sea (to America and Asia) in containers. Nevertheless, these results, and consequently the conclusions drawn from them, can vary according to the nature of flows. To assess possible differences concerning the evolution of the hinterland of the set of ports analysed according the composition of traffic, we have disaggregated the flows by following the Combined Nomenclature Classification (CNC).

Only 5 out of the 99 chapters of CNC concentrate half the export traffic. Consequently, we focus on them for this first approach to this topic. The definition of these chapters according to the CNC is (from highest to lowest traffic volume):

- 69: Ceramic products.
- 25: Salt; sulphur; earths and stone; plastering materials, lime and cement.

- 39: Plastics and articles thereof.
- 48: Paper and paperboard; articles of paper pulp, of paper or of paperboard.
- 32: Tanning or dyeing extracts; tannins and their derivatives; dyes, pigments and other coloring matter; paints and varnishes; putty and other mastics; inks.

In Table 2 we show their share (as mean of the flows from 2000 to 2010), and how these chapters were distributed among the analysed ports for the same period (by columns). We can see that the port of Valencia is by far the preferred one for channelling the first, second and fifth main chapters (and it is also the second one chosen for channelling the rest).

Those chapters for which the port of Valencia is the preferred (69, 25 and 32) are also those most important for this infrastructure along the whole period (regarding its container traffic coming from the Spanish foreign trade). This seems not to be casual. In the Appendix it is shown in Figure 2 the geographical origin of the export flows for these 5 main chapters (as mean of the period considered). From here it seems that there is a link between the spatial origin of the flows and the location of the chosen port for channelling them. If so, the hypothesis of (Bichou & Gray, 2005) and (Yap & Lam, 2006) about the influence of the economic environment on port activity would be confirmed.

Table 2. Share of traffic by chapter (mean for the period 2000-2010) and distribution of the chapters by port.

Chapter	69	25	39	48	32
For the whole of the traffic	28.4%	8.1%	6.2%	4.9%	4.5%
For the Port of Algeciras	0.1%	0.6%	3.7%	1.3%	5.9%
For the Port of Barcelona	3%	6.7%	54.4%	64.2%	12.2%
For the Port of Bilbao	1.2%	2.2%	5.7%	10%	2.3%
For the Port of Valencia	89.7%	84.3%	16.7%	23.2%	62.6%

And what has happened with the hinterland of the ports according to the evolution of the nature of the flows? In Table 3 we present the values for indexes *E* and *H* for 2000 and 2010.

Table 3. Values for indexes *E* and *H* for the main chapters of traffic in 2000 and 2010.

	Algeciras		Barcelona		Bilbao		Valencia	
Chapter	2000	2010	2000	2010	2000	2010	2000	2010
69	E= 0.86	E= 0.93	E= 0.30	E= 0.41	E= 0.67	E= 0.79	E= 0.01	E= 0.01
	H= 0.20	H= 0.89	H= 0.47	H= 0.85	H= 0.27	H= 0.26	H= 0.89	H= 0.83
25	E= 0.84	E= 0.86	E= 0.41	E= 0.46	E= 0.45	E= 0.89	E= 0.25	E=0.02
	H= 0.22	H= 0.46	H= 0.37	H= 0.32	H= 0.15	H= 0.78	H= 0.52	H= 0.38
39	E= 0.92	E= 0.84	E= 0.11	E= 0.08	E= 0.73	E= 0.84	E= 0.47	E= 0.05
	H= 0.26	H= 0.11	H= 0.41	H= 0.35	H= 0.17	H= 0.21	H= 0.17	H= 0.14
48	E= 0.94	E= 0.91	E= 0.09	E= 0.16	E= 0.67	E= 0.84	E= 0.59	E= 0.06
	H= 0.45	H= 0.94	H= 0.65	H= 0.88	H= 0.16	H= 0.38	H= 0.22	H= 0.24
32	E= 0.95	E= 0.98	E= 0.07	E= 0.14	E= 0.70	E= 0.73	E= 0.59	E= 0.03
	H= 0.79	H= 0.94	H= 0.57	H= 0.80	H= 0.14	H= 0.27	H= 0.79	H= 0.73

These results show that Valencia has significantly increased the scope of its hinterland in 4 out of the 5 chapters considered in this study (in chapter 69 it was not possible due to the high level of expansion already reached at the beginning of the period). The evolution experienced in chapters 25, 39 and 48 is particularly important. In chapter 25 because it experienced the biggest growth during the period; in chapters 39 and 48, because their flows were mainly channelled through Barcelona at the beginning of the period (besides their important increase also in traffic share).

The evolution of the scope of Algeciras and Bilbao was the opposite: much more reduced -especially in the case of

Algeciras- and not improving over time (even decreasing where it was better -chapter 25 of Bilbao-).

The scope of Barcelona is more uneven depending on the chapter considered. Its bigger expansion takes place for the chapters mainly generated in provinces located around this port (chapters 39 and 48), though it has decreased for chapter 48. Finally, this port had in 2000 the biggest hinterland for chapter 32, but it has also reduced its scope here.

The degree of dependency of the ports on a specific territory; that is, the degree of homogeneity in the flows generation inside the port hinterland (H index) is much more uneven by ports and by chapters of a precise port. For instance, the flows generation for chapters 69 and 32 is quite inhomogeneous inside the hinterland of Valencia. Nevertheless, this is due more to the high level of geographical concentration of the traffic generation than to this port's inability to attract these flows.

5. Conclusions

This paper aims to improve the knowledge about the spatial development of the hinterland of the ports. To achieve this goal, we suggest to focus on two main issues: the evolution of both the geographical scope of the hinterland and the spatial concentration of the traffic generation. The tools proposed for these assessments are the Expansion index and the Herfindahl index, respectively.

Beyond the port sector, the analysis of these flows is also interesting by its influence on the configuration of the traffic corridors and, therefore, by its influence on the evolution of the inland transport infrastructure and the economic regional activity. The utility of the analysis proposed has been illustrated through a case study: the evolution of the hinterland of the main Spanish peninsular ports.

This analysis has allowed us to confirm that the port of Valencia has reinforced its position among the Spanish peninsular ports over the last decade in the inland side. It has also allowed us to detect a relationship between the nature of its traffic and the economic activity of the surrounding provinces. In short, we could say that the development of the hinterland of the port of Valencia is a direct consequence of the nature of its traffic, mainly generated in provinces located in its surroundings, whose flows are so important that they influence the evolution of the whole of the national flows.

Data have also suggested two links: between the spatial origin of the flows and the location of the port chosen for channelling them, and also between the composition of the traffic channelled through a port and the nature of the foreign maritime flows generated in the nearest provinces. To confirm this hypothesis is out of the aim of this paper, but a deeper analysis would be desirable in future works. Two questions should have to be solved. First: to what extent the development of the port hinterland is influenced by the evolution of the economic activity in its geographical environment. And second, and even more interesting, to what extent the evolution of this economic activity is influenced by the nearest port infrastructure.

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Appendix

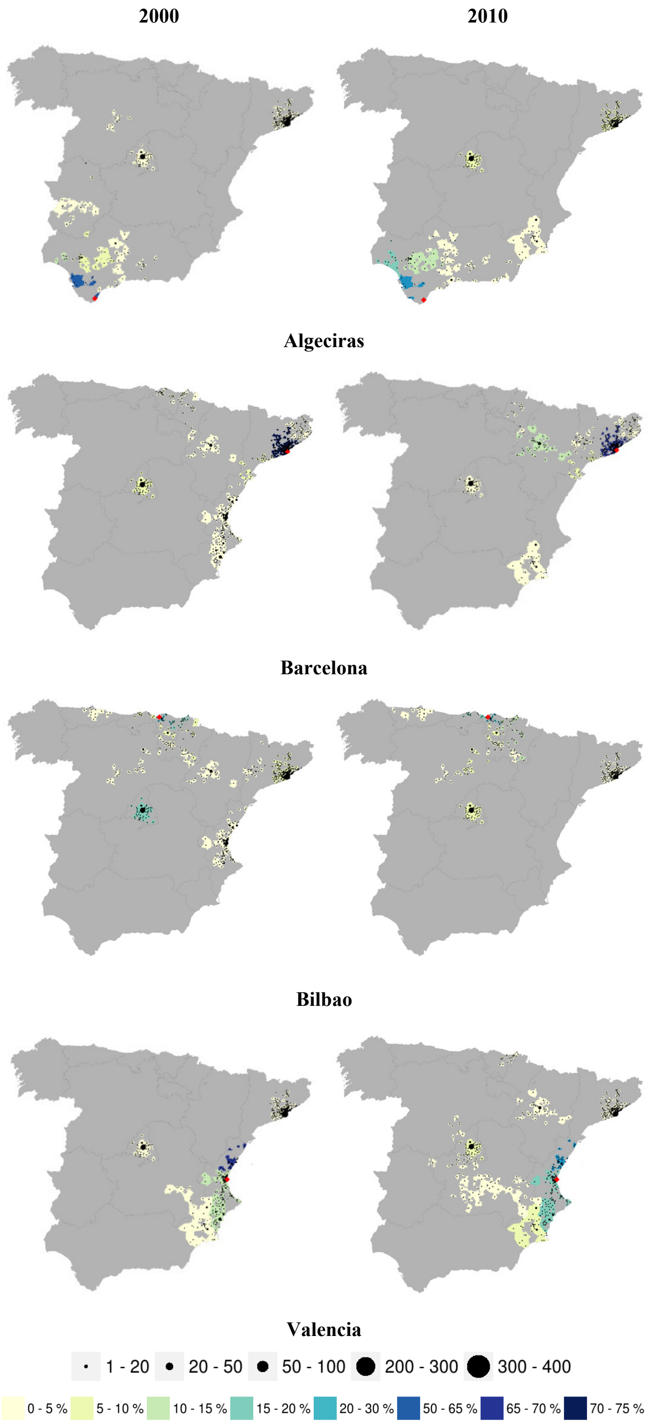
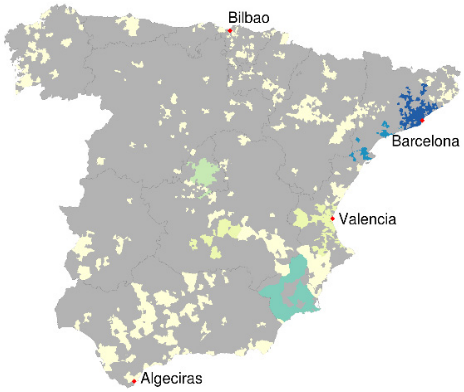
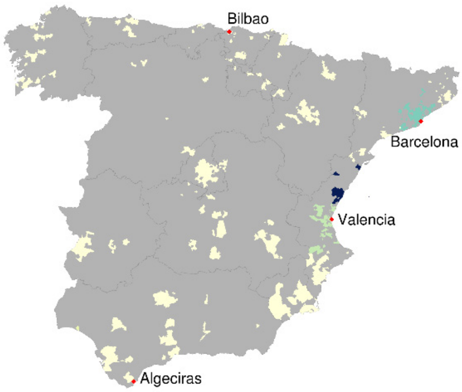


Fig. 1. Hinterland of ports in 2000 and 2010.

Chapter 69
Ceramic products.

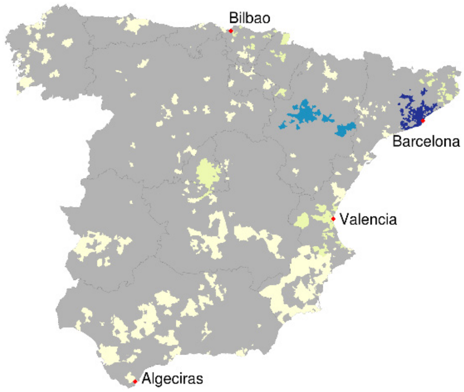


Chapter 39
Plastics and articles thereof.



Chapter 32
Tanning or dyeing extracts; tannins and their derivatives; dyes, pigments and otl coloring matter; paints and varnishes; putty and other mastics; inks.

Chapter 25
Salt; sulphur; earths and stone; plastering materials, lime a cement.



Chapter 48
Paper and paperboard; articles of paper pulp, of paper or paperboard.

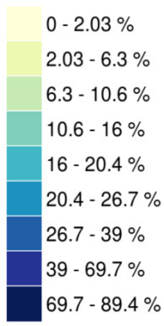


Fig. 2. Geographical origin of the maritime Spanish foreign traffic by CNC chapter (mean 2000-2010).

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