Why container specialisation make a difference: An efficiency analysis of the Spanish port authorities

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ABSTRACT

There is evidence of specialization around containerized cargo but also a lack of literature regarding its impact at ports. This essay aims to fill this gap in the Spanish port authorities. To this end, using DEA techniques, the efficiency of 26 ports been estimated over the period 1995-2015. In a second stage, we analyse the drivers of efficiency regarding container specialisation.

Our results shows that non-specialized ports are on average more efficient than the container ones. However, it would be advisable, for all port authorities, to increase share of container traffic on total traffic to enhance the efficiency levels. Moreover, the operating optimal size or being close to a logistics activity area are clear determinants of efficiency in the maritime sector for both groups of ports.

KEY WORDS: efficiency, DEA methodology, container ports, specialization, competitiveness.

Introduction

Container transportation is attracting the attention of international literature since its importance has been enhanced by the globalisation of production and consumption. Almost since the container invention, and especially since the last decades of the XX century, its use has sustained an exponential growth, which is evident in the trends of the annual statistics of major trading ports in the world.

The worldwide container port traffic was 36 million TEUs in 1980, and only after twenty years, this kind of traffic reached 234 million TEUs. In 2010, the transportation of containerized cargo was 579 million TEUs, after the 2009 drop caused by the international financial and economic crisis (De Larrucea, 2012). Currently, the international container port traffic is close to reaching 700 million TEUs (World Bank, 2016).

In the following figure, based on Puertos del Estado data (2016), the exponential growth of the container traffic in Spanish ports is shown. As we can see, the volume of containerized cargo was going up slowly until 1992, when this kind of traffic started to soar. According to Coto-Millán, et al. (2016), the main reason was the transformation of port model (starting in 1992 by the 27/1992 Law) from a state system, based on strictly administrative criteria, to a commercial understanding of port services.

Analysing the containerization ratio of the 26 Spanish Port Authorities – hereinafter PA –, there is a clear evidence of a higher concentration of container traffic in the Spanish south-east coast. The next table shows this statement, where eight of the ten PA with the highest ratios belong to this side of the Spanish littoral. This leads us to believe that there may be a tendency towards specialisation with regard to this type of traffic, which would corroborate proof of specialisation found by González-Laxe (2012).

Consequently, the main objective of this essay is to investigate if there is a tendency towards specialisation with regard to the containerized cargo traffic. This hypothesis has been analysed through an efficiency analysis since it is supposed that the cargo specialisation increases the productivity and operational efficiency of the Port Authorities. Moreover, specialization can be considered a result of inter-ports competition, which is a key factor for efficiency. Due to this fact, several determinants of inter – container ports competitiveness are going to be taken into account in this essay, in order to determine which factors boost the container ports efficiency.

There is a lack of empirical evidence in relation to the efficiency of the Spanish container port sector, within the international literature. That is why, this essay aims to fill this gap. Moreover, through the efficiency analysis, this paper will be able to point out several efficiency determinants that are related to the competitiveness among container ports. Which is quite an important contribution in this field as, knowing the factors that have a positive impact over the efficiency of the container port sector, will generate recommendations of economic policy.

This essay is divided into six sections. Following the current introduction, which presents the factors that have motivated this study and the main objective that has been analysed; a review of the international literature is presented. The next two sections give an explanation of the methodology and the data that have been used in order to find several results that are presented in Section 5. The conclusions, limitations and further research opportunities are presented in Section 6.

Literature review

The measurement and evaluation of ports technical efficiency has important academic interest. The growth of port efficiency literature is proof of that. Recently, efficiency studies focus on understanding what factors play on the efficiency score of a given port.

Two methods, both based on the estimation of technological frontiers, predominate over the resto to measure efficiency. These methodologies are the Data Envelopment Analysis (DEA) (Barros and Athanassiou, 2004; Cullinane et al., 2006, 2004; Lin and Tseng, 2007; Martinez-Budria et al., 1999; Tongzon, 2001; Wu and Goh, 2010) and the Stochastic Frontier Analysis (SFA) (Coto-Millán et al., 2000; Cullinane et al., 2006; Cullinane and Song, 2006, 2003; Liu, 1995; Núñez-Sánchez and Coto-Millán, 2012).

Both methods allow identifying and interpreting the strengths and weakness of the port authorities, in terms of relative efficiency within the sample or group in which they are being analysed. To do this, from the agents with best performance, the efficient frontier is identified. Then, with respect to this optimal frontier, the relative efficiency of the rest of agents is estimated. DEA[1] uses mathematical programming to identify the

[1] Farrell (1957) first introduced this methodology.

efficient frontier. However, SFA[2] hypothesizes a functional form. It is important to highlight that, only SFA can separate random noise from efficiency, since DEA incorporate noise as part of the efficiency score (Cordeiro et al., 2012). However, DEA do not need to impose any functional form to the production process of the agents, while SFA needs to impose a functional form and make some assumptions about the distribution of the inefficiency term[3]

Nowadays, many studies focus on the influence of external factors on ports' efficiency. These factors are assumed not controllable by ports, unless in the short term (Pérez et al., 2016). The most common included external factors are port ownership (private or public), type of port administration model, port size and port location (González and Trujillo, 2008a).

The ways to study the effect on those variables on efficiency vary across methods (parametric and non-parametric frontiers) and over the time.

A first approach widely used in literature and applied to both techniques, SFA and DEA, is the following two-step procedure. First, efficiency is estimated. In a second stage, observations are grouped or classified following a given criteria of interest (for example, port ownership) and then authors compare the efficiency scores of the different groups in order to check if there are significant differences between groups, and if such differences occur, investigate which groups have a better performance and which ones have worse. Some examples are (González and Trujillo, 2008b), or (Cullinane et al., 2005). González and Trujillo (2008), from the estimation of a stochastic distance function, analyse the impact of port reforms on Spanish port authorities' efficiency through the temporal evolution of efficiency in time. (Cullinane et al., 2005) obtain efficiency indices using DEA and then classified ports in groups according their organizational structure and their type of ownership, respectively, and compare the efficiency results among groups.

Regarding studies that applies SFA, the first studies that evaluated the impact of environmental factors on efficiency carried out a two-stage procedure. In the first stage, efficiency is estimated using stochastic frontiers. While in the second one, an ordinary least square estimator is used to regress efficiency scores on the external variables of interest. Following this approach, (Liu, 1995) and (Coto-Millán et al., 2000) investigate

[2] Initially, Aigner, Lowell and Schmidt (1977) proposed this methodology.
[3] For a more detailed explanation of the strengths and weaknesses of these approaches, see González and Trujillo (2009).

the effect of some port characteristics such as size or type of ownership/management on efficiency using production and cost stochastic frontiers, respectively. However, nowadays, methodologies that allows to estimate jointly efficiency with the impact of external factors on it in a one-step procedure are becoming most significant in literature, methodologies such as the one proposed by (Battese and Coelli, 1995) or true and random fixed effect estimators (TFE and RFE) developed by (Greene, 2005). (Rodríguez-Álvarez and Tovar, 2012), (Chang and Tovar, 2014), (Coto-Millán et al., 2016), or (Pérez et al., 2016) are some examples of authors that have used these approaches.

On the DEA side, to identify determinants of technical efficiency, a two-stage analysis, which use a truncated model (Tobit model) or bootstrapped parametric techniques (Simar and Wilson, 2007) in the second stage, are widely applied in literature. However, (Simar and Wilson, 2007) point out that the use of bootstrapped techniques is more convenient because of DEA efficiency estimates may be serially correlated, which in turn could led Tobit estimates to be invalid. The standard procedure using Tobit model is used in (Turner et al., 2004) and (Yuen et al., 2013). The later used both, Tobit regression model and Simar and Wilson bootstrap technique, in the second stage, and they do not find significant differences among the results obtained by each approach. On the other hand, the (Simar and Wilson, 2007) methodology is applied in the works of (Niavis and Tsekeris, 2012), (Wanke, 2013) or (Figueiredo De Oliveira and Cariou, 2015) among others.

Finally, table 1 summarize the studies surveyed in which efficiency determinants are investigated.

Data

The database has been built from the annual reports published by Puertos del Estado (central manager of the Spanish port system) and Spanish port authorities (individual manager of Spanish port of general interest). Statistical information on 26 port authorities have been collected for the period 1995-2015.

On one hand, the analysis take into account the multi-product nature of ports, separating cargo and passengers. On the other hand, we take special attention to container traffic, so we separate container traffic to the rest of types of cargo handled by port authorities (Cullinane et al., 2002; Valentine and Gray, 2001). Therefore, three outputs have been considered: thousand tons of container traffic (cont), thoousand tons of other cargo traffic (other), liquid bulk, solid bulk and non-containerized cargo, and thousand of passengers (pax). Few studies in port performance include passenger into the analysis, however this traffic is quite relevant for important ports in our sample. In this line, (Núñez-Sánchez et al., 2011) find out that, in spite of a passenger weights on average less than one tenth of a ton, it represents about three tons of containerized general cargo in terms of marginal costs.

Table 1 Summary of previous papers on investigating the effect of external factors on efficiency.

Authors	Methodology	Sample	Factors and their impact on efficiency
Liu (1995)	SFA (production)	28 British ports (1983-1990)	Ownership (private, trust vs municipal): no significant. Capital intensity: scarce effect on efficiency. Location: significant effect on efficiency. Size: positive effect.
Coto-Millán et al. (2000)	SFA (cost)	27 Spanish port authorities (1985-1989)	Type of management: autonomous ports are less efficient than those managed in a centralized way. Size: no significant effect
Turner et al. (2014)	DEA	26 US and Canadian container ports (1984-1997)	Port size: positive effect. Vessel size: positive effect. Connectivity (class I railroads): positive effect.
Culliname and Wang (2005)	DEA	30 container ports worldwide (1992-1999)	Ownership: privatization does not increases efficiency.
González and Trujillo (2008)	SFA (output-oriented distance function)	9 Spanish port authorities (1990-2002)	Ports reforms: no significant effect.
Niavis and Tsekeris (2012)	DEA	30 seaports in the region ofSouth-Eastern Europe and Italy (2008)	Port area: positive effect. Ownership port operation: positive effect. Distance from Suez channel: closer ports more efficient. Hinterland population and GPD: no effect.
Rodríguez-Álvarez and Tovar (2012)	SFA (cost)	26 Spanish port authorities (1993-2007)	Time (port reforms): effects of legislation vary across the reforms analyzed. Mechanization: positive effect.
Wanke (2013)	Two-stage DEA	27 Brazilian ports (2011)	Hinterland size: positive effect on shipment consolidation stage efficiency. Private administration: positive effect on physical structure stage efficiency.
Yuen et al. (2013)	DEA	21 Asian container terminals (2003-2007)	Ownership: no effect. Hinterland population: negative effect. Hinterland GPD: positive effect. Intra-port competition: positive effect. Inter-port competition: negative effect.

Table 1 (cont) Summary of previous papers on investigating the effect of external factors on efficiency.

Authors	Methodology	Sample	Factors and their impact on efficiency
Chang and Tovar (2014)	SFA (output-oriented distance function)	14 Peruvian and Chilean port terminals (2004-2010)	Bulk rate: negative effect. Containerization index: negative effect. Occupancy rate of berths: positive effect. Ownership: private terminals are more efficient than public-owned ones.
Coto-Millán et al. (2015)	SFA (input-oriented distance function)	26 Spanish port authorities (1986-2012)	Port reforms: have a positive effect.
Figueiredo De Oliveira and Cariou (2015)	DEA	200 container ports worldwide (2007-2010)	Hinterland population: negative effect. Hub: being a hub port increases efficiency. Linner shipping connectivity: positive effect. Inter-port competition: positive effect.
Pérez et al. (2016)	SFA (production)	40 Latin American and Caribean container terminals (2000-2010)	Intra-port competition: positive effect. Trade agreements: negative effect. Transshipment port: being a transshipment port reduces efficiency.

Source. Own elaboration.

Regarding port authorities' productive factors, two variable and one quasi-fixed input have been included. The variable inputs are labour (lab) and intermediate consumptions (ic). The first one is approximate by the number of workers ((Cullinane et al., 2002; Roll and Hayuth, 1993). Secondly, intermediate consumption is approximate by their expenses in 2001 monetary values (Martinez-Budria et al., 1999; Núñez-Sánchez et al., 2011). Finally, we have approximated capital, the quasi-fixed input, by the square meters of the port authorities' deposit areas (Song and Sin, 2005; Tongzon, 2001).

As we explain before, in a second stage we regress efficiency scores on external factors that could have a significative impact on it following the (Simar and Wilson, 2007) approach. The external determinants considered are highly related with port comptitiveness. They are container specialization, mechanization and logistics. Firstly, to measure container specialization, the containerization ratio has been considered the best approximation since it is supposed that, the more specialized the port authority is, the higher will be the volume of containerized cargo within its total traffic. Second, a measure of the degree of ports' mechanization has been obtained by the number of cranes installed in each port authority, a priori it is believed that port authorities with a high level of mechanization will report higher levels of efficiency. Also, the ports logistics performance was considered as a factor of interest in terms of competitiveness. Because the logistics activity areas (ZAL) helps to improve cargo storage and distribution, so it is assumed that they could be higly related with efficiency. To control this factor, we have included a dummy variable that takes the value 1 when the container port has an operating ZAL or 0 when it has not.

Additionally, we have divided the sample in two subsample: (1) container specialized port authorties and (2) the rest of port authorities[4]. This division allows us to check the differences in the impact of these factors on efficiency between both groups. The ports selected as container ports are Algeciras, Alicante, Barcelona, Las Palmas, Málaga, Valencia and Vigo. These ports are characterized by present the highest container shares in the last years of the sample (2011-2015) as table 2 shows.

It is important to highlight that, these specialized ports represent almost the 90% of the total containerized cargo traffic (Puertos del Estado, 2016) which means that, they make up a very representative sample.

To conclude with this section, table 3 gives a brief summary of the descriptive statistics and also, a short definition for the input and output variables that have been used on this analysis.

Methodology and data used

DEA Methodology

Farrell (1957) suggested a deterministic method of measuring the technical efficiency of a firm in an industry by estimating a frontier production function. Based on Farrell's work (Farrell 1957), Charnes, Cooper, & Rhodes, (1978) shape the deterministic non-parametric methodological technique of Data Envelopment Analysis (DEA) to measure the relative performance of a set of similar organizational units (DMUs) which, in this paper, correspond to airports. In the regional airport context, Merkert et al. (2012) have shown that DEA models are appropriate and useful for performance measurement with multiple inputs and outputs.

[4] Henceforth, we refer to the first group as specialized port authorities and to the second one as non-specialized port authorities.

DEA methodology can be used to derive both technical and scale efficiency, and to determine the nature of returns to scale. Furthermore, it can be used for measuring the relative performance of organizational units where there is a presence of multiple inputs and outputs. A firm is technically inefficient if production occurs within this production set. The inefficiency of a DMU is measured by the distance from the point representing its observed input and output values to the production frontier. A description of the DEA methodology is explained in Mantri (2008).

DEA can be output or input oriented. On the one hand, a model is input-oriented when the measure of efficiency is the distance between observed and minimum possible input for given outputs, and on the other side, it is output-oriented when trying to determine the maximum possible outputs with given levels of inputs.

Thus, for the jth airport out of n airports, the input-oriented technical efficiency under constant return to scale (CRS) is obtained by solving the following linear programming problem:

$$\min_{\theta_j^{CRS}\lambda} \theta_j^{CRS} \; subject\ to: \; \theta X_j \geq X\lambda; \; Y_j \leq Y\lambda; \; \lambda \geq 0 \tag{1}$$

Where X and Y are the input and output vectors, respectively, $\varphi_j^{CVS} = 1/\theta_j^{CVS}$ is the technical efficiency (TE) of airport j under CRS and λ is an n x 1 vector of weights. The non-negative weights λ measures the contribution of the efficient airports selected to define a point of reference for the inefficient jth airport. In general, $0 \leq \varphi_j^{CRS} \leq 1$, where $\varphi_j^{CRS} = 1$ if the airport is producing on the production frontier and hence, technically efficient. When $\varphi_j^{CRS} < 1$, the airport is technically inefficient. In the case of variable returns to scale, one can find technical efficiency φ_j^{VRS} by adding the convexity constraint $\sum_{j=1}^{n} \lambda_j = 1$ to (1) (Banker et al., 1984).

Because the distances are the technical efficiency scores from CRS-DEA and VRS-DEA models, scale efficiency (SE) can be easily obtained by the ratio of technical efficiency scores of CRS-DEA and VRS-DEA specifications (Coelli 2005)

We apply the smoothing homogeneous bootstrap approach with 2000 iterations to overcome the potential problem of biased results in our second-stage regressions (for a more in-depth discussion see (Simar & Wilson, 2000 and Simar & Wilson, 2008).

Simar-Wilson bootstrapping regression analysis

In the second stage, the efficiency values estimated in stage one are regressed on some relevant exogenous variables not included in the DEA analysis. According to Liebert & Niemeier (2013) an advantage of second-stage approaches is that explanatory variables are not included in the first-stage of the analysis and, therefore, do not affect the discriminatory power of the first-stage procedures.

Simar and Wilson (2007) describe a data generating process under which two-step methods are consistent. Following the Simar and Wilson (2007) approach, the paper assumes and tests the following regression specification:

$$\varphi_j^{VRS} = a + z_j\delta + \varepsilon_j \qquad (2)$$

which can be understood as the first-order approximation of the unknown true relationship. In Eq. (2), a is the constant term, ε_j is the error term, and z_j is a (row) vector of observation-specific variables for DMU_j that we expect is related to the DMU's efficiency score, φ_j^{VRS}.

Based on a truncated-regression with a double bootstrapping procedure, the Simar and Wilson (2007) approach assume that the distribution of ε_j is truncated normal with zero mean, unknown variance, and (left) truncation point determined by this very condition.

Eq. (2) is estimated by maximizing the corresponding likelihood function concerning δ parameters and the variance of the error term. Algorithm#2 from Simar and Wilson (2007) is applied. For the sake of brevity, we refer the reader to Simar and Wilson (2007) for the details of the bootstrap procedure.

Results

The DEA methodology described in section 3 has been used to determine the efficiency scores of Spanish port authorities.

As we explained above, DEA methodology allows estimating efficiency by two models. The first one is the CCR model. This model assumes constant returns to scale and measures the overall efficiency for each DMU by aggregating pure technical and scale efficiency into one score (Golany and Roll, 1989). The second model is the BBC model. In this case, variable returns of scale are allowed and technical efficiency is disaggregated in pure technical efficiency (related to managerial skills) and scale efficiency. Scale efficiency can be obtained by dividing overall technical efficiency by pure technical efficiency (Barros and Managi, 2008).

Table 2. Port authorities average cargo shares during the last years of the sample (2011-2015)

Ranking	Port authority	Container ratio	Solid ratio	Liquid ratio	No container ratio
1	Valencia	0.77	0.04	0.06	0.13
2	Algeciras	0.62	0.02	0.29	0.07
3	Vigo	0.62	0.08	0.02	0.28
4	Las Palmas	0.58	0.02	0.24	0.16
5	Alicante	0.49	0.40	0.03	0.09
6	Málaga	0.47	0.28	0.03	0.13
7	Barcelona	0.42	0.10	0.26	0.22
8	Melilla	0.26	0.02	0.07	0.65
9	Villagarcía	0.24	0.34	0.19	0.23
10	Cádiz	0.23	0.50	0.05	0.23
11	Bilbao	0.21	0.14	0.54	0.11
12	Tenerife	0.20	0.04	0.52	0.24
13	Castellón	0.17	0.25	0.56	0.02
14	Pontevedra	0.16	0.46	0.00	0.38
15	Tarragona	0.06	0.29	0.62	0.04
16	Ceuta	0.05	0.04	0.45	0.45
17	Gijón	0.04	0.86	0.05	0.06
18	Cartagena	0.03	0.16	0.80	0.01
19	Baleares	0.03	0.12	0.12	0.73
20	Almería	0.01	0.68	0.19	0.11
21	Coruña	0.00	0.34	0.57	0.09
22	Santander	0.00	0.62	0.05	0.33
23	Pasajes	0.00	0.43	0.00	0.56
24	Huelva	0.00	0.17	0.81	0.02
25	Ferrol	0.00	0.74	0.19	0.06
26	Avilés	0.00	0.64	0.12	0.24

Source. Own elaboration based on Puertos del Estado data (2011-2015).

In table 4, the average scores (1995 – 2015) for these three types of efficiency are reported. These scores are relative measure with respect the most efficient unit (100%), which range between zero (inefficient) to one (efficient). Seeing these results, a number of points arise. First, all the Spanish port authorities are found to be relatively inefficient in terms of both overall and pure technical efficiency. Second, on average, non-specialized ports are more efficient than specialized ones considering the three types of efficiency. On average, non- specialized port authorities presents scores of 0.61 for overall technical efficiency, 0.72 for pure technical efficiency and 0.85 for scale efficiency. On the other hand, the average scores of specialized port authorities for overall

Table 3. Definition and descriptive statistics of the variables in the model

	Variables	**Variable definition**
Outputs	Containerized cargo traffic	Containerized cargo handled by a port (thousands of tons)
	Other cargo traffic	Liquid bulks, solid bulks and non-containerized cargo handled by a port (thousands of tons)
	Passengers	Thousands of passengers moved by a port
Inputs	Labour	Number of employees
	Capital	Square meters of deposit area
	Intermediate consumption	Other operating expenses in thousands of 2001 EUR
Exogenous factors	Container specialization	Ratio between container cargo and total cargo
	Mechanization	Number of cranes
	Logistics	Dummy variable with value equal to one the port has an operating ZAL

		Mean	**Standard deviation**	**Minimum**	**Maximum**
	Container specialized ports				
Outputs	Containerized cargo traffic	13254	15366	12	55477
	Other cargo traffic	21184	21622	1350	84951
	Passengers	1402	1559	0	5527
Inputs	Labour	293	128	124	621
	Capital	1648491	1545967	149875	5005767
	Intermediate consumption	9867	7841	1869	36396
Exogenous factors	Container specialization	0.45	0.18	0.00	0.79
	Mechanization	49	48	0	355
	Logistics	0.09	0.28	0.00	1.00

		Mean	**Standard deviation**	**Minimum**	**Maximum**
	Non container specialized ports				
Outputs	Containerized cargo traffic	711	1312	0	6608
	Other cargo traffic	9840	9162	223	34631
	Passengers	696	1447	0	7058
Inputs	Labour	173	76	58	388
	Capital	679123	733391	11354	3368045
	Intermediate consumption	4300	3266	353	16538
Exogenous factors	Container specialization	0.07	0.09	0.00	0.59
	Mechanization	30	47	0	356
	Logistics	0.02	0.14	0.00	1.00

Source. Own elaboration based on Puertos del Estado data (1995-2015).

technical, pure technical and scale efficiency are 0.48, 0.57 and 0.80, respectively. The most efficient ports are, on one hand, Baleares and Tenerife, important island ports in terms of non-containerized general cargo; and on the other hand, Algeciras, the main Spanish port in terms of container traffic. Third, in most of cases, pure technical efficiency

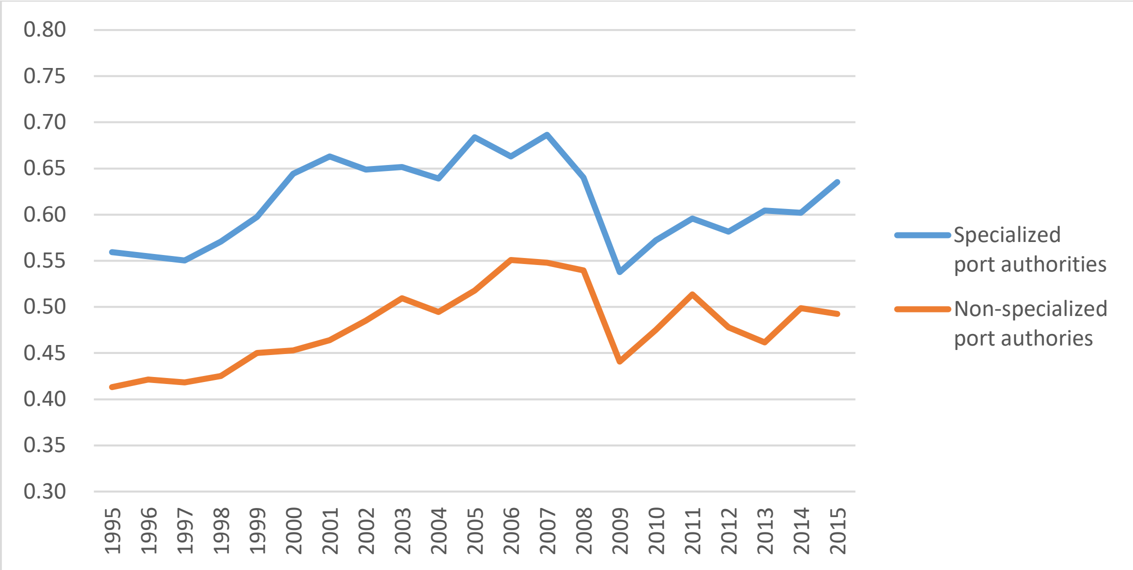
Table 4. Spanish port authorities' average efficiency levels.

Port Authority	Overall technical efficiency (constant returns to scale)	Pure technical efficiency (variable returns to scale)	Scale efficiency (economies of scale)
		Container specialized ports	
Algeciras	0.82	0.83	0.99
Valencia	0.73	0.73	1
Barcelona	0.54	0.56	0.98
Las Palmas	0.5	0.55	0.9
Vigo	0.3	0.42	0.7
Málaga	0.26	0.42	0.63
Alicante	0.20	0.49	0.42
Average	**0.48**	**0.57**	**0.8**
		Non container specialized ports	
Baleares	0.86	0.85	1.02
Tenerife	0.80	0.82	0.98
Ferrol	0.76	0.79	0.95
Cartagena	0.74	0.74	0.99
Bilbao	0.73	0.72	1.02
Melilla	0.70	0.87	0.8
Ceuta	0.69	0.75	0.91
Castellón	0.68	0.73	0.93
Gijón	0.65	0.76	0.84
Huelva	0.65	0.77	0.86
Tarragona	0.64	0.77	0.83
Avilés	0.62	0.79	0.78
Pasajes	0.58	0.66	0.89
Coruña	0.5	0.51	0.98
Almería	0.48	0.58	0.86
Pontevedra	0.46	0.84	0.56
Cádiz	0.42	0.51	0.8
Santander	0.35	0.46	0.77
Vilagarcía	0.35	0.83	0.41
Average	**0.61**	**0.72**	**0.85**

Source: Own elaboration

is higher than overall technical efficiency; this indicates the existence of scale diseconomies, which are an important source of inefficiencies and could be related to the overcapitalization problems of the Spanish port system. On the other hand, figure 1 shows the evolution of the overall technical efficiency for both groups. Analysing this figure, we can obtain the interesting conclusions. First, both groups' efficiency follows a similar pattern. Second, the economic crisis occurred in year 2008 and subsequent has a high impact on efficiency, mainly explained by the fall of port traffic in 2009. Third, in those years there is a convergence process between both groups. However, from 2011, efficiency differences between both groups grow again.

Figure 1. Evolution of overall technical efficiency (1995-2015)



Source: Own elaboration

In the second stage of this analysis, three models have been estimated for both groups, the only difference among those models is the dependent variable (y), which is represented by one of the efficiency scores estimated in the first stage, using DEA. That is,

$$y_1 = overall\ technical\ efficiency$$

$$y_2 = pure\ technical\ efficiency$$

$$y_3 = scale\ efficiency$$

These models try to explain the effect of previously mentioned external factors (specialization, mechanization and logistic) on the different measures of efficiency. These factors are highly related with port competitiveness. Additionally, carrying out this estimation separately for both groups of airports allows providing solutions to improve port performance, taking into account possible differences in ports' technology according to their specialization. The second-stage specification is formulated as follow:

$$y_i = \beta_0 + \beta_1 Specialization_i + \beta_2 Mechanization_i + \beta_3 Logistics_i + e_i \qquad (x)$$

Equation X has been estimated using the bootstrapped technique proposed by Simar and Wilson (2007) and the corresponded results for specialized port authorities are presented in table 5 while table 6 displays the results for the non-specialized ones.

Table 5. Parameter estimates for the Simar and Wilson regression model (Spanish container ports)

Variable	Overall technical efficiency (constant returns to scale)	Pure technical efficiency (variable returns to scale)	Scale efficiency (economies of scale)
Specialization	0.959***	0.286***	1.022***
Mechanization	0.002***	0.000	0.008***
Logistics	0.157***	0.020	0.851***

Notes: ***, **, and *: Below the 1%, 5% and 10% statistical significance thresholds, respectively. Likelihood ratio chi-square (df = 2)

Table 6. Parameter estimates for the Simar and Wilson regression model (rest of port authorities)

Variable	Overall technical efficiency (constant returns to scale)	Pure technical efficiency (variable returns to scale)	Scale efficiency (economies of scale)
Specialization	9.700***	0.133***	45.027***
Mechanization	-0.005*	-0.001***	0.034**
Logistics	1.0204	-0.0336	8.5169*

Notes: ***, **, and *: Below the 1%, 5% and 10% statistical significance thresholds, respectively. Likelihood ratio chi-square (df = 2)

A priori, it is supposed that competitiveness and efficiency are positively correlated, which means, higher levels of efficiency should be showed in the most competitive ports. So we expect that the degree of specialization in containerized traffic, the level of mechanization or having an own logistic centre affects positively to port efficiency. This hypothesis is fulfil for specialized port authorities, but not completely for the other group.

Regarding container specialization, it can be seen that it has a positive effect on all types of efficiency for both groups. This means that increase the container traffic share improves efficiency at all levels, management and scale. Additionally this effect is higher for non-specialized port authorities than for specialized ones; and higher on scale efficiency than pure efficiency. This result suggest, on one hand, that those ports with lower shares of container traffic has biggest incentives to increase those shares than specialized ports; and on the other hand, increasing container traffic helps to solve problems of overcapacity[5] when ports do not operate in their optimal scale.

With respect the mechanization degree, we find conflicting results between both groups of ports. When specialized port authorities increase their degree of mechanization, i.e., the number of cranes, they improve their overall efficiency by increasing their scale efficiency. Not having effect on pure technical efficiency. However, in non-specialized port authorities, higher level of mechanization have a negative effect on overall technical efficiency. The effects on effects on pure technical efficiency and scale efficiency are conflicting, negative for the first and positive for the last. Therefore, when these ports operate in their optimal scale, increase mechanization reduce pure technical efficiency. However, if these ports are not efficient from the scale point of view, increase the level of superstructure helps to solve scale problems (overcapitalization problems).

Finally, with respect logistic performance, having an operating logistics activity area next to the port has a positive influence on efficiency, since the activities carried out in these areas are related to high added value procedures (Wang and Cullinane, 2006).

Analysing these results as a whole, we can check that competitiveness factor affect mainly scale efficiency. Therefore, the gains on efficiency are the result of improving scale efficiency, which means than the size of the ports and the existence or not of overcapacity matters in terms of technical efficiency. These findings are in line with previous research on container ports such as, (Tongzon and Heng, 2005) who concludes that the container port/terminal size is a determinant of efficiency.

Thus, in order to be more competitive, and therefore, to present higher levels of technical efficiency, the operating optimal size or being close to a logistics activity area are clear determinants of efficiency in the maritime sector for both groups of ports, those that are specialised in containerized cargo traffic and for those that do not.

Conclusions

This paper analyse the technical efficiency of Spanish port authorities and the effect of competitive factors, as degree of containerization, mechanization or the

[5]. From 2002 to 2008 Spanish ports duplicated their capacity, this growth of the infrastructure has been too much higher than the growth of traffics (Hidalgo-Gallego et al., 2017). This fact makes that Spanish port system presents an important problem of overcapacity (Hidalgo Gallego et al., 2015; Puertos del Estado, 2015)

existence of a logistic centre in the port, on such efficiency. The novelty of the paper is that we separate in two subsamples container specialized port authorities and port authorities that are not specialized in this type of cargo. This allows us to check the differences and make comparisons about the impact of those factors on efficiency when ports are grouped according their specialization. To do this, a two stages DEA analysis has been carried out. In the first stage we obtain the efficiencies score applying the DEA methodology to the whole sample. In the second one, we divided the sample in two subsamples (specialized and non-specialized ports) and, for each subsample separately, we regress those efficiency scores on the set of variables related with the competitive factors following the approach of Simar and Wilson (2007).

The Spanish port sectors has followed an uptrend to containerization. Not only the share of container traffic on total traffic has grown for specialized port authorities, but also it has grown in non-specialized ports (González Laxe, 2012). Moreover, after reviewing the literature related with port efficiency and its determinants, we notice that on one hand, there is a lack of studies related to the Spanish container port sector; and on the other one, there are no studies that compare the effects of exogenous variables on efficiency among ports with different characteristics, for example, their specialization.

Our results shows that non-specialized ports are on average more efficient than the container ones. However, increasing container specialization (measure as the share of total traffic corresponding to container traffic) improves in a great extent the efficiency of non-specialized port authorities than the specialized ones'. Therefore, port authorities should make an effort to attract this type of traffic in order to improve their performance, and so, their results. Additionally, our results suggest that higher gains of efficiency could be achieved improving scale efficiency. In other words, port authorities are operating over their optimal size or capacity. Therefore, port policies have to be addressed to solve overcapacity and underused infrastructure problems. Finally, we can conclude that increasing ports competitiveness could lead to improve ports efficiency, as long as overcapacity is reduced.

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