EFFICIENCY ASSESSMENT OF CONTAINER OPERATIONS OF SHIPPING AGENTS IN SPANISH PORTS

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Abstract

In this paper a two-stage Data Envelopment Approach (DEA) is used to assess the relative efficiency of container shipping agents operating in Spanish ports, studying also its influencing factors. In the first stage, an input-oriented, Variable Returns To Scale (VRS) model is used to compute efficiency scores of the different shipping agents. The model considers labor as input and numbers of loaded and unloaded containers handled as outputs. Scale efficiency, Returns to Scale and average efficiency of shipping agents in each port are reported. In the second stage, different regression approaches are applied to relate the efficiency scores obtained to a number of exogenous variables. The results identify as significant some of these variables such as the number of container lines with which it operates. Belonging to each of four clusters identified from the dataset seems also to have a significant influence on the efficiency of the studied agents.

Keywords: Maritime transport, shipping agents, efficiency, DEA, two-stage analysis

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1. Introduction

As globalization emerged in the international economy, maritime traffic has been increasing continuously in the last decades and its agents have internationalized its activity (Gadhia *et al.*, 2011). The ports, that traditionally were simple points of transhipment between ships and land transportation (Mangan *et al.*, 2008), have became in logistic platforms and in important clusters of economic activities (Thai, 2012) due to the fact they are indeed linkages between service providers, facilitators, operators and end customers (Pettit and Beresford, 2009).

Vessel size has increased dramatically in that period and fewer ports were able to handle larger vessels, concentrating this large maritime traffic in certain ports (Mangan *et al.*, 2008). While global maritime freight has grown, there is an imbalanced traffic across different corridors, especially in the case of containerised traffic (Mangan *et al.*, 2008). On the other hand, in the maritime shipping supply chain, the performance and coordination of four different players are required: ports, shippers, containers depots and shipping agents. In the literature review, several studies about the first three agents are found (Wang and Meng, 2012; Thai, 2012; Pallis *et al.*, 2010; Benito *et al*., 2003). Regarding the shipping agents, they are the representatives of the shippers in the port, in charge of all the administrative and commercial tasks. Their activity increases the efficacy in the supply chain operations, as a result of their experience and know-how (Bichou, Bell, 2007). One possible way of measuring that efficacy is by assessing the service quality, the load/unload ratios, and handling costs, all of which serve as key factors for the selection of a specific shipping agent (Saeed, 2009). Their role is determinant also in the development of the short sea shipping and the sea motorways (Beškovnik, 2006). However, in spite of their importance in the efficient operation of maritime transportation, shipping agents have deserved limited attention from researchers, with just a few works dealing with that role (Saeed, 2009, González-Torre *et al*., 2013).

For our study we are going to focus on data coming from the Spanish ports. In the last 50 years, the million tonnes moved through its maritime port system was multiplied by 7, reaching more than 400 millions tonnes per year. Furthermore, the Spanish shipping agents studied here handled an annual average of 16,886 exported TEU and 19,356 imported TEU. That national port system, composed of 28 ports, includes one of the most important Mediterranean hubs (Barcelona), the largest Mediterranean (and fifth in Europe) in container traffic (Valencia, with 3.7 million TEUs in 2009, out of the 7.7 millions of all Spain), or Bilbao, one of the most important transport and logistics centres in the European Atlantic Arc. For that reason, the Spanish shipping agents are mainly concentrated around these three ports. And although in most of cases the shipping agents belong to a multi-organisational business group, they are mainly small firms, which activity in the maritime industry began 30 years ago.

The motivation to use DEA in the present research is supported by DEA being a well established non-parametric frontier analysis technique, capable of evaluating the relative efficiency of a set of operating units (commonly termed Decision Making Units, DMU) with multiple inputs/outputs (for further details see, for example, Thanassoulis, 2001, Cooper *et al*., 2004, 2006, Zhu, 2002). DEA has been applied in many different industrial and service sectors, among them to maritime transport. Thus, the efficiency of both general ports and container terminal has been extensively studied (e.g. Tongzon, 2001, Barros and Athanassiou, 2004, Cullinane *et al*, 2006, Wang and Cullinane, 2006, Barros, 2006, Ríos and Maçada, 2006, Pallis and Syriopoulos, 2007, Kamble *et al.*, 2010, Lin and Tseng, 2007, Hung *et al.*, 2010, Wu and Goh, 2010, Cullinane and Wang, 2010). Special mention may be made to Bichou (2011) for it uses a network DEA approach for measuring container terminal efficiency. DEA has also been used to estimate the productivity growth of ports (e.g. Estache *et al*, 2004, Barros and Peypoch, 2007, Guironnet *et al.*, 2009, Lozano, 2009, Haralambides *et al*, 2010, Barros *et al.*, 2012) and of shipping companies (Managi, 2007, Gutiérrez *et al.*, 2014) as well as for capital budgeting of ports (Lozano *et al.*, 2011). However, probably because of data availability issues, the efficiency of shipping agents seems not to have been studied before. This is surprising given the importance of shipping agents as the agents of shipping companies at a port and, as such, responsible for the handling of the freight loaded and unloaded in that port.

In this paper the results of a study of 85 shipping agents operating in Spanish ports are presented. The data have been obtained through a survey of the companies. Details of the survey are reported in González-Torre *et al*. (2013) in which a clustering of the shipping agents has also been carried out. From the survey responses input and output data were selected for an efficiency assessment using DEA. Specifically a two-stage approach is used so that the efficiency scores obtained in stage one are regressed in stage two against some exogenous variables.

The structure of the paper is the following. In section 2 the stage one of the DEA approach and the corresponding relative efficiency results are presented. Section 3 presents the second stage of the analysis. Section 4 summarizes and concludes.

2. Stage one: Efficiency scores of shipping agents

To gather data for the analysis, we considered the census of all shipping agents listed in the documentation published by the Spanish Port Authorities (250 companies). During 2008, we carried out a survey in which 85 of these companies participated (among them 19 shipping agents from Valencia, 18 from Bilbao and 13 from Barcelona), which means a response rate of 34% and a sample error of 8.43% at a confidence level of 95%.

The data collected from the survey and used to assess the efficiency of Spanish shipping agents are shown in Table 1. DEA models require the identification of inputs and outputs. Wang et al. (2005) discuss the variable definition for port efficiency estimation. They stated that port production depends on the efficiency use of labor, land and equipment. In our case, due to lack of direct information on port infrastructure/superstructure, only information on labor input has been considered (Notteboom et al. 2000). On the other hand, container throughput is a crucial factor for port management (Cullinane and Wang, 2006) since it is related to cargo-related services in the port, constituting the benchmark for comparing the port efficiency. Empty container throughput has also been included because empty container management is one of the sharpest problems suffering the logistics industry worldwide (e.g. Boile and Aboobaker, 2006; Sun and Yang, 2006). Hence, this study use a single input, namely number of employees, and two outputs that describe the container operations of shipping agents, namely the number of loaded and empty containers handled. Note that although some outputs are zero, this should pose no problem to DEA, provided no-radial output oriented models are avoided, as in our case. Of course, the radial efficiency score used does not include possible output slacks that may remain. This is a limitation of Farrell efficiency, which only guarantees weak efficiency but not Pareto-Koopmans efficiency. An alternative, which we have not pursued, is to use for example the Measure of Efficiency Dominance as efficiency score (Bardhan *et al*., 1996).

=========================== Table 1 ===========================

Table 2 shows the technical efficiency scores of the different shipping agents computed using the well-known DEA-BCC model (Banker *et al*., 1984). Although other, more sophisticated DEA models (e.g. non-radial or slacks-based) could have been applied, the DEA-BCC model was chosen because is the simplest and still most widely used DEA approach. LINGO optimization software has been used. Since there may be scale effects and since there is no guarantee that the DMUs operate at their Most Productive Scale Size (Banker, 1984) Variable Returns to Scale (VRS) have been assumed. An input orientation has been chosen because it is assumed that shipping agent management has no control over outputs. As suggested by one of the reviewers, we have tested if the efficiency results obtained considering loaded and empty containers differ from the efficiency results integrating full and empty container in one single output. This would happen if a significantly different level of effort were needed by shipping agents in dealing with both types of containers. The results of the Mann-Whitney test (W statistic=7662.5; p-value=0.2188) cannot reject the null hypothesis that the results of both DEA models come from a common efficiency distribution. Thus, the Pearson correlation coefficient of both sets of efficiency results is rather high (0.922). This suggests that there does not seem to be great differences in the effort levels in the administrative work required by empty and loaded containers and that similar results can be obtained considering a single, pooled output. This can be seen as a confirmation of the validity of the obtained efficiency results.

============================ Table 2 ============================

The application of the iterative procedure of Ahn Tran *et al*., (2010) has allowed the identification and removal of 8 outliers (namely DMUs 7, 11, 14, 38, 49, 61, 76 and 85) which leads to a reduced dataset of 77 DMUs. Table 3 shows the $\lambda - \text{sum}$ and $\lambda - \text{count}$ values corresponding to the DMU removed in each iteration of the Ahn Tran *et al*., (2010) method. Note that the removed DMUs had actually high values of both of these indicators and therefore can be identified as outliers. Note also that, after removing 8 DMUs, the maximum values of both indicators were much reduced and the process stopped.

============================ Table 3 ============================

The technical efficiency scores of the remaining DMUs as well as their corresponding Returns To Scale (Constant=CRS, Increasing=IRS or Decreasing=DRS) and the output slacks corresponding to the two outputs (LC=Loaded Container, EC= Empty Container) are also shown in Table 2.

In order to determine the Returns to Scale (RTS), the efficiency measures of DEA model can be calculated with different scale assumptions. Thus, the Scale Efficiency is just the ratio $S.Eff = \frac{T.Eff\,'_{CRS}}{T.Eff\,'_{VRS}}$, where a value of *S. Eff*= 1 indicates that a shipping agent is fully scale efficient and therefore exhibits CRS. On the other hand, a value of *S. Eff* < 1 indicates that the shipping agent might be operating either in a region of IRS or DRS. To discriminate between those two cases the Non-Increasing returns to scale (NIRS) efficiency measure is computed so that if $T.Eff\,'_{CRS} = T.Eff\,'_{NIRS} < T.Eff\,'_{VRS}$ IRS prevail while if $T.Eff\,'_{CRS} < T.Eff\,'_{NIRS} = T.Eff\,'_{VRS}$ then the DMU exhibits DRS.

The slacks represent the feasible output increases that remain after the input reduction given by the efficiency scores. Note that only eight out of the 77 remaining shipping agents (shown in bold) are technically efficient and of those only two (in italics) are also scale efficient. One of the two global efficient shipping agents operates in Vigo and the other in Bilbao. Of the other six technically efficient shipping agents four (one in of the ports of Algeciras, Barcelona, Bilbao, Gijón and Las Palmas) exhibit Increasing Returns to Scale (IRS) and just one (operating in the port of Valencia) seems to exhibit Decreasing Returns to Scale (DRS). All the technically inefficient shipping agents exhibit IRS. It can therefore be concluded that the majority of shipping agents operating in Spanish ports have IRS, which means that they would benefit from a certain consolidation in the sector.

The distribution of the technical efficiency per port is shown in Figure 1. The corresponding box and whisker plots show the mean, median, minimum, and maximum values as well as the 25th and 75th percentiles (lower and upper quantile, respectively) for each port. The mean values of the technical efficiency for the three main ports (Barcelona, Bilbao and Valencia) are 0.35, 0.39, and 0.40 while for the other Spanish ports the median technical efficiency is 0.49. Note that the main three Spanish ports have slightly lower technical efficiency than the Other Spanish ports. Moreover, the location of the median line suggests more skewness in the technical efficiency of Valencia than in Barcelona, Bilbao or Other ports. Three efficient shipping agents are identified as local outliers within the group of shipping agents in the ports of Barcelona (DMU 79) and Bilbao (DMUs 57 and 60), after screening the whole dataset for global outliers.

=================== Figure 1 ===================

Finally, not only the efficiency scores have been computed but also target input values and peer groups. In total, around 1,000 employees may be redundant, which corresponds to around 60% of the current total. This gives an overall idea of the inefficiency level of the industry.

3. Stage two: Influencing factors analysis

In this section, a regression analysis of the technical efficiency scores of the different shipping agents is carried out using as explanatory variables whether the shipping agent is operating in one of the three main ports (dummy variables labeled *Barcelona*, *Bilbao* and *Valencia*) or in one of the other ports, the number of shipping companies (labeled *ShipComp*) and the number of container shipping lines with which it works (labeled *ShipLines*), and, finally, the cluster (as per González-Torre *et al*., 2013) to which the shipping agent can be assigned (dummy variables labeled *C1, C2 and C3*). According to that study, shipping agents can be grouped in four clusters. Cluster 1 is the largest cluster, made up of firms specialized in nationally-focused container transportation, i.e. they are less import/export oriented. The typical shipping agent in this cluster has many years experience and have the largest value of the number of shippers with which they work. Cluster 2 shipping agents have the largest average number of employees. Much of their container traffic is at the regional level and they process a smaller number of ships. Cluster 3 is formed by shipping agents with the lowest number of years of operation. Although it is not the majority of their activity, they are the ones that handled more international container traffic. Shipping agents in Cluster 4 also have many shippers and a good number of years in operation but they have the lowest container traffic at all levels: international, national and regional.

These regression models aim at explaining the efficiency of shipping agents through their geographical location, number of clients (container shipping lines and shipping companies) and the classification of shipping agents. These variables have been chosen among those gathered in the survey of Spanish shipping agents (see González-Torre et al. 2013) because they may have an influence on the efficiency of the shipping agents, although the specific sign (positive or negative) of such influence is not known a priori. Table 4 presents the data used in the regression analysis of the shipping agents. Note that there are a few (exactly six) shipping agents that do not belong to any of the four clusters. That occurs because they are dissimilar to the other agents that belong to each cluster.

============================ Table 4 ============================

With respect to the specific regression approach to use, when dealing with efficiency measures, most researchers have used either Ordinary Least Squares (OLS) (e.g. Ataullah and Le 2006, Hwang and Kao 2008) or Tobit regression (e.g. Lansink and Reinhart 2004, Afonso and St. Aubyn 2006, Yeh et al 2010). Although some studies indicate that both approaches work similarly well (Hoff 2007, Banker and Natarajan 2008) there seems to be some advantages in using OLS over Tobit, due to Tobit estimation procedure providing inconsistent estimates (McDonald 2009, Estelle et al 2010). In this respect, different methodologies have been proposed in order to provide consistent inferences from the DEA model, such as Quasi-Maximum Likelihood Estimation (QLME) approach (Papke and Wooldridge 1996) and Truncated Bootstrapped Regression (TBR) (Simar and Wilson 2007).

In this paper we have used OLS as well as QMLE and TBR to regress the DEA scores on the explanatory variables. The specifications of the different models are shown in Table 5.

============================ Table 5 ============================

Linear regression was the first model specification considered, finding evidence to reject the normality of the efficiency scores at the 5% significance level (Anderson Darling statistic A^2=1.480; p-value=0.005). As a remedial action to non-normality a proper Box-Cox transformation (λ=0, i.e. logarithmic transformation) was successfully applied. Table 6 shows the results of OLS, QLME and TBR. These results were obtained using R package (release 9) and Stata (release 11). Note that the estimated coefficients that are significant are the number of container shipping lines which the shipping agent works with, as well as, the dummy variables that correspond to the three clusters (C1, C2 and C3). Nevertheless, C1, C2 and C3 have more impact than *ShipLines.* Moreover, all three models (1-3) agree in the sign of the influence of significant exogenous variables. Respect to OLS model, the overall significance of the OLS regression (model 1) passes the F test, indicating significant relationships between the efficiency score and the exogenous variables considered. In addition, residual analysis of model (1) satisfies independence assumption (Durbin-Watson statistic DW=2.4935, p-value 0.9745), and there is not statistical evidence of heteroscedasticity (Goldfeld-Quandt GQ statistic= 1.5829, p-value 0.1227).The functional form of the model (1) and model (2) were tested by computing Ramsey's RESET statistic without finding empirical evidence of misspecification in the models (Papke and Wooldridge 1996). A direct comparison of models (1), (2) and (3) from log-likelihood criterion, evidence that model (3) is the best for explaining the efficiency of the container operations of shipping agents in Spanish ports.

============================ Table 6 ============================

The estimated regression models indicate that the efficiency score is related to the clusters variables and to the number of container shipping lines. According to the three models, the variables indicating the clusters 1, 2 and 3 are all significant with the coefficient of C1 larger than that of C2 and this larger than that of C3. Thus, for example, according to model (3), where the coefficients are corrected for bias, on average, the influence of cluster 1-3 is 0.36, 0.22 and 0.20, respectively. This reveals to what extent the management practices of shipping agents belonging to the C1 contribute further to their efficient performance, probably due to their having a longer experience.

On the other hand, the marginal effect in terms of the *ShipLines* over *Efficiency* is 0.0321, i.e., the mean technical efficiency can increase 0.0321 for every 1-unit increase in number of shipping lines the shipping agent operates with. This variable turns out to have positive coefficient providing evidence of size of shipping line portfolio potentially affects efficiency. This increase in efficiency due to working with a larger number of shipping lines may be interpreted in the following way: shipping lines looking for a shipping agent to manage their local business will be inclined to contract those agents that are more efficient. It can also happen that the concentration of work from multiple shipping lines allows to these shipping agents obtain economies of scale that result in more efficient services.

In contrast, the geographical location of the port and number of shipping companies with which Spanish shipping agents work are insignificant in the three models. This is important to shipping agents in order to avoid support their performance strategy in location decisions, as well as the number of shipping companies they offer their services to.

To obtain additional insights into the efficiency of shipping agents, a regression model was estimated incorporating an additional dummy variable (labeled *Delegation*) to test whether the operating benefits of the shipping agents depend on its being a branch of a larger shipping agency company. The results confirmed those of Table 6, but the *Delegation* variable was statistically insignificant in the regression models (1-3) at the 0.10 level, remaining the sign of the significant variables the same. These findings provide evidence supporting the view that the shipping agents' efficiency is not influenced by its being, or not, a branch of a large shipping company.

4. Summary and conclusions

In this paper a two-stage DEA study of the technical and scale efficiency of the shipping agents operating containers in Spanish ports is presented. After detecting and removing a few outliers, eight technical efficient and two global efficient shipping agents are identified. Overall efficiency levels are low with most companies employing a larger number of employees than required. The average efficiency of the shipping agents operating at each of the main ports has also been computed. Also, the efficiency of shipping agents belonging to each of the four clusters identified in the literature has been analysed.

Finally, in the second stage, technical efficiency scores have been regressed against a number of exogenous variables and a number of factors (e.g. number of associated container lines and cluster to which the agent belongs) have been found to be significant in explaining the observed efficiency scores. In particular, those shipping agents belonging to cluster 4 are less efficient than the rest while agents belonging to cluster 1 are more efficient than the rest.

Regarding the managerial implications of this research, we have provided clues to better understand what are the main factors affecting the technical efficiency of the shipping agents' operations, and therefore, what could be important when defining strategies for those firms. We have shown how inefficient is this industry overall, and have collected proofs supporting that consolidation in the sector could be advantageous for companies.

Our results show that the number of container lines operated has a positive influence in the efficiency of the shipping agents, although possibly more as a consequence than as a cause. Both the experience curve effect and the economies of scale gained when working with so many lines could explain the relevance of this factor, while such benefits are not observed when working with many shippers. Finally, these companies, according to our results, would not obtain significant efficiency benefits due to relocating to bigger ports or for the fact of being a subsidiary of a shipper instead of an independent firm.

As for possible continuations of this research, one would be to include in the analysis not only the container processing activity but also their cargo freight business. It would also be interesting to extend the analysis to other countries and see if similar results are found. It would also help to benchmark the best practices of the different countries and test whether the regulatory environment has an influence.

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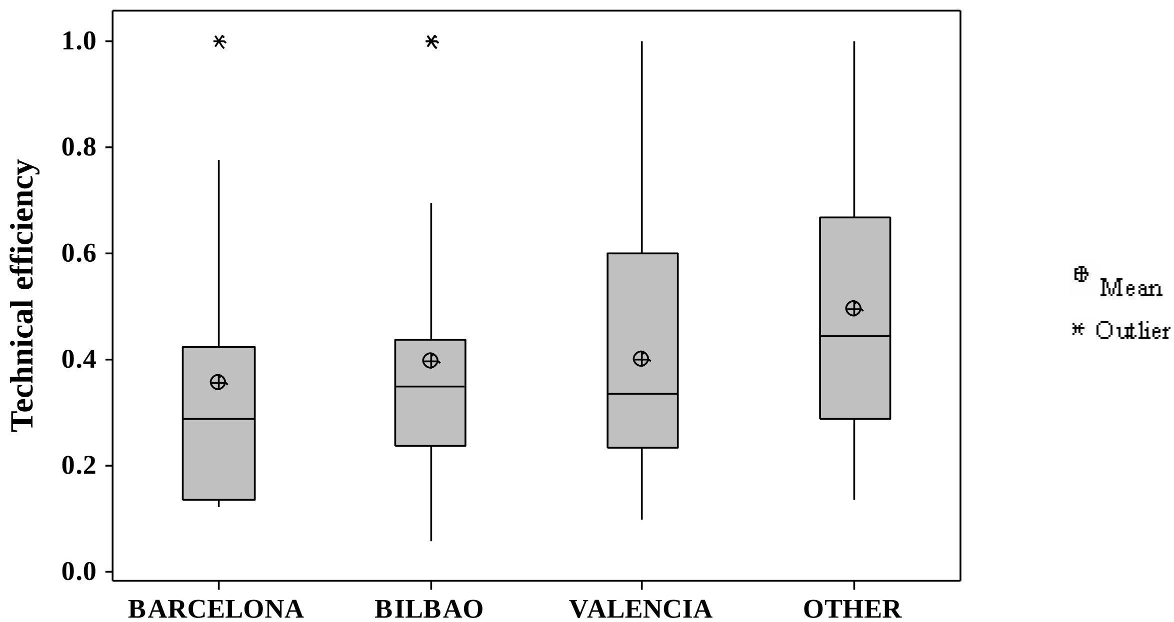

Note: Based on 77 observations

Figure 1. Technical efficiency by port

ID	# employees	Loaded cont.	Empty cont.
1	14	10000	1700
2	43	7000	4500
3	30	18000	7000
4	12	500	2000
5	9	1200	7000
6	12	2000	780
7	3	1000	0
8	6	2050	0
9	30	57000	0
10	18	20000	5000
11	2	520	7800
12	10	1500	2500
13	35	25000	18000
14	3	800	0
15	18	150	1850
16	6	3000	0
17	48	5760	9600
18	6	2904	20
19	9	8552	360
20	20	2000	6000
21	13	22000	0
22	21	500	1900
23	13	1000	16000
24	14	2500	0
25	22	15000	0
26	7	1110	1820
27	4	1400	500
28	30	50	1250
29	10	150	1200
30	13	950	29050
31	23	24000	1500
32	9	3500	2000
33	6	1200	0
34	23	9000	25000
35	7	10724	8900
36	9	3300	0
37	10	800	0
38	3	540	0
39	32	33343	3372
40	35	15000	0
41	9	4116	0
42	12	13428	0
43	50	7258	15901
44	70	120	0
45	9	3800	200
46	16	7500	0
47	6	1000	1000
48	11	4400	300
49	1	100	0
50	13	3000	3000
51	14	4000	120
52	12	5000	0
53	6	470	2590
54	15	4800	0
55	45	5450	0
56	12	3000	1000
57	4	600	0
58	10	6989	0
59	30	200	0
60	12	100000	500
61	3	1300	200
62	12	6000	1200
63	9	3500	0
64	21	1500	2500
65	26	20823	18569
66	40	6145	3592
67	100	75000	500
68	4	10000	0
69	210	267000	128300
70	18	2600	5000
71	20	18000	4500
72	9	3120	4860
73	9	2200	6000
74	10	4376	365
75	7	1000	1050
76	6	54013	20863
77	14	2000	10000
78	49	25100	5100
79	4	150	60
80	30	12000	6000
81	52	17000	5000
82	5	100	1600
83	11	1020	0
84	7	2500	0
85	3	5200	800

Table 1. Database of Spanish shipping agents: inputs and outputs. Source: González et al (2013)

ID	T.Eff.	T.Eff.’	S. Eff.	RTS	LC slack	EC slack
1	0.137	0.326	0.423	IRS	0	0
2	0.043	0.125	0.526	IRS	0	0
3	0.089	0.234	0.746	IRS	0	0
4	0.106	0.373	0.212	IRS	876	0
5	0.214	0.672	0.537	IRS	98	0
6	0.098	0.342	0.142	IRS	0	0
7	0.361	-	-	-	-	-
8	0.197	0.667	0.062	IRS	7950	0
9	0.213	0.273	0.836	IRS	0	261
10	0.158	0.362	0.701	IRS	0	0
11	1.000	-	-	-	-	-
12	0.138	0.463	0.278	IRS	0	0
13	0.146	0.324	0.963	IRS	0	0
14	0.355	-	-	-	-	-
15	0.069	0.246	0.189	IRS	1229	0
16	0.211	0.667	0.090	IRS	7000	0
17	0.053	0.145	0.710	IRS	0	0
18	0.210	0.667	0.088	IRS	6752	0
19	0.198	0.454	0.286	IRS	0	0
20	0.092	0.287	0.504	IRS	0	0
21	0.233	0.390	0.521	IRS	0	67
22	0.060	0.211	0.203	IRS	878	0
23	0.347	0.684	0.812	IRS	156	0
24	0.087	0.286	0.075	IRS	7500	0
25	0.108	0.202	0.405	IRS	0	28
26	0.182	0.631	0.212	IRS	269	0
27	**0.280**	**1.000**	**0.097**	**IRS**	**0**	**0**
28	0.039	0.141	0.132	IRS	1338	0
29	0.115	0.422	0.130	IRS	1239	0
30	***1.000***	***1.000***	***1.000***	***CRS***	***0***	***0***
31	0.140	0.248	0.611	IRS	0	0
32	0.156	0.501	0.288	IRS	0	0
33	0.184	0.667	0.036	IRS	8800	0
34	0.415	0.536	0.986	IRS	0	0
35	**0.370**	**1.000**	**0.745**	**IRS**	**0**	**0**
36	0.144	0.444	0.099	IRS	6700	0
37	0.106	0.400	0.024	IRS	9200	0
38	0.347	-	-	-	-	-
39	0.128	0.223	0.759	IRS	0	0
40	0.068	0.127	0.405	IRS	0	28
41	0.152	0.444	0.123	IRS	5884	0
42	0.186	0.359	0.374	IRS	0	19
43	0.090	0.182	0.871	IRS	0	0
44	0.014	0.057	0.004	IRS	9880	0
45	0.149	0.444	0.134	IRS	2760	0
46	0.105	0.250	0.225	IRS	2500	0
47	0.194	0.693	0.135	IRS	392	0
48	0.127	0.364	0.163	IRS	440	0
49	1.000	-	-	-	-	-
50	0.116	0.371	0.350	IRS	0	0
51	0.097	0.286	0.131	IRS	3936	0
52	0.121	0.333	0.150	IRS	5000	0
53	0.224	0.776	0.259	IRS	897	0
54	0.096	0.267	0.144	IRS	5200	0
55	0.033	0.089	0.164	IRS	4550	0
56	0.106	0.349	0.190	IRS	0	0
57	**0.262**	**1.000**	**0.018**	**IRS**	**9400**	**0**
58	0.164	0.400	0.210	IRS	3011	0
59	0.034	0.133	0.006	IRS	9800	0
60	***1.000***	***1.000***	***1.000***	***CRS***	***0***	***0***
61	0.370	-	-	-	-	-
62	0.129	0.359	0.288	IRS	0	0
63	0.146	0.444	0.105	IRS	6500	0
64	0.066	0.221	0.278	IRS	0	0
65	0.204	0.430	0.956	IRS	0	0
66	0.043	0.127	0.458	IRS	0	0
67	0.087	0.098	0.922	IRS	0	0
68	**0.480**	**1.000**	**0.300**	**IRS**	**0**	**0**
69	**1.000**	**1.000**	**0.421**	**DRS**	**0**	**0**
70	0.097	0.302	0.464	IRS	0	0
71	0.133	0.309	0.666	IRS	0	0
72	0.194	0.601	0.467	IRS	0	0
73	0.205	0.639	0.508	IRS	0	0
74	0.140	0.401	0.169	IRS	0	0
75	0.167	0.596	0.140	IRS	391	0
76	1.000	-	-	-	-	-
77	0.191	0.501	0.667	IRS	0	0
78	0.068	0.143	0.746	IRS	0	0
79	**0.252**	**1.000**	**0.011**	**IRS**	**8818**	**0**
80	0.076	0.205	0.662	IRS	0	0
81	0.049	0.120	0.674	IRS	0	0
82	0.241	0.869	0.166	IRS	1283	0
83	0.099	0.364	0.031	IRS	8980	0
84	0.175	0.571	0.075	IRS	7500	0
85	0.491	-	-	-	-	-

Table 2. Technical and scale efficiency, RTS and slacks. Note: T. Eff: Technical Efficiency based on 85 observ.; T. Eff’: Techical Efficiency based on 77 observ., S. Eff: Scale Efficiency; RTS: Returns To Scale

Iteration	**No. of DMUs**	**Removed DMU**	$\lambda - \text{sum}$	$\lambda - \text{count}$
1	85	49	56.408	71
2	84	11	66.870	77
3	83	85	51.773	69
4	82	61	56.645	73
5	81	7	49.959	61
6	80	76	16.713	71
7	79	14	55.382	72
8	78	38	61.523	75
9	77	*Max*	*34.587*	*53*

Table 3. Iterations of the outlier detection method

ID	Port	ShipComp	ShipLines	Cluster
1	Valencia	1	1	1
2	Valencia	3	6	2
3	Valencia	4	5	2
4	Valencia	3	3	2
5	Valencia	3	3	2
6	Valencia	3	3	2
7	Vigo	1	1	2
8	Melilla	4	1	1
9	Barcelona	1	2	3
10	Barcelona	3	3	3
11	Gijon	2	2	2
12	Valencia	1	1	3
13	Valencia	12	12	1
14	Vigo	3	3	1
15	Cartagena	3	2	4
16	Cadiz	2	1	1
17	Cartagena	1	1	1
18	Algeciras	1	2	1
19	Barcelona	4	4	1
20	Barcelona	5	5	1
21	Barcelona	1	2	1
22	Cartagena	1	1	4
23	Alicante	1	3	3
24	Tenerife	4	1	1
25	Barcelona	1	4	1
26	Cadiz	1	15	1
27	Algeciras	1	1	2
28	Barcelona	1	1	-
29	Cadiz	1	1	2
30	Vigo	1	2	3
31	Vigo	1	1	3
32	Vigo	6	6	1
33	S.C.Tenerife	1	1	2
34	Sevilla	1	2	2
35	Gijón	3	5	-
36	Vigo	2	2	1
37	Alicante	4	4	4
38	Algeciras	1	3	1
39	Valencia	1	2	1
40	Barcelona	2	2	1
41	Las Palmas	2	3	4
42	Barcelona	1	1	1
43	Marin	8	9	1
44	Bilbao	3	3	2
45	Bilbao	1	1	4
46	Bilbao	1	15	2
47	Bilbao	1	2	2
48	Bilbao	3	3	-
49	Bilbao	1	4	1
50	Bilbao	4	4	4
51	Bilbao	2	5	4
52	Bilbao	1	7	1
53	Barcelona	2	2	1
54	Bilbao	3	2	4
55	Bilbao	2	2	4
56	Bilbao	2	2	-
57	Bilbao	2	2	-
58	Melilla	2	1	1
59	S.C.Tenerife	1	6	4
60	Bilbao	1	1	3
61	Vigo	1	1	1
62	Bilbao	1	3	4
63	Tenerife	3	3	1
64	Bilbao	5	5	4
65	Bilbao	1	2	3
66	Barcelona	3	3	3
67	Valencia	6	7	1
68	Las Palmas	1	46	-
69	Valencia	1	18	2
70	Valencia	2	2	4
71	Valencia	1	2	1
72	Valencia	3	3	2
73	Valencia	1	2	2
74	Valencia	1	1	1
75	Valencia	1	1	2
76	Vigo	2	2	3
77	Cadiz	1	1	1
78	Valencia	1	3	1
79	Barcelona	1	1	2
80	Bilbao	2	2	1
81	Barcelona	1	4	1
82	Tarragona	1	1	2
83	Vigo	2	2	1
84	Tenerife	1	3	1
85	Valencia	1	2	1

Table 4. Database of Spanish shipping agents: exogenous variables

#	Model Specification
(1)	$E\ \ ln(Efficiency)/x\ = \beta_0 + \beta_1 Valencia + \beta_2\ Barcelona + \beta_3\ Bilbao + \beta_4\ ShipComp + \beta_5\ ShipLines + \beta_6 C1 + \beta_7 C2 + \beta_8 C3$
(2)	$E\ \ Efficiency/x\ = G\ \ \beta_0 + \beta_1 Valencia + \beta_2\ Barcelona + \beta_3\ Bilbao + \beta_4\ ShipComp + \beta_5\ ShipLines + \beta_6 C1 + \beta_7 C2 + \beta_8 C3$
(3)	$E\ \ Efficiency/x\ = \beta_0 + \beta_1 Valencia + \beta_2\ Barcelona + \beta_3\ Bilbao + \beta_4\ ShipComp + \beta_5\ ShipLines + \beta_6 C1 + \beta_7 C2 + \beta_8 C3$

Note: $G(z) = \frac{exp(z)}{1 + exp(z)}$

Table 5. Regression models specification

	OLS	**QMLE**	**TBR**
Model	**(1)**	**(2)**	**(3)**
Intercept	-1.4193** (0.3657)	-1.1602* (0.5285)	-0.1052 (0.0657)
Barcelona	-0.2168 (0.2301)	-0.2334 (0.3813)	-0.1145 (0.0991)
Bilbao	-0.3175 (0.2411)	-0.4209 (0.3526)	-0.0012 (0.0172)
Valencia	-0.1898 (0.1569)	-0.3091 (0.2386)	-0.0679 (0.0967)
ShipComp	-0.0396 (0.0375)	-0.0835 (0.0514)	-0.1269 (0.0220)
ShipLines	0.0594* (0.0292)	0.1255* (0.0604)	0.0321* (0.1399)
C1	0.7510* (0.3201)	1.4143** (0.4934)	0.3627* (0.1100)
C2	0.4971* (0.2854)	0.9409** (0.3959)	0.2296* (0.0951)
C3	0.3765* (0.3084)	0.7803* (0.3643)	0.2033* (0.1567)
Robust RESET statistic [p-value]	2.80 [0.2455]	2.69 [0.2611]	-
Log-Likelihood	-60.7077	-33.6980	-3.0577

Notes:
Figures in parentheses are the estimated standard errors of the regression coefficients
Based on 71 observations
OLS: Ordinary Least Squares; QMLE: Quasi-Maximum Likelihood Estimator; TBR: Truncated Bootstrapped Regression (total number of replications: 2000)
* significant at 5% level; ** significant at 1% level
F ratio model (1)=2.0319*
$\hat{\sigma}_{\varepsilon}$ model (3): 0.0199**

Table 6. Second-stage results using OLS, QMLE and TBR