HAVE SPANISH PORT SECTOR REFORMS DURING THE LAST TWO DECADES BEEN SUCCESSFUL? A COST FRONTIER APPROACH

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De conformidad con la base quinta de la convocatoria del Programa de Estímulo a la Investigación, este trabajo ha sido sometido a evaluación externa anónima de especialistas cualificados a fin de contrastar su nivel técnico.

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Have Spanish port sector reforms during the last two decades been successful? A cost frontier approach[1,]

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Abstract

The evolution of the port management model in Spain has been marked by three legislative reforms in the last two decades. This legislation was designed so that the Spanish regulatory framework could embrace the forms of port organization and management. This would in turn permit the Spanish ports to function competitively and efficiently, and to be suitably positioned within the distribution systems. This paper aims to analyze the impact of these regulatory changes upon the economic efficiency of the Spanish port authorities during 1993-2007 period. To do this, we use a short run total cost model. This is the most appropriate because after contrasting our results suggest, they that this sector is not in a long-run equilibrium. The results demonstrate that the impact of these legislative reforms has not been equal. The most significant changes, in terms of economic efficiency, took place in the first period. The results were also positive for the second period, although the efficiency gains were much more modest. Finally the third legislative reform seemed to have had a contrary effect upon economic efficiency.

Keywords: Port reform, cost frontier, efficiency evolution

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1. INTRODUCTION

The technological advances that have taken place in maritime transport in recent decades have stimulated ever increasing competition within the sector. Moreover, intermodality has intensified the competition among ports, and has forced them to be more involved in both the physical and logistical distribution systems. These trends have affected the organization and regulation of the port sector, generated deregulation processes and introduced private shareholding, which in some cases has taken the form of privatization.

The Spanish port management model is not new to this environment, and has followed the worldwide tendency of the adaptation of marine transport to the new technologies. This model has sought to adapt the Spanish regulatory framework to methods of port organization and management, in order to allow the Spanish ports to effectively and efficiently compete, and to be suitably placed within the distribution systems.

The evolution of the port management model within Spain can be assessed by analyzing the three laws that, during the last two decades, have established the port functions. They are the “27/1992 State Owned Ports and Merchant Shipping Law” passed on the 24th November 1992, the “62/1997 Law” passed on 26th December 1997 that amended the 27/1992 law, and finally the “48/2003 Economic System and the Provision of General Port Services Law” passed on the 26th November 2003.

Prior to the 27/1992 law two port management models coexisted in Spain. The autonomous ports of Barcelona, Bilbao, Valencia and Huelva were governed by the corresponding regional statutes, while the others were centrally managed.

The 1992 reform introduced a responsive organization and management model. The ports were unshackled from inflexible administrative laws and were able to operate with commercial flexibility and criteria. The 27/1992 law envisaged one single organization and management model for general interest ports that delegated management to a legally established public body, the Port Authorities, with its own budget but controlled and coordinated by the State Owned Enterprise of National Ports (Ente Publico Puertos del Estado, EPPE)[1].

The 1992 reform transformed the port management system, by abandoning the service ports[2] in favour of a landlord model. Before the reform the public sector bore all or nearly all the responsibility for the activities carried out within the confines of the port. Now, the public sector owns the infrastructure, but as many activities as possible are in the hands of the private sector.

In 1997 the 62/1997 law, which amended the existing 27/1992 law, brought about the greater involvement of the autonomous regions in port management. It gave impetus to the professionalization of port management and to the presence of the private sector in port operations. The innovation of this more in depth version of the 1992 reform is that it put the regional governments in charge of designating the chairman and having the final choice over a port authority's board of directors.

The 48/2003 law significantly reduced some of the port authority's functions. The port authorities were assigned a new role, which can now be understood as regulatory bodies and providers of infrastructure, and only secondarily as suppliers of services. The

[1] This public body, which has comprehensive responsibilities for the whole port system and holding functions over the port authorities, is in charge of executing the government's port policies as well as coordinating and controlling the efficiency of the systems at state owned ports.
[2] See Tovar et al. (2004) for a description of the different port management models.

landlord port authority model is maximized by the declared goal of promoting private sector participation in financing, in exploiting port installations and in the provision of services; all this is achieved by measures stemming from the granting of concessions and public works. Moreover, the law sets uniform tariffs for all the ports and as a result interport competition is limited, see Castillo-Manzano et al. (2008).

Conversely, the 48/2003 law establishes that the State Owned Loading and Unloading Companies (Sociedad Estatal de Estiba y Desestiba, SEED) be converted into Economic Port Associations (Agrupaciones Portuarias de Interés Económico, APIEs), so all the public stake would be privatized. In accordance with this law APIEs should have been constituted within one year of its coming into effect, which is to say before 27th February 2005. In October 2004 the new Spanish Government announced a reform of the recently passed 48/2003 law. However, the lack of agreement between the Government and opposition blocked its enforcement. This meant that four years after its enactment the APIEs still hadn't been constituted, which in 2008 provoked a strike in all Spanish ports. After this date, the APIEs began to be constituted in those ports that fulfilled the conditions established by law.

To sum up, Spanish ports are regulated by a system whereby their infrastructure such as quays and berthing areas, are under public ownership, but the superstructures, tugs, warehouses, cranes etc., are privately owned. The public authority sets the terms for private initiative by fixing the prices, the operating conditions, and the duration and conditions of the concessions. With the law's enforcement the private status of port service provision has been guaranteed. However, this announced reform, which still has not been introduced, has caused further uncertainty in the sphere of Spanish ports, and may negatively affect a strategic sector within the Spanish economy.

This paper aims to analyze the impact of these regulatory changes on the economic efficiency of the Spanish port authorities by means of a cost frontier approach. Other papers that have analyzed the impact of legislative reforms in Spain are González and Trujillo (2008) and Castillo-Manzano et al. (2008)[3]. However, both differ from this paper, in that they did not include the latest legislative reform. The Castillo-Manzano model uses a demand focus, which can be considered as complementary to the supply focus used in this article. Although González and Trujillo (2008) use a similar approach, they only concentrate on a few ports authorities, those that have a high level of container traffic. Furthermore, they analyze the evolution of the technical efficiency instead of the economic efficiency[4]. So the evolution of the port authorities' costs, which is a key factor in their competitiveness, has not been taken into account in their paper. Another significant difference between the González and Trujillo (2008) paper and ours is that they considered the effect of the reforms to be constant during each legislative period; however, as we demonstrate this assumption is restrictive and unrealistic.

The article is organized as follows. In Section 2 the theoretical model is described. In Section 3 the empirical model, the database and the econometric specifications used for estimating the cost function are presented; and in Section 4 the results are discussed. Finally in Section 5 the paper's main conclusions are presented.

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[3] The impact of legislative reforms in port efficiency have been analyzed in others countries. Among others Estache et al (2002) for Mexico, Barros (2003) for Portugal and Trujillo and Tovar (2007) for European Union There are also papers which analyze changes in port productivity after port reforms, Martin (2002) for Spain and Estache et al (2004) for Mexico are examples.

[4] This includes both the technical efficiency and the allocative efficiency

2. THEORETICAL MODEL. THE SHORT TERM TOTAL COST FUNCTION

The only long term restrictions that exist when choosing the optimum combination of factors to produce a fixed output quantity are derived from technology and input prices. However, the short run choice is restricted by other aspects, such as contracts or commitments that mean a certain factor must be employed. Consequently, it may be that the optimum quantity of this specific factor, which minimizes the total long run costs is not used; see Caves et al. (1980, 1981), Friedlaender et al. (1993), Keeler and Formbyl (1994), Morrison (1988), Nemoto et al. (1993), and Oum and Waters (1997) among others. In this case, it is possible to modelize the technology using the following short run total cost function:

$$\mathrm{TC}(y, w, K) = \mathrm{VC}(y, w, K) + K.r \qquad (1)$$

Where TC is the total short run cost function, y is the output vector (i =1,…,n), w is the price vector for the input variables (j=1,…,m), K is the quasi-fixed input, VC is the short run variable cost function, and K.r is the fixed costs (r being the price of the quasi-fixed factor).

We can now analyze the properties of the defined cost function, with respect to its arguments. By deriving (1) with respect to each price for the variable factors we obtain the Shephard lemma, the optimum input quantity j (X_j^*) given the market price w_j:

$$\frac{\partial \mathrm{TC}(y, w, K)}{\partial w_j} = X_j^*(y, w, K) \qquad (2)$$

Deriving (1) with respect to the quasi-fixed input:

$$\frac{\partial \mathrm{TC}(y,w,K)}{\partial K} = \frac{\partial \mathrm{VC}(y,w,K)}{\partial K} + r \tag{3}$$

If K is the optimum long run capital level, it should fulfil the minimum first order condition:

$$\frac{\partial \mathrm{TC}(y,w,K)}{\partial K} = \frac{\partial \mathrm{VC}(y,w,K)}{\partial K} + r = 0 \tag{4}$$

From expression (4) we obtain:

$$\underbrace{\frac{-\partial \mathrm{VC}(y,w,K)}{\partial K} = r^s}_{} = r \tag{5}$$

Where the first term represents the reduction in the variable cost due to a variation in the quantity of the quasi-fixed factor. This may be interpreted as a shadow price of the quasi-fixed input (r^s), or a measure of the tension upon the generated costs by restrictions on the quantity of capital. On the other hand, the right side of the expression is the quasi-fixed input price. Only when the equality (5) is fulfilled, will the given quantity of short run K coincide with the long run optimum. In other circumstances, the short run quantity of K used is not optimal.

By combining equations (3) and (5) we obtain the relationship between the market price and the shadow price whereby given K the total costs are minimized. By comparing both prices we may understand how the capital is being used in the short run, in relation to the long run optimum.

$\frac{\partial \mathrm{TC}(y,w,K)}{\partial K} > 0 \Rightarrow -r^s + r > 0 \Rightarrow r > r^s$ The factor K is overused and vice versa (6)

$$\frac{\partial \mathrm{TC}(y,w,K)}{\partial K} = 0 \Rightarrow -r^s + r = 0 \Rightarrow r = r^s \text{ The level of K is optimal} \tag{7}$$

3. EMPIRICAL MODEL

The objective of this section is to propose an econometric model that studies the effects on efficiency of the reforms that took place in the Spanish port sector from 1993 to 2007. In order to do this we use a panel of data from twenty-six port authorities.

This methodology's starting point is a total short run cost frontier that, as we have analysed in the previous section, indicates the minimum costs needed to produce a quantity of output, given the prices of the factors, the fixed factors and the technology. In order to measure the economic efficiency for each company, their observed costs are compared to the minimum cost defined by the estimated frontier.

From this, and using the pioneering work of Battese and Coelli (1995), our paper specifies a model to analyze the factors that determine the evolution of the economic inefficiency, in terms of a set of explicative variables that may vary over time.

Thus, to estimate a stochastic cost frontier using a panel of data, our model can be expressed by the following series of equations:

$$CT_{it} = CT(y_{it},w_{it},K_{it};\beta) + v_{it} + u_{it} \qquad i=1,...,N; \quad t=1,...,T. \tag{8}$$

$$\mu_{it} = \delta_0 + z_{it}\delta, \tag{9}$$

Where CT_{it} indicates the estimated total short run cost function, y_{it} is the output vector for company i in the period t, w_{it} is an input price vector for company i in the period t, β is the estimated parameter vector for technology. The estimated model is a stochastic frontier[5] where the error term has two components. The first v_{it} is a random variable that assumes a distribution of iid. $N(0,\sigma_V^2)$. The second u_{it} is expressed as a linear function of port-specific variables that may explain differences in efficiency. The component u_{it} is assumed to be obtained from truncations at zero of the normal distribution and describes how far the port operates above the economic efficient cost frontier. The untruncated distribution has port-specific means μ_{it}, and a common variance σ_u^2 that is to say:

$$u_{it} \sim \text{i.i.d } N^+(\mu_{it}, \sigma^2) \qquad (10)$$

In this way, we can write (9) as:

$$\mu_{it} = \delta_0 + z_{it}\,\delta + W_{it} \qquad (11)$$

Where z_{it} is a vector (p×1) of variables that may influence port efficiency, and δ is the 1×p parameter vector to be estimated.[6] W_{it} is a random variable obtained from the truncation of a normal distribution, where $(- z_{it}\,\delta)$ is the point of truncation.

This proposed methodology's relevance is that it allows us to determine economic inefficiency in terms of a set of explicative variables that may change with time, without recurring to second stage analysis. The analysis of the determinants of efficiency has

[5] The cost frontier is deterministic if we assume that the observed cost deviation with respect to the optimum is due only to economic inefficiency, and is stochastic if random factors are allowed to influence.

[6] Battese and Coelli (1995) have suggested that the explicative variables of the production function and any other variables capable of determining changes in inefficiency could be regressors in the inefficiency equation. With this model the inconsistency of the second stage analysis is avoided. To review the literature, see Kumbhakar and Lovell (2000).

traditionally been carried out by means a second stage analysis, that is to say, after the efficiency indexes have been obtained; they are regressed with respect to a series of explicative variables. However, some researchers have indicated problems of inconsistency with this methodology; see Wang and Schmidt (2002).

With the methodology developed by Battese and Coelli (1995) the frontier and the equation of the determinants of efficiency are estimated together, thus avoiding the aforementioned problems. The model is ideal for the proposed objectives, since it allows for inefficiency and its determinants may vary in time. If we include the time period in which the different reforms have taken place as explicative variables in the inefficiency model, then it is possible to see the effect of the different reforms on the evolution of economic efficiency.

3.1 The Data

The statistical information that makes up the panel of data used in the empirical estimation has been obtained from various sources. The EPPE publishes accounts and management reports, and the port authorities provide information in their annual reports and their websites. Furthermore, the information, whether quantitative or qualitative, has been completed and contrasted with telephone interviews and direct requests for information via email to the EPPE and the relevant port authorities.

The unit of analysis is the port authority, which may manage one or more ports. In 2000 Spain had 28 port authorities that are in charge of 44 general interest ports. When selecting the port authorities to be analyzed, the sample used the availability of the required minimum information as the criterion. Specifically the Almeria-Motril port authority was excluded because in 2005 it was split into two. The final sample is made up of 390 observations that correspond to a total of 26 port authorities between 1993 and 2007. The port authorities analyzed are: La Coruña, Alicante, Avilés, Bahía de Algeciras, Bahía de Cádiz, Baleares, Barcelona, Bilbao, Cartagena, Castellón, Ceuta, Huelva, Las Palmas, Málaga, Marín y Ría de Pontevedra, Melilla, Motril, Pasajes, Sta. Cruz de Tenerife, Santander, Sevilla, Tarragona, Valencia, Vigo and Villagarcía.

The 26 port authorities included in the sample vary widely in terms of size, specialization etc. Some of them manage ports in which activity involves cargo and passenger traffic, whereas others run ports whose main activity is cargo and passenger transport is virtually non existent. Even for cargo orientated ports, there is a variety of classifications and not just one main type of merchandise; also, their sizes and roles as distribution centres or ports of final destination is important.

Port activity is multi-productive. Port infrastructure service provision may be viewed in terms of the merchandise handled and the passengers using the port. The tonnes of different types of merchandise for each of the sampled port authorities can be classified by type: bulk liquids, bulk solids, general containerized merchandise, general merchandise not in containers and passenger numbers. The port authorities may also provide other services such as rental of equipment and land, bunkering and so on. However, the lack of data on these activities makes their inclusion in the analysis impossible. With the available information it is possible to estimate different models, in terms of the level of aggregation, which is how the products are evaluated. In our econometric specification, production has been approached by using four outputs: bulk solids (y_1), bulk liquids (y_2), general merchandise (y_3) and passengers (y_4).

The information available allows for three variable inputs used by port authorities to be considered: capital, labour and intermediate consumption. The depreciation during the period is used to calculate the capital expenses. Capital prices are obtained by dividing capital costs by the total surface area. Labour is measured using the average number of port authority employees, and labour prices are calculated as the ratio between annual personnel costs and the number of employees. Finally, the other productive factors that have not been included in the two previous categories have been grouped under the title of intermediate consumption. The intermediate consumption has been divided by the total surface area, in order to calculate their price indicator.

Moreover, a quasi-fixed input entitled total surface is included. This latter factor is measured in terms of the port's land area[7], including the whole grounds; i.e. both the port authority's own land area and areas granted to companies operating in the port. Table 1 presents the descriptive statistics for the variables.

Table 1 Descriptive analysis of the data

Variable	Unit	Description	Average	Standard Deviation	Minimum	Maximum
CT	**€ deflated**	Total cost	1.88E+07	1.38E+07	2.47E+06	8.04E+07
CV	**€ deflated**	Variable cost	1.14E+07	8.68E+06	1.86E+06	5.38E+07
y_1	**Tm**	Bulk solids	3.24E+06	3.39E+06	36128	1.97E+07
y_2	**Tm**	Bulk liquids	4.93E+06	6.13E+06	377	2.28E+07
y_3	**Tm**	General merchandise	4.44E+06	7.71E+06	79606	4.71E+07
y_4	**Number**	Passengers	691040	1.31E+06	0	5.93E+06
w_L	**€ deflated /Workers**	Labour price	30610.9	6538.69	16789.8	53016.8
w_I	**€/m^2**	Intermediate inputs price	2.60082	1.79541	0.198284	16.1609
K	**m^2**	Quasi-fixed input	2.47E+06	2.84E+06	194314	1.72E+07
t	**Year**	Trend	8	4.32604	1	15
DCONT		Dummy	0.884615	0.319896	0	1
INDCONT		Index	0.334522	0.284668	0	0.902554
$SHARE_L$	**€ deflated**	Labour share	0.61923	9.68E-02	0.283546	0.853789
$SHARE_I$	**€ deflated**	Intermediate inputs share	0.38077	9.68E-02	0.146211	0.716454
r	**€ deflated / m^2**	Capital price	4.29056	2.55909	0.394062	20.444

[7] Water surface area is excluded.

The maximum and minimum values in the sample show a high degree of heterogeneity, in terms of the size and specialization of the port being managed.

3.2 Econometric Specification

To select the form of the cost function to be estimated, we have used translogarithmic stochastic frontier, which due to its flexibility is widely used. As usual, we imposed the symmetry conditions. Moreover, the total cost function is homogeneous of degree one in variable inputs. This latter condition has been imposed by normalizing the total cost function with one of the input prices. We have divided the total costs and the intermediate consumption input price by the labour price (w_L)[8]. So the model to be calculated is as follows:

$$\begin{aligned}
&\ln(\mathrm{CT/w_L}) = \beta_0 + \beta_1 \ln y + 0.5\beta_{11}(\ln y)^2 + \beta_2 \ln(w_I / w_L) + \\
&0.5\beta_{22}(\ln(w_I / w_L))^2 + \beta_3 \ln K + 0.5\beta_{33} \ln(K)^2 + \beta_4 t + 0.5\beta_{44}(t)^2 + \\
&\beta_{12} \ln y \ln(w_I / w_L) + \beta_{13} \ln y \ln K + \beta_{14} \ln y\, t + \beta_{23} \ln(w_I / w_L) \ln K + \\
&\beta_{24}(w_I / w_L)t + \beta_{34} \ln K\, t + v_{it} + u_{it}
\end{aligned} \qquad (12)$$

Where β_0 is the constant i represents port authorities (i=1, ...,26), and t is a time trend that gathers the non-neutral technical changes (t = 1, ...,15 years).

One problem with this specification is that some ports have zero output levels for the passenger variable, which presents a problem since the natural logarithm of zero is undefined. One solution is to make the translog function more flexible by modifying the variable passenger using Box-Cox transformation: [9]

[8] Result is invariant to the choice of input price to be dropped.

[9] Using L`Hôpital's rule: $\lim_{\lambda_B \to 0} \frac{y_{it}^{\lambda_B} - 1}{\lambda_B} = \ln y_{it}$

$$y_{it}^* = \frac{y_{it}^{\lambda_B} - 1}{\lambda_B}$$

For sufficiently small values of λ_B (λ_B close to zero) the function approximates the ordinary translog function. On the other hand, if λ_B is close to one, the function tends towards a quadratic cost function (for more details, see, for example Caves et al. 1980 or more recently Smet, 2006).

On the other hand, the error term in equation (12) has two components: v_{it} which is a random term, and u_{it} represents economic inefficiency as explained in the previous section. The components of u_{it} are defined as:

$$u_{it} = \delta_0 + \delta_t t + \delta_{tt} t^2 + \delta_{indcont} INDCONT + W_{it} \tag{13}$$

Where δ_0 is the constant, *t* is a time trend that shows how the inefficiency evolves over time. This variable indicates how the 1992, 1997 and 2003 reforms have affected the evolution of inefficiency. Finally, INDCONT, defined by dividing containerized merchandise by the total merchandise, is a variable that accounts for the degree of mechanization at the ports. The idea is to discern the differences in the degree of mechanization at the Spanish ports, which may in some way affect the efficiency of the port authorities.

4. EMPIRICAL RESULTS

The results of the estimation of the equations (12) are presented in Table 2[10].

[10] The estimation was carried out using the Limdep 9.0 statistical package.

Table 2 Estimated total short run cost function

Variable	Pooled Model		Fixed Effect Model (FEM)	
	Coefficient	t statistics	Coefficient	t statistics
Constant	16.4972	334.752	164.1591	389.807
$L(W_L)$	0.4776	16.608	0.6566	29.887
$L(W_I)$	0.5224	18.165	0.3434	15.634
L(K)	0.5596	19.842	0.3586	13.476
$L(y_1)$	0.0624	3.730	-0.0228	-0.863
$L(y_2)$	0.0274	4.443	0.0408	4.047
$L(y_3)$	0.0921	5.745	0.0055	0.255
$L(y_4)$	0.0034	2.497	0.0015	-0.791
t	-0.0235	-5.062	-0.0068	-2.715
$L(w_L)L(w_L)$	0.2811	4.701	0.0089	0.267
$L(w_I)L(w_I)$	-0.2811	-4.701	0.0089	0.267
L(K)L(K)	-0.3332	-5.239	0.0308	0.605
$L(y_1)L(y_1)$	-0.0199	-1.157	0.3434	-0.583
$L(y_2)L(y_2)$	-0.0007	-0.437	0.0024	1.133
$L(y_3(L(y_3)$	-0.0536	-2.387	0.0216	0.942
$L(y_4)L(y_4)$	-0.0001	-0.862	-0.0001	-1.584
t t	-0.0006	-0.035	0.0007	0.971
$L(w_L)L(w_I)$	-0.2811	-4.701	-0.0089	-0.267
$L(w_L)L(K)$	0.3216	5.709	-0.0278	-0.773
$L(w_L)L(y_1)$	-0.1609	-5.594	-0.0358	-1.851
$L(w_L)L(y_2)$	-0.0005	-0.034	-0.0023	-0.246
$L(w_L)L(y_3)$	-0.1400	-4.184	0.0257	1.332
$L(w_L)L(y_4)$	0.0001	0.042	-0.0011	-0.994
$L(w_L)$ t	-0.0044	-0.731	-0.0016	-0.539
$L(w_I)L(K)$	-0.3215	-5.709	0.0277	0.773
$L(w_I)L(y_1)$	0.1609	5.594	0.0358	1.851
$L(w_I)L(y_2)$	0.0005	0.034	0.0023	0.246
$L(w_L)L(y_3)$	0.1400	4.184	-0.0257	-1.332
$L(w_L)L(y_4)$	-0.0001	-0.042	0.0011	0.994
$L(w_I)$ t	0.0044	0.731	0.0016	0.539
$L(K)L(y_1)$	0.1007	4.160	0.0012	0.049
$L(K)L(y_2)$	0.0028	0.193	0.0021	0.204
$L(K)L(y_3)$	0.1804	4.753	-0.0361	-1.364
$L(K)L(y_4)$	-0.0012	-0.500	0.0006	0.050
L(K) t	0.0113	2.007	0.0015	0.484
$L(y_1)L(y_2)$	0.0055	0.721	-0.0020	-0.290
$L(y_1)L(y_3)$	-0.0886	-4.213	0.0249	1.504
$L(y_1)L((y_4)$	-0.0015	-1.034	-0.0006	-0.542
$L(y_{1)}$ t	-0.0108	-3.777	-0.0080	-4.384
$L(y_2)L(y_3)$	-0.0121	-1.817	0.0154	2.806
$L(y_2)L(y_4)$	0.0015	2.974	0.0003	0.574
$L(y_2)$ t	-0.0008	-0.614	-0.0007	-0.887
$L(y_3)L(y_4)$	-0.0033	-2.371	-0.0002	-0.236
$L(y_3)$ t	0.0007	0.238	0.0035	1.449
$L(y_4)$ t	0.0004	2.247	0.0001	0.660

Table 2 Estimated total short run cost function (continuation)

Variable	Pool Model		Fixed Effect Model (FEM)	
	Coefficient	t statistics	Coefficient	t statistics
D_2			-0.2064	-3.426
D_3			-0.3716	-6.528
D_4			0.1468	0.957
D_5			0.2330	3.992
D_6			0.3624	4.295
D_7			0.5087	3.976
D_8			0.3187	4.329
D_9			0.0751	2.277
D_{10}			-0.4753	-7.047
D_{11}			-0.4131	-2.685
D_{12}			-0.5073	-6.538
D_{13}			0.3502	4.172
D_{14}			0.0758	1.212
D_{15}			0.3582	4.094
D_{16}			0.0732	1.223
D_{17}			-0.4380	-3.203
D_{18}			-0.6022	-3.975
D_{19}			0.0921	1.346
D_{20}			0.2142	2.015
D_{21}			0.1413	3.038
D_{22}			-0.0701	-1.210
D_{23}			0.2694	4.737
D_{24}			0.4509	3.721
D_{25}			0.2184	2.817
D_{26}			-0.7625	-6.052

The variables were taken from the deviations in their geometric averages, therefore the first order coefficients can be interpreted as cost elasticities in the mean average of the data sample even for the Box-Cox rescaled output variable (for details, see Smet 2006). The results were robust to changes in the Box-Cox λ_B parameter. Following the research by Smet (2006) and Vita (1990), we have contrasted those estimations of λ_B between 0.0001 and 0.1 and that did not significantly change the sign nor the magnitude of the estimated parameters.

It can be seen that all the first order parameters are statistically significant and have the correct sign. The negative coefficient in the variable trend indicates technical progress during the period analysed. Following Gonzalez and Trujillo (2008), we have also checked other variables) in the cost function: the containerization dummy, port localization and refinery. However these variables did not yield estimates that were significantly different from zero and did not improve the model.

Moreover, in the sample's mean average, the estimated cost function fulfils the properties required by the theory; the regularity conditions are satisfied as the outputs are increasing, and the input prices are non-decreasing and quasi-concave.

However, the Battese and Coelli (1995) model has one main drawback, which is that it considers the dataset as a pooled data. This limitation seems to be important in the context of our analysis, since unobservable heterogeneity among ports authorities can arise. If this heterogeneity is not considered in the model, it may lead to biased estimates. The main advantage of using a panel of data model instead of pooled data is that it is possible to capture the unobservable systematic differences among the ports. Therefore, we proposed re-estimating the model within a *fixed effect model* (FEM) framework by introducing port authority dummy variables into (12) to capture unobservable heterogeneity:

$$
\begin{aligned}
&\ln(\mathrm{CT/w_L}) = \beta_0 + \sum_{i=1}^{26} \beta_i D_i + \beta_1 \ln y + 0.5\beta_{11}(\ln y)^2 + \beta_2 \ln(w_I / w_L) + \\
&0.5\beta_{22}(\ln(w_I / w_L))^2 + \beta_3 \ln K + 0.5\beta_{33}\ln(K)^2 + \beta_4 t + 0.5\beta_{44}(t)^2 + \\
&\beta_{12}\ln y \ln(w_I / w_L) + \beta_{13}\ln y \ln K + \beta_{14}\ln y\, t + \beta_{23}\ln(w_I / w_L)\ln K + \\
&\beta_{24}(w_I / w_L)t + \beta_{34}\ln K\, t + v_{it} + u_{it}
\end{aligned}
\qquad (12b)
$$

Where D_i is an individual dummy which captures the effect of the specific characteristics that are constant over time for each port. As we have indicated, the inclusion of these individual effects is very convenient for our sample, because we are dealing with units, in this case Spanish ports authorities, with widely differing individual characteristics. The results of the estimation of the equations (12b) are presented in Table 2 (FEM).

The FEM model nests the previous pooled model, which does not account for any individual effects. That is, under the appropriate set of parameter restrictions, the FEM collapses to the pooled model, which makes the coefficients on all the dummy variables "Di" equal to zero. This provides a convenient basis for checking the validity of the FEM against the previous restricted model. On the basis of likelihood ratio tests, the restricted model was rejected[11], and the FEM was thus found to be a better representation of the technology for our sample. We have contrasted that the FEM fulfils the regularity conditions relative to input prices; i.e. non-decreasing and quasi-concave. However, as we can see in Table 2, some outputs are not statistically significant. Given that the FEM only uses the within variance for the estimation, and disregards the between variance, this result is normal for the FEM; this is because it estimates the effect of the variables that have very little internal variance.[12]

The immediate implication is that a model which does not account for individual effects would, for our dataset, be unspecified and would therefore provide biased parameter estimates and misleading inference. Therefore, to fulfil our aim of analyzing the impact

[11] The test value was 546 for 25 degrees of freedom.

[12] Given that we do not use the output coefficients in our efficiency analysis, these results are not relevant for the aims of this paper.

of regulatory changes upon the economic efficiency of the Spanish port authorities we will use the FEM.

To do this in an adequate framework, and given the input price coefficients estimated, we have checked whether the Shephard lemma is fulfilled at the mean. This is achieved by transforming equation (2), in order to take into account the fact that our coefficients are in logarithms:

$$\frac{\partial \ln TC(y,w,K)}{\partial w_j} = \frac{\partial VC(y,w,K)}{\partial w_j}\frac{w_j}{VC} = X_j^* \frac{w_j}{VC} = S_j^*(y,w,K) \qquad (13)$$

Where Sj* represents the optimum proportion of costs to acquire input j or the cost share of input j in the total cost. As for the estimated coefficients, it can be deduced that the optimum labour and intermediate consumption shares are S^*_L=0.6565 and S^*_I=0.3434 respectively (see Table 2); which are within their respective intervals of confidence[13]. So the quantity of variable inputs used is the optimum for minimizing costs, which is to say that the Shephard lemma is fulfilled for variable inputs.

The parameter that accompanies capital indicates whether or not this quasi-fixed factor is used in the quantity that minimizes the long run costs. After expression (6) and according to the values in Table 2:

$$\frac{\partial TC(y,w,K)}{\partial K} = \frac{\partial \ln TC(y,w,K)}{\partial \ln K}\frac{TC}{K} = 0.3585\frac{18.8}{2.47} = 2.30 > 0$$

It can be deduced that, on average, the capital shadow price is higher than the market price, so the quasi-fixed capital input is overused in the short run. This result suggests that adjustments in capital investments are necessary, and then that this sector is not in a

[13] The intervals of confidence (95%) are: S_L=(0.699, 0.613), S_I=(0.3864, 0.3004).

long-run equilibrium. Hence, our short run total cost model is appropriate in this case, and it will permit us to make our efficiency analysis within a theoretically consistent framework.

To do this, we analysed the estimated coefficients obtained by equation (13) to check the evolution of the economic inefficiency of the port authorities over time (see table 3). From these coefficients we can deduce that time has a negative and significant impact on the inefficiency; i.e. ceteris paribus, inefficiency diminishes in the time period studied. Also, the variable that accounts for the degree of mechanization in the ports is negative and significantly different from zero, which could indicate that the degree of mechanization at the Spanish ports affects the efficiency of the port authorities; that is to say, a greater degree of mechanization contributes to reducing inefficiency. Other variables that could explain differences in efficiency were checked, but they did not yield estimates that were significantly different from zero and did not improve the model.[14]

Table 3 Explicative effects of the economic efficiency level

Variable	Coefficient	Standard Error	T-Statistic
Constant	0.5331	0.4198	4.214
t	-0.2256	-0.2813	-3.391
$\mathbf{t^2}$	0.0119	-0.0010	3.266
INDCONT	-0.3650	0.1168	-1.924
$\gamma=\sigma_u^2/\sigma_v^2$	6.8221	1.7973	3.796

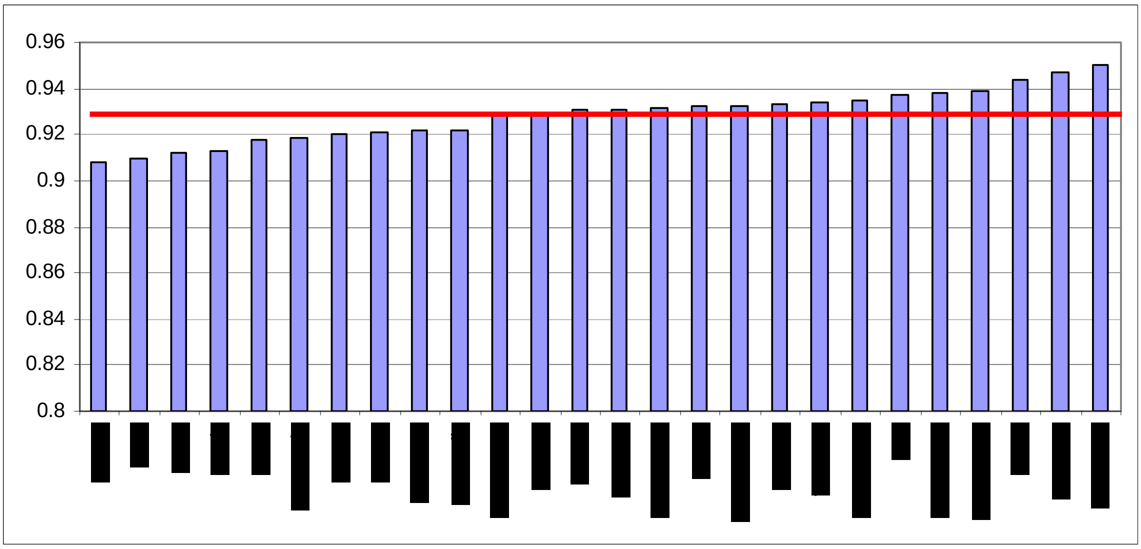
On the other hand, γ indicates the proportion of the variance of u, with respect to the variance of v. In this way, the value of γ will indicate whether the use of a stochastic cost frontier is appropriate or not. From the results, we can deduce that the value of γ is

[14] The following variables were checked: port localization and refinery.

higher than one and significant. This indicates that, in our case, the stochastic frontier is better than the average cost function model, where the deviations from the cost efficient frontier are only due to random noise.

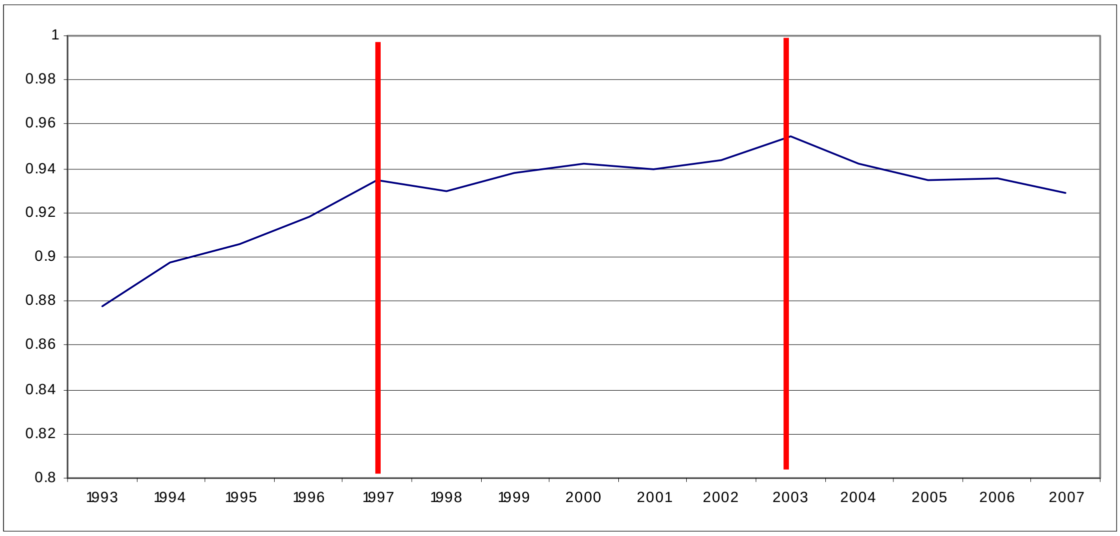
Figure 1 shows the average economic efficiency for the whole sample, and also for each port authority in the period analyzed. The average economic efficiency has been 92.8%, and there have not been huge fluctuations in the efficiency of the different Spanish port authorities during this period. Once the heterogeneity in the activity and technology of the different port authorities has been accounted for, then the economic efficiency among them is reasonably similar.

Figure 1 Average economic efficiency during the period, by port authority.



More interesting is the analysis of the information gathered in Figure 2, which shows the evolution in the economic efficiency for all the sampled port authorities. To facilitate the analysis of the impact of the legislative reforms, the red line on the figure indicates each of the legislative reforms during the period studied[15].

Figure 2 Evolution of economic efficiency during the period.



Note: The red lines mark the three periods defined by the legislative reforms: Law 27/1992, Law 62/1997 and Law 48/2003

From Figure 2 we can deduce that the 27/1992 law reforms favoured the evolution of economic efficiency for the port authorities, as between 1993 and 1997 it grew from 87.7% to 93.4%, or by 5.7%. With regard to the second reform brought about by the 62/1997 law, Figure 2 also shows a favourable evolution; however, at 1.9% the efficiency improvement is less spectacular than for the previous period. Finally, the third period was different, when compared to the two previous periods. This was due to negative growth in the economic efficiency of the port authorities, which was probably caused by delays in introducing some of the measures included in the law; for example,

[15] The three laws whose impact has been analyzed were passed either in November or December, so their effects began to be observed in the following year.

the setting up of the APIs and also the uncertainty over the announcement of the law reform, which occurred just after it came into force.

5. CONCLUSIONS

This article evaluates the impact of the legislative reforms that have taken place in the Spanish port sector in the last fifteen years within an appropriate short run total cost model. We have followed the model proposed by Battese and Coelli (1995), which estimates a short run total cost frontier using data from 26 Spanish port authorities for the 1993-2007 period.

However, a drawback of the Battese and Coelli model (1995) is that this model analyses the data as a pooled data. This seems to be important in this sector where there could be unobservable heterogeneity among the port authorities. Therefore, we proposed re-estimating the model within a fixed effect model (FEM) framework by introducing the dummy variables for the port authorities into (12) to capture the unobservable heterogeneity. In this way the FEM model nests the previous pooled model and, on the basis of likelihood ratio tests, the restricted model was rejected and hence for our sample the FEM was found to be a better representation of the technology.

The originality of this paper lies not just in it being the first to consider the three legislative reforms that took place in Spain in the last fifteen years, but also in that it allows the impact of the economic efficiency for each reform to vary from year to year within each legislative period.

In our analysis three legislative periods have been defined. The first starts with the 27/1992 law, and covers the period from 1993 to 1997 The second begins with the passing of the 62/1997 law and runs from 1998 to 2003. The third corresponds to the 42/2003 law, and covers the period from 2004 to 2007. The results demonstrate that the impact of the legislative reforms has not been evenly distributed.

For the port authorities, the most significant changes, in terms of economic efficiency, took place in the first period. They were perfect for opening and facilitating the change over from a "service port", which was bureaucratic and centralized, to a "landlord port" model; this brought about greater private sector participation and more independent management.

The results were also positive for the second period, although the efficiency gains were much more modest. This is in accordance with the reduced relevance of this stage's reforms, compared to the previous one. The 62/1997 law did not represent such a radical change as the previous period, as it fundamentally followed the same lines as before. Its real innovation was to enable the regional governments to participate in the port authorities' decision making bodies.

Finally the third legislative reform, the 48/2003 law, seemed to have had a contrary effect upon economic efficiency, since during the third period it shrank by 2.49% As we stated before, this was probably caused by delays in introducing some of the measures included in the law, and also by the uncertainty over the announcement of the law reform that occurred just after it came into force.

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