Effects of Economic regulation in the case of Spanish Port System 1986-2003

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ABSTRACT

Spanish port system during the period 1986-2003 was subject to a cost based regulation in order to correct adverse effects of such natural monopolies. In this way Spanish administration intervened by fixing an adequate rate of return based upon the net investment on fixed assets. In this paper we define a theoretical model of port's behaviour introducing this type of regulation. The multiproduct cost function approach is used to test empirically the existence of economic inefficiency as a result of this type of regulation. The results show that when port's regulation becomes tighter, the cost of production increases, that it can be identified as a Averch Johnson effect (1962).

JEL Codes: L5, D2, L9.

1. INTRODUCTION

Spanish port authorities (called *Autoridades Portuarias*) are public bodies which are responsible for the tasks of construction, administration and sometimes the operation of port facilities. These entities are subject to the regulation of a central agency (called *Puertos del Estado*) which is responsible for coordination and efficiency control. *Puertos del Estado* depends on the Spanish Ministry for Transport and Public Works

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and is charged with the execution of the Government's port policy. The legislation provides the Spanish port system with the necessary instruments to improve its competitive position in an open, global market, setting up extended self-management faculties for the port authorities, which must be run on commercial business criteria.

Within this framework, the general interest ports are intended to respond to the 'landlord' model, whereby the port authority does no more than provide the port land and infrastructure and regulate the use of this public property, whereas the port services are essentially provided by private sector operators under an authorization or concession regime.

Spanish port system during the period 1986-2003 was subject to a cost based regulation in order to correct adverse effects of such natural monopolies. In this way *Puertos del Estado* intervened by fixing an adequate rate of return based upon the net investment on fixed assets. This type of regulation is applied in other public services, such as those provided by airports, electrical, gas or water companies and is based on a tradition that goes back to the mid-70s.

Averch and Johnson (1962) developed a model to illustrate that public regulation creates an incentive for the firm to over-invest in tangible assets. A company is taken to produce outputs using inputs, e.g. labour and capital, each of which is available at a fixed market price. The regulator do not permit to earn more than some fixed proportion of the value of its capital – the regulatory fair of return on its rate base. Since the fair rate of return is based upon the net investment on fixed assets and it is always higher than the cost of capital, the firm has an incentive to augment its capital stock. This result was called *Averch-Johnson effect*. Over-capitalization has obvious implications for rates paid by consumers and also for the efficiency of resource allocation. The model also showed that when firm's regulation became tighter, overcapitalization increased[3].

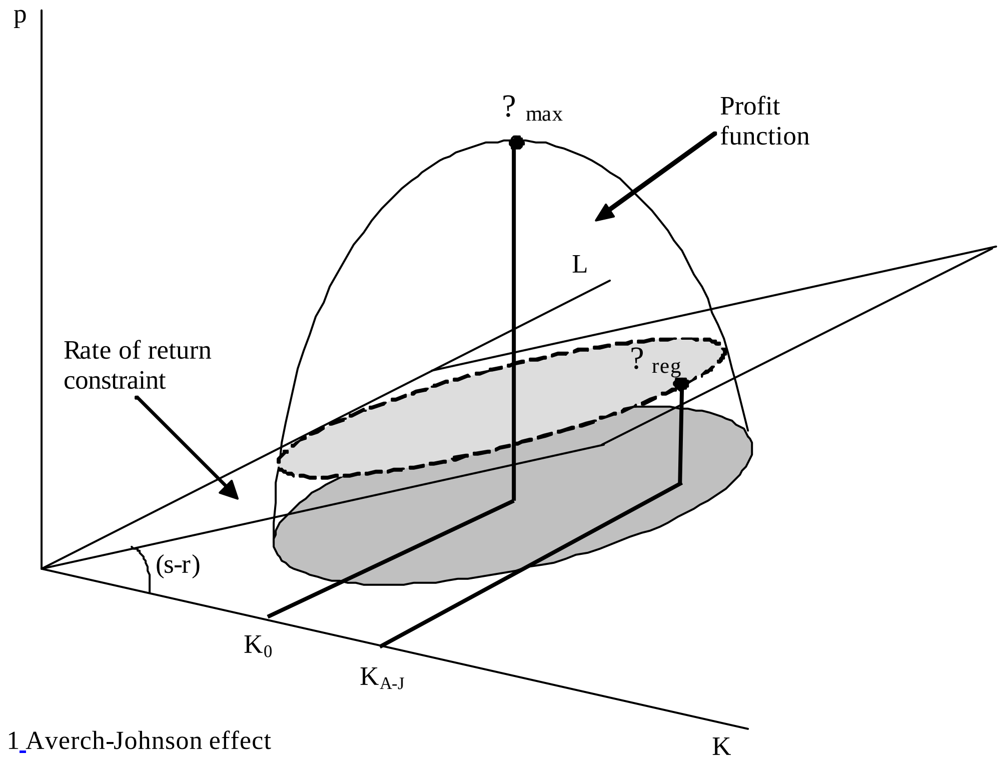

Figure 1 Averch-Johnson effect

Figure 1 is a three-dimensional diagram that represents the Averch-Johnson effect. It shows a plane depicting the rate of return constraint: total profit of regulated firm is at most the difference between the value of capital measured at fair rate of return (*s*) and the value of capital measured at capital market price (*r*), p = (*s*-*r*)*K*. We see from this equation that the slope of any of the cross sections of a constraint plane taken parallel to the any (*K*,p) plane represents (*s*-*r*), the excess of regulatory fair rate of return over the cost of capital. In this diagram we have included the firm's profit function, being the broken curve the intersection of the profit surface and the regulatory constraint plane. Its projection on the *L*-*K* plane represents all combinations of the two inputs which just satisfy the rate of return constraint requirement.

Without regulation, profit-maximizing firm would select the highest point on the profit surface, represented as p_{max}, being the optimal stock of capital equal to K_0. However in

[3] To see more details about the effects of rate of return regulation, see Baumol and Klevorick (1970).

a situation of regulation, the same profit-maximizing firm would choose a different point on the profit surface, p_{reg}, trying to satisfy the regulatory constraint. p_{reg} must be the rightmost point on the regulatory constraint curve since this gets the firm to the highest total profit point on the constraint plane. Comparing this point with p_{max}, we observe that capital intensity on production process with rate of return regulation (K_{AJ}) is higher than in a situation in absence of regulation (K_0). So the introduction of a rate of return regulation promotes inefficiency costs, through an overcapitalization process.

Baumol and Klevorick (1970) point out that inefficiency cost could be higher when fair rate of return gets closer to the cost of capital. In Figure 1 if $s \to r$, the slope of any of the cross sections of the constraint plane decreases, so the firm will use combinations of inputs more capital intensive in its production process, increasing the overcapitalization effect. In the extreme case that $s=r$, firm's combination of inputs will be situated inside of the projection L-K plane of the broken curve but it will be uncertain. When fair rate of return is equal to the cost of capital, rate of return regulation leads that any combination of inputs guaranteed the same level of profits (zero economic profits) so firm is indifferent to place in any point of the shadow projection L-K plane.

Some empirical tests of this effect have been carried out by Spann (1974), Craig Petersen (1975), Oum, Zhang (1995) or Ai and Sappington (2002). Spann (1974) test the effects of rate of return regulation in electric utility industry estimating a translog production function and confirming the Averch-Johnson thesis. Craig Petersen (1975) try to test the effects in electric industry estimating a cost function suggesting that lower fair rates of return approaches the cost of capital, costs of electric utilities increase. Oum and Zhang (1995) show that competition in the US telephone industry, subject to rate of return regulation, induces the incumbents to use capital inputs closer to unscontrained optima, thereby reducing the allocative inefficiency caused by the Averch-Johnson effect. Ai and Sappington (2002) examine the impact of state incentive regulation on network modernization in the US telecommunications industry finding that industries under price cap regulation generate greater network modernization than under rate of return regulation.

In this paper we define a theoretical model of port's behaviour introducing this type of regulation. The multiproduct cost function approach is used to test empirically the existence of economic inefficiency as a result of this type of regulation. The results show that when port's regulation becomes tighter, the cost of production increases, that it can be identified as a Averch Johnson effect (1962). The approach of this paper in port behaviour studies is novel. Some previous related studies are Kim and Sachish (1986), Baños-Pino *et al.* (1999) and Jara-Díaz *et al.* (2002).

Kim and Sachish (1986) estimate the structure of production, technical change and total factor productivity growth using data from the port of Ashdod located in Israel. Their findings indicate that technical change has been labour saving and capital using. Baños-Pino *et al.* (1999) analyze how it is possible to estimate the degree of overutilization of capital in the Spanish Port Authorities for the 1985-1997 period using two alternative methods: the cost function and the input distance function. Although their results suggest that both methods identify overcapitalization, they don't explain the causes of it. Jara-Díaz *et al.* (2002) estimate a long run multiproduction cost function for Spanish Port Authorities during 1985 until 1995 calculating specific marginal costs and the degree of economies of scale and scope to a port level. Their results show that increasing returns to scale are present for each and every port and that port specialisation is not appropriate from the viewpoint of infrastructure.

The paper is structured as follows. In the second part we present the theoretical model of port's behaviour introducing the cost-based regulation, showing that the existence of a fair rate of return based upon the net investment on fixed assets generates a situation of economic inefficiency. In the third part we specify the econometric specification defining a multiproduct cost function which allows to test empirically the predictions of the theoretical model. In the forth section we present data, the description of the variables and the results of the estimation. In this section we also calculate partial elasticities of substitution and cross and own price elasticities. Finally, in the fifth section we preset the main conclusions of this work.

2. THEORETICAL MODEL

We assume that ports minimize costs subject to a regulatory constraint, their revenues should be, at least, a percentage of fixed assets fixed by *Ministerio de Obras Públicas* for the period 1986-1992 and *Puertos del Estado* after 1992:

$$\begin{aligned} &Min\, \mathrm{C} \equiv \mathrm{p_L L + p_K K + p_M M} \\ &\mathrm{s.t.\ F(K,L,M,\overline{Q}) \geq 0} \\ &\mathrm{\overline{R} - p_L L - p_M M \geq sK} \end{aligned} \tag{1}$$

where L, K, and M are labour, capital, and intermediate consumption inputs, p_L, p_K, p_C are labour, capital and intermediate consumption, respectively, $\overline{Q}$ is a vector of chosen output quantities, s is the allowed rate of return on capital, and $\overline{R}$ is total revenue, $\overline{I'Q}$ where I' is a vector ($1\times N$) of chosen output prices and Q is a vector ($N\times 1$) of chosen output quantities.

The A-J assumption of s-p_K > 0 is adopted. Both the regulatory constraint and the transformation function constraints are assumed binding so the two restrictions hold as equalities.

The problem is solved by using the Lagrangian multiplier method.

$$\lambda(L,K,M,l,n) = p_L L + p_K K + p_M M - m\left[F(K,L,M,\overline{Q})\right] - l\left[\overline{R} - p_L L - sK - p_M M\right] \tag{2}$$

The first-order conditions are:

$$\frac{\partial \lambda}{\partial L} = p_L - mF_L - l p_L = 0 \tag{3}$$

$$\frac{\partial \lambda}{\partial K} = p_K - mF_K - l p_K = 0 \tag{4}$$

$$\frac{\partial \lambda}{\partial M} = p_M - mF_M - l p_M = 0 \tag{5}$$

$$\frac{\partial \lambda}{\partial m} = F(K, L, M, \overline{Q}) = 0 \tag{6}$$

$$\frac{\partial \lambda}{\partial l} = \overline{R} - p_L L - sK - p_M M = 0 \tag{7}$$

Another A-J assumption is that $0 < l < 1$ (Averch-Johnson, 1962; Spann, 1971; Craig Petersen, 1975).

Since $s > p_K$, then $ls > lp_K$ and $-ls < -lp_K$. Adding p_K to each side, $p_K - ls < p_K - lp_K$. Dividing by $1 - l$ gives:

$$\frac{p_K - ls}{1 - l} < r \tag{8}$$

Equations (3), (4), and (5) imply the following relationships:

$$\frac{F_L}{F_K} = \frac{p_L}{\frac{p_K - ls}{1 - l}} \tag{9}$$

$$\frac{F_L}{F_M} = \frac{p_L}{p_M} \tag{10}$$

$$\frac{F_M}{F_K} = \frac{p_M}{\frac{p_K - ls}{1 - l}} \tag{11}$$

So the term (8) could be interpreted as the shadow price of capital used by constrained port in its decision process. In that this price is less than the market price, *r*, capital is used in more intensively in production than would be the case if the port were allowed unconstrained cost minimization.

If we solve the system of (7), (9), (10) and (11) we can obtain the conditional demand functions K^*, L^*, and M^* in terms of $\overline{Q}$, p_L, p_K, p_M, and s. Since $C^* = p_L L^* + p_K K^* + p_M M^*$,

$$C^* = C(\overline{Q}, p_L, p_K, p_M, s) \qquad (12)$$

If we differentiate the Lagrangian function λ with respect to s:

$$\frac{\partial \lambda}{\partial s} = l K \qquad (13)$$

Applying the envelopment theorem, partial derivative of Lagrangian function with respect to s at K^*, L^*, M^*, and l^* is equal to the partial derivative of optimal cost function $-C^*$ with respect to s.

$$\frac{\partial \lambda}{\partial s} = \frac{\partial (-C)}{\partial s} = -l K < 0 \qquad (14)$$

Since we suppose $s > p_{K,}$ we identify tighter regulation to the ports when s® $p_{K,}$, so when regulation becomes tighter, cost of production increases. The cost of overcapitalization is motivated by the rate of return regulation This result confirms Averch-Johnson implications.

3. ECONOMETRIC SPECIFICATION

For the estimation of the regulation effect over the cost of production we consider a translog multiproduct cost function

$$\ln C_{it} = a_0 + \sum_{r=1}^{M} b_r \ln Q_{rit} + \frac{1}{2}\sum_{r=1}^{M}\sum_{s=1}^{M} b_{rs} \ln Q_{rit} \ln Q_{sit} + \sum_{j=1}^{N} g_j \ln p_{jit} + p_R \ln s_{it} + p_{RR}\frac{1}{2}(\ln s_{it})^2$$
$$+ \sum_{r=1}^{M} p_{Rr} \ln s_{it} \ln Q_{rit} + \sum_{j=1}^{N} p_{jr} \ln s_{it} \ln p_{jit} + \frac{1}{2}\sum_{j=1}^{N}\sum_{k=1}^{N} g_{jk} \ln p_{jit} \ln p_{kit} + \sum_{r=1}^{M}\sum_{j=1}^{N} r_{rj} \ln Q_{rit} \ln p_{jit} + \sum_{t=1}^{T} D_T T \quad (13)$$
$$+ \sum_{i=1}^{P} D_i P + e_{it}$$

Applying the dual Shephard Lemma:

$$S_j = \frac{\partial \, ln \, C_{it}}{\partial \, ln \, p_{jit}} = \frac{X_{jit} \, p_{jit}}{C_{it}} = g_j + \sum_{k=1}^{N} g_{jk} \, ln \, p_{kit} + \sum_{r=1}^{M} r_{rj} \, ln \, Q_{rit} + n_{it} \tag{14}$$

We impose homogeneity of degree 1 on the cost function in input prices:

$$\sum_{j=1}^{N} g_j = 1, \; \sum_{k=1}^{N} g_{jk} = 0, \; \sum_{j=1}^{N} r_{rj} = 0, \; \sum_{r=1}^{M} p_{jr} = 0 \qquad \forall \, r = 1, \ldots.., M, \; \forall j, k = 1, \ldots\ldots, N$$

It has been also imposed the symmetry condition:

$$b_{rs} = b_{sr}, \quad g_{jk} = g_{kj}, \quad r_{rj} = r_{jr}, \quad p_{Rr} = p_{rR}, \quad p_{jr} = p_{rj}$$

$$p_R = \frac{\partial \ln C_{it}}{\partial \ln s_{it}} = \frac{\partial C_{it}(\overline{Q}, \overline{p}_L, \overline{p}_K, \overline{p}_M, s)}{\partial s_{it}} \frac{s_{it}}{C_{it}(\overline{Q}, \overline{p}_L, \overline{p}_K, \overline{p}_M, s)}$$

p_R gives the change in $\ln C(\overline{Q}, \overline{p}_L, \overline{p}_K, \overline{p}_M, \overline{s})$ due to a unit increase in $\ln s - \ln \overline{s}$ evaluated at the mean values, that is the elasticity of total costs with respect to regulated price of capital evaluated at mean values.

Economies of size are measured by the reciprocal of the cost elasticity:

$$e(Q, p, s) = \left(\overset{M}{\underset{r=1}{?}} \; \frac{\partial \ln C(Q, p, s)}{\partial \ln Q_r} \right)^{-1} = \left(\overset{M}{\underset{r=1}{?}} \; b_r \right)^{-1} \tag{15}$$

Increasing returns to scale are present at (Q,p,s) according ε(Q,p)>1, decreasing returns to scale are present according ε(Q,p)<1, and constant returns to scale according ε(Q,p)=1.

Economies of diversification are measured by the symmetric $M \times M$ matrix of cost complementarities:

$$cc(Q, p, s) = \frac{\partial^2 C(Q, p)}{\partial Q_r \partial Q_s} = b_r b_s + b_{rs} \tag{16}$$

There are economies of diversification if *cc(Q,p,s)*<1, and diseconomies of diversification if *cc(Q,p,s)*>1.

We can also calculate the Allen partial elasticities of substitution, defined as:

$$s_{jk} = \frac{g_{jk} + S_j S_k}{S_j S_k}$$

$$s_{jj} = \frac{g_{jj} + S_j (S_j - 1)}{S_j^2}$$

and the cross and own price elasticities as:

$$e_{jk} = \frac{g_{jk} + S_j S_k}{S_j}$$

$$e_{jj} = \frac{g_{jj} + S_j (S_j - 1)}{S_j}$$

4. DATA AND RESULTS

4.1. Data description

The sample consists of 27 port authorities considered as ports of public interest in Spain. We have annual data from 1986 until 2003, period of rate of return regulation. The final panel data set consists of 484 observations.

The dependent variable represent the total costs (*C*) that includes labour expenditures (*LE*), capital expenditures (*KE*) and intermediate consumption expenditures (*IE*).

The output variables of ports are two: total cargo of the port (*mtot*) and total rent received (*canr*) as a proxy for the physical amount of space constructed by the port and rented to private firms[4].

Capital price, *r*, is calculated as an index price of public works (*ICNC, índice de precios de la Confederación Nacional de la Construcción*) multiplied by the sum of real long-term interest rate (R) and depreciation rate of port's property and equipment (d).

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[4] This variable was also used by Jara-Díaz et al. (2002).

$$r = ICNC\ (R + d)$$

s is the fair rate of return on capital and it was obtained by the sum of real long-term interest rate (*R*), depreciation rate of port's property and equipment (*d*) and fair rate of return for the Spanish port system (six per cent of the net value of property and equipment) multiplied by the index price *p*.

$$s = (R + d + 0.06)p$$

Labour price, *w*, is calculated as the total labour expenditure over the total number of employees.

Intermediate input price, *pcir*, is defined as the ratio between the sum of consumption, services externally provided plus other expenses, and the annual revenue.

A descriptive analysis of the variables used are presented in Table 1. As we can observe, Spanish port system present large size differences among the ports. The most important ports in Spain in terms of traffic are Algeciras, Barcelona and Valencia relatively specializated in containerised general cargo.

Results

Table 1
Description of the variables (mean for each port)

	c constant €	le constant €	ke constant €	ie constant €	w constant €	r %	s %	pcir %	mtot tons.	can constant €
alge	18,400,000	7,399,378	9,301,732	4,871,181	27,139	4.097	14.362	11.575	35,800,000	3,092,782
ali	7,685,688	4,602,910	2,913,957	2,014,862	25,642	3.179	13.379	20.300	2,623,667	2,047,406
alme	6,451,114	3,378,340	2,700,491	1,512,158	24,915	3.764	13.899	13.460	7,916,209	841,740
avi	6,802,990	4,097,367	2,437,710	2,074,983	26,500	3.185	12.837	22.780	3,808,117	735,152
cad	13,900,000	7,719,486	6,812,149	2,657,143	25,951	3.419	13.295	17.470	3,862,916	2,330,135
bcn	46,800,000	21,000,000	18,800,000	17,700,000	37,852	3.370	13.479	22.417	23,400,000	13,800,000
bil	33,000,000	12,800,000	17,300,000	11,300,000	37,949	2.970	12.783	19.960	27,700,000	7,076,827
cart	9,900,551	5,444,285	4,724,060	1,893,700	29,597	3.657	13.715	8.999	13,400,000	1,865,175
cast	5,207,500	2,423,991	2,463,601	1,355,463	26,619	3.450	13.505	14.135	8,176,367	1,272,276
ceu	7,281,530	4,378,937	2,896,944	1,693,625	34,303	4.190	14.904	18.996	3,611,982	988,907
ferr	3,400,770	1,808,128	1,541,168	714,033	20,743	3.321	13.448	11.841	5,295,344	5,408,298
gij	21,500,000	11,700,000	10,200,000	5,108,932	31,095	3.650	13.517	14.405	14,500,000	3,012,839
hue	14,900,000	7,354,946	7,334,903	4,219,716	33,459	2.870	12.732	17.023	13,600,000	1,663,213
cor	11,500,000	5,009,862	5,995,934	2,958,046	24,612	3.997	14.030	13.680	12,000,000	769,316
pal	20,500,000	8,666,263	10,200,000	5,856,362	29,107	2.948	12.670	15.523	11,600,000	777,032
mal	9,936,978	5,192,637	4,861,878	2,190,965	27,590	4.206	14.983	17.410	6,905,588	5,964,521
mel	4,168,186	2,730,900	1,491,474	863,491	34,038	3.370	13.410	22.694	1,112,686	839,726
bal	15,600,000	6,608,547	8,228,366	3,737,346	23,745	4.225	14.677	16.753	8,099,834	3,643,950
pasa	13,000,000	8,101,427	4,993,073	3,621,925	39,825	3.480	13.606	22.437	4,235,953	794,743
pont	3,614,892	1,844,023	1,611,344	808,384	20,569	3.756	13.863	14.849	1,112,858	1,940,288
ten	17,100,000	6,228,988	9,559,553	4,593,383	28,680	3.241	12.849	17.196	14,000,000	2,909,353
sant	13,400,000	6,339,294	6,400,881	3,870,724	26,320	3.250	13.724	19.582	4,451,895	3,609,192
sev	12,300,000	6,357,481	5,889,820	3,364,168	25,105	2.558	12.374	22.672	3,566,741	2,286,757
tarr	18,600,000	7,701,009	8,698,714	5,806,753	24,849	3.319	13.095	15.191	26,200,000	3,315,042
val	28,300,000	12,300,000	13,100,000	8,872,878	34,557	3.170	13.133	15.937	17,700,000	6,009,148
vig	12,400,000	6,593,096	4,898,374	3,681,311	31,896	4.101	14.358	18.817	3,314,138	2,742,234
villa	2,894,563	1,730,674	1,246,382	525,993	24,473	4.655	15.386	17.466	668,216	729,157

4.2. Results

We have estimated system (13)-(14) by iterative seemingly unrelated regression (SUR) method. The variables have been specified in terms of deviations with respect to their means, so the first-order conditions can be interpreted as elasticities evaluated at the sample mean. As we can see on Table 2, all of these coefficients are highly significant. We have observed that, at the mean, the estimated cost function is increasing in outputs and in the variable input prices and quasi-concave in the variable input prices[5].

The elasticity of total costs with respect to regulated price of capital evaluated at mean values is negative and statistically significant. Then if we assume *s*>*r*, we then demonstrate that if the fair rate of return, *s*, move away from the cost of capital, *r*, port's costs decreases. When fair rate of return gets closer to the cost of capital, then ports will tend to increase the over-investment in capacity so port's production costs increase. If fair rate of return moves away from the cost of capital, overcapitalization process diminishes so port's production costs decrease. This incentive to increase the level of capital beyond what is needed for economically efficient production can be partially explained by this type of regulation, however we should consider other important factors, as regulation of port's labour market, the existence of X inefficiency .

The degree of scale economies and the economies of diversification at the mean of all observations are 6.15 and -0.018, respectively so we demonstrate that Spanish ports present increasing returns to scale and positive economies of diversification. These results are similar that those obtained by Jara-Díaz *et al.* (2002).

In Table 3 we can see the Allen partial elasticities of substitution estimates evaluated at the mean. These estimates suggest that in Spanish ports for the period 1986-2003,

[5] Berdnt (1991) shows that it is possible to check the regularity conditions for the estimated translog cost function demostrating that fitted values all be positive (condition of monotonicity) and the n × n matriz of substitution elasticities is negative semidefinitive at each observation (condition of quasi-concavity).

capital, labour and intermediate consumption were substitutable inputs. We have also estimated the cross and own price elasticities confirming the substitutability condition of inputs and showing that capital is the most price-inelastic input (-0.289). The most elastic

Table 2

Cost system estimated

	Coefficient	Standard Error	t-statistic		Coefficient	Standard Error	t-statistic
l(wd)	0.419	0.012	33.87	ali	-0.673	0.078	-8.64
l(rd)	0.390	0.011	34.36	alme	-0.926	0.078	-11.83
l(pcird)	0.191	0.009	20.20	avi	-0.734	0.080	-9.19
l(sd)	-0.177	0.073	-2.43	cad	-0.064	0.077	-0.83
l(mtotd)	0.101	0.035	2.89	bcn	1.094	0.076	14.43
l(canrd)	0.061	0.024	2.57	bil	0.728	0.075	9.67
l(mtotd)l(mtot)	0.157	0.080	1.97	cart	-0.587	0.086	-6.81
l(canrd)l(canrd)	0.027	0.019	1.40	cast	-1.226	0.085	-14.34
l(wd)l(wd)	0.091			ceu	-0.844	0.079	-10.65
l(rd)l(rd)	0.126	0.005	26.68	ferr	-1.428	0.085	-16.86
l(pcird)l(pcird)	0.055	0.004	14.38	gij	0.403	0.078	5.16
l(sd)l(sd)	-0.076	0.466	-0.16	hue	-0.051	0.076	-0.67
l(sd)l(wd)	0.084	0.012	6.81	cor	-0.412	0.080	-5.16
l(mtotd)l(canrd)	-0.025	0.020	-1.26	pal	0.228	0.077	2.96
l(rd)l(wd)	-0.081	0.005	-17.23	mal	-0.547	0.078	-7.00
l(rd)l(sd)	0.035	0.011	3.10	mel	-1.327	0.078	-16.92
l(rd)l(pcird)	-0.045	0.003	-14.52	bal	-0.026	0.077	-0.34
l(sd)l(pcird)	-0.119	0.009	-12.61	pasa	-0.099	0.079	-1.25
l(pcird)l(wd)	-0.010	0.004	-2.46	pont	-1.390	0.082	-16.86
l(wd)l(mtotd)	-0.013	0.008	-1.64	ten	-0.019	0.075	-0.25
l(wd)l(canrd)	-0.002	0.003	-0.67	sant	-0.123	0.079	-1.55
l(rd)l(mtotd)	-0.007	0.007	-0.93	sev	-0.173	0.079	-2.18
l(rd)l(canrd)	0.002	0.003	0.54	tarr	0.064	0.076	0.84
l(sd)l(mtotd)	-0.031	0.108	-0.29	val	0.607	0.079	7.70
l(sd)l(canrd)	-0.132	0.097	-1.37	vig	-0.199	0.077	-2.59
l(pcird)l(mtotd)	0.019	0.006	3.25	villa	-1.589	0.081	-19.72
l(pcird)l(canrd)	0.001	0.003	0.22	constant	16.736	0.059	281.84

Equation	Obs.	RMSE	R^2	Chi^2	P-value
Cost (C)	484	0.2248	0.9066	8435.15	0.00
Capital share (KE)	484	0.0478	0.7057	1236.76	0.00
Intermediate consumption share (IE)	484	0.0391	0.6117	853.12	0.00

Table 3

Partial elasticities of substitution and cross and own price elasticities

Allen partial elasticities of substitution ij (evaluated at the means of data)

		i: K	L	I
j	K	-0.789	-	-
	L	0.472	-0.861	-
	I	0.424	0.886	-2.478

Cross and own price elasticities ij (evaluated at the means of data)

		I		
		K	L	I
	K	-0.289	0.173	0.155
j	L	0.199	-0.362	0.373
	I	0.090	0.189	-0.528

5. CONCLUSIONS

In this paper we have defined a theoretical model of port's behaviour introducing its regulatory structure. The multiproduct cost function approach is used to test empirically the existence of economic inefficiency as a result of this type of regulation, as predicted theoretically Averch and Johnson (1962). We have shown that the regulation structure of Spanish ports for the period 1986-2003 generates over-investment in capital stock, although we demonstrate that it is the most price-inelastic input in the port's production process. This incentive to increase the level of capital beyond what is needed for economically efficient production can be partially explained by this type of regulation, however we should consider other important factors, as labour-specific regulatory environment, or the existence of X-inefficiency.

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