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A Multioutput Cost Function for Port Terminals

Some Guidelines for Regulation

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Abstract

Cargo handling in ports is a multioutput activity, as freight can arrive in many forms such as containers, bulk, rolling stock, or non-containerised general cargo. In this paper the operation of port terminals is analysed through the estimation of a multioutput cost model that uses monthly data on three firms located at the Las Palmas port in Spain. This permits the calculation of product specific marginal costs, economies of scale (general and by firm) and economies of scope, which are key tools to help the regulators in their task.

Key words: multiproduct, economies of scale and scope, regulation, port terminals and cargo handling.

JEL Classification system: L9

1. Introduction

Broadly defined, a port can be described as a group of facilities and movable equipment used to provide different types of services which, in economic terms, are highly heterogeneous. Since ports are a key component of the logistics chain, their deficient operation directly affects relevant economic variables such as export competitiveness and import final prices, which can negatively affecteconomic development. This explains governments' (concerns with setting adequate competitive or regulatory conditions to enable the efficient operation of ports.

Generally, all the activities developed at each port are coordinated by an entity known as the Port Authority. Although *private* port authorities exist, in most countries port authorities are typically e public entities that act as the regulatory entity for all the companies operating at the port.

Port regulation is not an easy task considering the diversity of activities that occur at port facilities.[1] Among those activities, cargo handling is of special relevance since it generally represents over 80% of the costs incurred by a ship loading or unloading goods at a port. In spite of the importance of cargo handling for the regulation of the port sector, little is known in practice about the economics of this service.

This paper is an effort to increase understanding of this issue by presenting an estimation of a cost function for general cargo handling services at multi-purpose terminals. This estimation provides some of the key concepts for the regulation of the sector, such as marginal costs and economies of scale and scope.

This paper is structured as follows: Section 2 describes certain aspects of the organization and regulation of the port sector in general and of cargo handling services in particular, from which it can be inferred that cargo handling is a multioutput activity. Section 3 presents the main cost concepts used by the multiproduct theory to describe an economic activity, which will be used for the empirical application of this paper. Section 4 summarizes previous works estimating output or cost functions in the port sector. Sections 5 and 6 present the information used to build the database, as well as the findings of the analyses made. Lastly, section 7 presents the final conclusions.

2. Production and Regulation in the Port Sector

Ports have traditionally been subject to some kind of governmental control, although the applicable legal system and the degree of dependence and control may vary from country to country. Even though there is not a uniform pattern for port organization, the *landlord* model is the one most widely used in the world. Under this model, the public sector provides port infrastructure in the strict sense (lighthouses, quays, loading and unloading areas, etc.) and private companies supply the superstructure required to provide port services (office buildings, machinery, etc.).

[1] For an updated summary, see *Trujillo and Nombela (2002)*

These services, which are generally provided by private companies, include cargo handling, which encompasses all handling operations from placing cargo on the dock to loading it on the ship and vice versa. The most common means of introducing private sector participation into cargo handling services at port terminals is through the granting of concessions. In general, international experience has shown that the substitution of public property by private property in relation to certain port services produces a remarkable increase in productivity and a reduction in the waiting time of vessels, thus improving the efficiency of such services *(Estache, González and Trujillo, 2002)*.

In the past several decades, new cargo handling and vessel design technologies have been developed that allow the maximization of mechanization, a reduction in the need for labor and consequently, an improvement in the productivity of the vessel by dramatically reducing her stay time at the port. This new technology can be labeled as the “unitization” or “unit load” concept. Cargo unitization implies packing several small cargo items into a standard unit which can be handled with specifically designed equipment. The main standard units used are pallets, containers, roll-on/roll-off trucks and trailers. The unitization process leads to ship, port and terminal specialization and has placed emphasis on the fact that in regards to cargo handling, the type of package used to unitize the cargo is more important than the nature of the cargo itself.

Multi-purpose terminals provide services to ships carrying cargo which are heterogeneous but presents identical generic characteristics. As a result of the present global trend towards general cargo containerization, many multi-purpose terminals will eventually become container terminals.

General cargo handling operations vary depending on whether the cargo is in break-bulk or unitized form, and if it is unitized, whether it is containerized or roll-on/roll-off cargo (cargo that is driven on and off the vessel). These different handling processes imply that costs vary in each case and therefore, it is logical to treat them as separate products and to acknowledge the multioutput character of the activity under consideration.

3. Multiproduct Cost Concepts[2]

Generally, the main issue when discussing economic regulation is cost, and consequently cost is the focus of this paper. Specifically, a multioutput cost function estimate provides regulators with key concepts, such as marginal costs per company or product, which allow them to define tariff caps, if this were the regulatory system to be applied. Also, it allows the calculation of global and specific economies of scale, which are useful in determining the feasibility of a marginal cost tariff structure and facilitating the development of an optimal tariff structure. On the other hand, the economies of scope calculation show whether it is advisable to specialize the company. In the case of multi-purpose port terminals, this information provides guidelines for adequate port planning, since it objectifies the decision to make port terminals container-specialized or diversified instead.

[2] This title is based on the seminal paper of *Baumol et al (1982)*.

Unlike single-productive firms, whose cost-production structure can be described with relatively few interrelated concepts, multiproductive firms' cost analysis requires the description of several new concepts. This led to the development of a theory which, as could be expected considered single-production as a particular case.

Empirical determination of all cost concepts for a certain industry can be achieved through the econometric estimation of the corresponding cost function *C(W,Y).* The explanatory variables of such function, after all variable factors have been assumed, are product vector *Y* and price vector of productive factors *W*. The latter has been eliminated in the expressions below in order to simplify the mathematical formula.

Thus, the marginal cost of product *i* can be obtained as a derivative of the cost function with respect to such product.

$$\frac{\partial C}{\partial y_i} = Cm_i \tag{1}$$

On the other hand, the degree of global economies of scale is a technical property of the productive process which is defined in transformation or production functions. However, dual relations allow the calculation of the degree of the economies of scale directly through the cost function (*Panzar and Willig, 1977*) as follows:

$$S = \frac{C(Y)}{Y \ \nabla_y C(Y)} \tag{2}$$

The degree of global economies of scale represents the maximum growth rate that the product vector can reach when the productive factors vector increases in a certain proportion. Therefore, the presence of increasing returns of scale (S>1) implies that an increase of productive factors by a certain proportion λ enables an increase of the set of products by a proportion greater than λ, showing that a production expansion enjoys advantages from the point of view of costs.

Another way in which the firm's operations can change is through the variation of a certain output's production, considering the amount of the rest of the products is constant. In order to study the cost of such variation in production, it is necessary to define the incremental cost of product *i*.The incremental cost of product *i* is represented by the cost of adding *i*th product plus the vector of products produced by the firm and can be expressed as:

$$CI_i = C(y_1, y_2, ..., y_n) - C(y_1, y_2, ..., y_{i-1}, 0, y_{i+1}, ... y_n) \tag{3}$$

Although the average cost is not defined in multiproduct because *Y* is a vector[3], the average incremental cost is defined and reads:

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[3] In this case, it is possible to define a *ray average cost C/λ* related to the product proportional expansion from a bundle of products Y^0.

$$CIMe_i = \frac{CI_i(Y)}{y_i} \tag{4}$$

Incremental cost and average incremental cost definitions are used to identify the specific returns to scale of a given product y_i :

$$S_i(Y) = \frac{CI_i(Y)}{y_i \frac{\partial C(Y)}{\partial y_i}} = \frac{CIMe_i(Y)}{\frac{\partial C(Y)}{\partial y_i}} = \frac{CIMe_i(Y)}{C_i(Y)} \tag{5}$$

where $C_i\ (Y)$ is the marginal cost of product i. Then, the degree of scale economies specific to a product y_i are the quotient between the product's average incremental cost and marginal cost, and they will be increasing, constant or decreasing depending on whether $S_i(Y)$ is larger than, equal to, or smaller than one, respectively.

Incremental cost definition can be extended to a subset of products R and it is very useful since it allows identification of the specific return to scale of a given subset of products. Accordingly, the degree of economies of scale specific to subset R is defined as follows:

$$S_R(Y) = \frac{CI_R(Y)}{\sum_{j \in R} y_j \frac{\partial C(Y)}{\partial y_i}} = \frac{CI_r(Y)}{\sum_{j \in R} y_i C_i(Y)} \tag{6}$$

so the economies of scale specific to subset of products R will be increasing, constant or decreasing depending on whether $S_R(Y)$ is larger than, equal to, or smaller than one, respectively. Consequently, if $S_R > 1$, the application of tariffs to the marginal cost would not cover incremental costs. Note that equation (2) represents a particular case of equation (6) when R equals M.

Cost complementarity between two different products can be analyzed following the expression below that when showing values smaller than or equal to zero, indicates a weak cost complementarity:

$$C_{ij}(Y') = \frac{\partial^2 C(Y')}{\partial\, y_i y_j} \le 0, \quad i \ne j, \quad \forall\ 0 \le Y' \le Y \tag{7}$$

On the other hand, the expansion of the output vector may mean the introduction of new products in the production line giving rise to a new concept related to production diversification. This last possibility leads to a specific concept of multiproduct called economies of scope.

The economies of scope concept is useful to analyze whether it is advisable or not to have the firm diversified or specialized. Thus, economies of scope measure the relative cost increase that would result from the division of the production of Y into two different production lines T and N-T. Formally, if an orthogonal partition of product vector M into two subsets T and N-T is carried out, the degree of economies of scope ED_T of subset of products *T* with relation to its complementary subset *N-T* will follow this expression:

$$ED_T(Y) = \frac{1}{C(Y)}\left[C(Y_T) + C(Y_{N-T}) - C(Y)\right] \tag{8}$$

in such a way that the partition of the production will increase, decrease or not alter total costs depending on wether $ED_T(Y)$ is larger than, equal to, or smaller than zero, respectively. Accordingly, if $ED_T(Y) > 0$, there are economies of scope and, therefore, it is cheaper to produce product vector *Y* jointly than product vectors Y_T and Y_{N-T} separately. In other words, it is not advisable to specialize but rather to diversify the production. It is easy to see that *ED* should be in the interval (-1, 1).

Lastly, there is a relation between the degrees of economies of scale and scope represented by the equation:

$$S_N(Y) = \frac{\alpha_T S_T(Y) + (1-\alpha_T)S_{N-T}(Y)}{1 - ED_T(Y)} \tag{9}$$

where

$$\alpha_T = \frac{\sum_{j\in T} y_j \frac{\partial\ C(Y)}{\partial\ y_j}}{\sum_{j\in N} y_j \frac{\partial\ C(Y)}{\partial\ y_j}} \tag{10}$$

This relation shows that in the absence of economies of scope (*ED=0*), *S* would be a weighted average of the specific economies of scale of each subset. However, the existence of economies of scope (*ED>0*) favours the presence of economies of scale.

4. Empirical Literature

In a systematic and detailed analysis of empirical works on the econometric estimation of production and cost functions in the port sector, the first thing noticed was the limited literature on this issue, particularly in connection with cargo handling activities. This may be because it is difficult to gather the necessary data to produce such works. Table 1 summarizes the works on the estimation of production and cost functions in a single-output environment in the port sector.

With respect to the three production function estimation papers, all of them analyze single-output scenarios and use the same Cobb-Douglas functional form and measurement of economies of scale. Furthermore, two out of the three papers (*Reker et al., 1990 and Tongzon, 1993)* assess the same activity at the same port and during the same time period, but with a somewhat different definition of variables. This allows a comparison of the results of the economies of scale estimation but it is disappointing, because they are contradictory.

With regard to the single-output cost function estimation, the findings are more significant. In the two studies shown in Table 1, it can be observed that they expressly acknowledge that the activity under consideration is a multioutput activity. In the *Kim and Sachis (1986)* work, a single-productive cost function is estimated since they only have a limited number of observations. There are updated versions of the paper by *Martinez Budría (1996*) (i.e. *Jara Díaz et al., 1997 and Jara Díaz et al., 2002*) which estimate a multioutput cost function. Although these two studies analyze different activities, they both arrive at the conclusion that there are increasing economies of scale at the approximation point.

The studies estimating cost functions in a multioutput environment, which are summarized in Table 2, are also very limited in number. There are only three in total, out of which one is an upgraded version of another (*Jara Díaz et al., 1997 and Jara Díaz et al., 2002*). As in the single-output case, although the activities assessed differ, the estimated economies of scale are increasing at the approximation point.

The comparison that yields the most interesting results is probably that between the studies by *Martinez Budría (1996)* and *Jara-Díaz et al., (1997, 2002)* since they only differ in the approach (the first one is single-output and the other two are multioutput) and the functional form used - Cobb-Douglas and quadratic, respectively. Both papers lead to the conclusion that there are increasing returns to scale in infrastructure provision services in Spanish ports; however, the figure obtained in the single-output case was larger. The authors themselves point out that this is due to the existence of economies of scope, which are present in the multioutput scenario but which can not be revealed from an aggregate description of the product. This shows that it is not irrelevant to disregard that this is a multioutput activity.

This study reveals that no previous paper analyzes the multioutput character of costs in the cargo handling activity.

5. A Model as an Empiric Study on Port of *La Luz* and *Las Palmas*[4]

La Luz and Las Palmas Port, located in the Canary Islands, has been chosen to carry out a practical application aimed at estimating a cost function based on the data coming from the three container terminals operating within the port area. Although they are called as such, these terminals are not container terminals in the strictest meaning of the term. Other types of goods can be handled in the site facilities such as Ro-Ro goods and general break-bulk cargo, and therefore they are considered to be pure multi-purpose terminals despite their denomination.

[4] Within the Spanish port system, it is the public authority that determines the conditions for the private sector to operate by fixing prices, number and type of terminals, conditions for exploitation, concession terms and features, among others. In accordance with the rules in force, in order for public authorities to decide on these conditions they should observe efficiency, economy, productivity and security standards, which calls for a wide knowledge of service costs.

Table 1. Estimation of monoproductive functions of production and costs

Author	Activity	Functional specification	Economies of scale	Other Measurements
		Production Function		
Chang (1978)	Infraestructure?	Cobb-Douglas	Constants	Average Productivities Marginal Productivities
Reker el al. (1990)	Containers Manipulation	Cobb-Douglas	Diminishing	None
Tongzon (1993)	Containers Manipulation	Cobb-Douglas	Increasing	Berth efficiency
		Cost functions		
Kin y Sachis (1986)	Infrastructure and services	Translogarithmic	Increasing in the point of approximation	Minimal efficient scale Factor demand price elasticity Cross elasticities
Martínez Budría (1996)	Infrastructure	Cobb-Douglas	Strongly Increasing in the point of approximation	Cost factor elasticities Individual specific effects of each port Second stage analysis

Table **2. Estimation of multiproductive functions of cost**

Author	Activity	Functional specification	Economies of Scale	Other Measurements
Jara Díaz et al. (1997,2002)	Infrastructure	Quadratic	Moderate Increasing in the point of approximation	Marginal costs of the product i Economies of scope
Martínez Budría et al. (1998)	Activity of the *Estiba* and *Desestiba* public societies (SEED)	Translogarithmic	Increasing in the point of approximation	Marginal costs of the product i Elasticities costs - products Total productivity of the factors for a subsample of 14 SEED

The Model
Generally, the method used for estimating a cost function implies a company's optimizing behavior consisting in choosing, in each case, the optimal combination of productive factors resulting in the product vector, as long as such prices are considered to be exogenous to the company.

It is helpful for a cost analysis to distinguish between the long and short term. The difference between them lies in whether or not it is possible to adjust productive factors. Thus, all productive factors are adjustable in the long run, and this is why the model to be estimated tries to explain the aggregated economic expenses using both the levels of production for each of the products and the prices of the productive factors used in such production process as explanatory variables. A short-run cost function implies the existence of non-adjustable fixed factors, and therefore the model to be estimated tries to explain the economic expense using the quantum of the fixed factors involved in addition to the vectors for products and prices for variable productive factors.

The Data
The database used for this empirical work is an asymmetric pool of monthly data relating to production, productive factors, and the expenses in relation with the three terminals operating within the port area of La Luz and Las Palmas located in the Canary Islands—referred to below as T.1, T.2, and T.3. More precisely, from 1992 through 1997 for T.1., from 1991 through 1999 for T.2., and from 1992 through 1998 for T.3.

The production of the three terminals may be aggregated into three products —general break-bulk cargo ("general cargo") representing a mean value amounting to 9.9% of the monthly moved tons, and general consolidated cargocontainers and Ro-Ro's, with respective mean values for the entire sample of 87.4% and 2.7% of the monthly moved tons. Table 3 shows the monthly values obtained for the entire sample and for each of the three terminals, both in terms of the three defined products as well as the total expense incurred during service provision. It also includes a production-aggregated volume, which results from the addition of the monthly moved tons concerning the three products in all.

The analysis of the information contained in Table 3 leads first to an approximation of the size of companies. Thus, taking into consideration the aggregated product volume, the largest company is T.3., followed by T.1 and by T.2. The average volume of movement in the entire sample amounts to approximately 67,000 monthly tons.

It is interesting to observe the maximum and minimum values because they point to a significant variability during the study period. In fact, maximum values reveal that monthly figures have been five times the average value. Furthermore, nil as minimum values is relevant because economies of scope calculations require products to reach those value levels.

Table 3. Total expense (million pesetas of December, 1999) and monthly average production (thousands of tons) for the total sample

Variable		Sample	Terminals		
			T.1	T.2	T.3
Total monthly expense	**Mean**	94,8	73,6	81,9	129,4
Containers	**Mean**	59,2	53,1	33,5	97,4
	max.-min.	310-15	74-32	62-15	310-49
General cargo	**Mean**	5,6	0,6	9,9	4,4
	max.-min.	29-0	3-0	29-0	14-0
Ro-Ro cargo	**Mean**	2,1	1,0	0,8	4,7
	max.-min.	11-0	3-0	4-0	11-0
Production-aggregated	**Mean**	66,8	54,7	44,1	106,5
	max.-min.	325-15	78-32	77-15	325-58

On the other hand, where the variable used as a size indicator is the total monthly production expense (mean value), even though T. 3. is still found in the first place, the other two companies, T.1 and T.2. interchange positions. The reason for this change in positions between T.1 and T.2. is to be found in the combination of products produced by each. Indeed, general cargo has a heavier bearing on T.2 than on the other two —1.9% as opposed to 0.9% in T.1. and 4.7% in T.3. This would indicate that it is more expensive to move general cargo than other products, which suggests that the marginal cost of general cargo will be higher.

Finally, as a first approach it is interesting to observe data as if it were the case of a single product process. For that, a "pseudo-mean-cost" for the activity has been estimated based on the aggregated production volume. The graphic representation generates a dotted area in the shape of a curve for mean costs —as expected— which suggests that the data retrieved are sensible.

The variable to explain is the total monthly production expense for the terminals, which results from the aggregation of expenses of all the productive factors defined below.

The productive factors used in production of the three referenced products have been grouped into four categories: personnel, total area, capital and intermediate inputs. The personnel working in port terminals may be classified in two categories of workers: the non-port workers, who are those that carry out other tasks than the handling of cargo (administrative, executive, control personnel, maintenance, among others); and stevedores or port workers, who are charged with handling cargo. In addition, the port worker category branches off into two: workers under *Relación Laboral Común (RLC)* (Ordinary Employment Relationship) and workers under *Relación Laboral Especial (RLE)* (Special Employment Relationship). The first category of port workers, i.e. RLC workers, are those which are on the payroll, i.e., employed permanently by a company. Should their employment be terminated, these types of workers will revert to their former situation as RLE workers —i.e. port workers who are not on the payroll of a particular stevedore company and therefore are available to be recruited on a provisional basis by any company to work 6-hour shifts, and who fall under the management of the *Sociedad Estatal de Estiba y Destiba (SEED) (*State-owned Loading and Unloading Company). The possibility of recruiting port workers on a per-task basis provides a significant degree of flexibility to stevedore companies.

The information available regarding the amount of work used is expressed in number of men per month for non-port workers, and in number of shifts per month for port workers. A shift is a 6-hour work schedule. The price of each type of work is calculated as the quotient of the cost of such type of work and the number of workers in the case of non-port workers, or the number of worked hours in the case of port workers computed on a 6-hour shift basis.

With regard to area, the terminals under analysis may make use of an area that has been granted under concession, which may be increased by provisionally renting —upon prior request— additional area from the port authority.[5] The addition of both types of areas is called total area and the area used is measured in monthly square meters. The price of the total area is the quotient of the area-related expense divided by the total area square meters.

Capital encompasses all the components of tangible assets of the company —i.e. buildings, machines, etc. The monthly cost results from the addition of the accounting depreciation for the period plus the return on the active capital of the period and the shares of stock of the SEED. This rate of return evidences the compensation earned by risk-free capital, which is made up of bank interest plus a risk premium. It has been considered that for the period under analysis the return for both concepts amounts to 8% per annum. The price of capital is the quotient of the cost of capital divided by the active capital of the period (net fixed assets under exploitation for a given period t.)

Lastly, the rest of the productive factors used by the company and that have not been included in any of the three preceding categories, such as office supplies, water, electricity, and the like, have been denominated under intermediate consumption. The monthly expense results from the aggregation of the rest of the current expenses other than depreciation, personnel expenses and payment for area, after the pertinent corrections in a manner such that the resulting monthly expense truly reflects consumption and not accountancy. The price of electricity has been used as an indicator of the price of intermediate consumptions, as the prices of the other components do not undergo variances.

The most important productive factor in terms of its share of total expense is personnel, with a mean amounting to 53% of the monthly expense of the entire sample. The other referenced

[5] Note that this fact may turn area into a variable factor.

factors represent different shares of the mean total expense of the entire sample, with total area representing 13%; capital, 8%; and intermediate consumption 26%.

Within personnel, non-port workers account for 21% of personnel expenses and port workers account for a mean value amounting to the remaining 79% of the entire sample. Within this latter group, the mean value of RLC and RLE workers for the entire sample amounts to 36% and 43% respectively. The figures per company reveal similar patterns.

Because the database available for this estimation is made up of monthly observations, at first it seems sensible to choose a short-run model as it does not appear to be an easy task for all productive factors to be adjusted on a monthly basis. If any of the productive factors are not adjusted, the amount used of such factor is considered instead of the price.

The factors eligible as fixed factors are non-port personnel, total area and equipment.[6] This last factor indicates the available machinery and movable equipment at the terminal. The possibility for terminals to rent additional area and machinery and to recruit port personnel under special labor relationships suggests certain adjustability in the short run.

The correlation matrix was analyzed in order to determine the type of model to estimate — either short or long run. The correlation coefficients between production and the factors prompt to be fixed factors show that non-port personnel, equipment and total area are not as "fixed" as it could presumably been thought of at the outset. Such analysis leads to the conclusion that terminals are somehow adapting these factors with production and a long-run model is to be estimated. Even so, in an attempt to contrast the adequacy of a long-run model, a short-run estimation will be carried out considering total area as the only fixed factor[7], since it appears as the most discrete candidate among all the others, and the rest of factors as variables.

6. Model and Results Estimation

Both models estimate a system of equations made up by the total cost function and the equation of expense in factors resulting from the application of Shephard's lemma.

In cost function estimations it is preferable to use flexible functional forms. The most popular ones are translogarithmic and quadratic forms. The selection between them both depends on

[6] Unlike area and non-port personnel, which are measured in homogeneous units —sq. m and men/month respectively— and therefore they do not present any problems for aggregation purposes, equipment as a variable comprises such different machinery as a postpanamax crane, a forklift truck, or a chassis. For aggregation purposes, two possible indicators were considered: power and purchase value. The former was considered inadequate because it weighs very different machines on an equal footing, such as a crane and a forklift truck because they have similar lifting power, and therefore purchase price of equipment was chosen.

[7] As this is considered a fixed factor, it is used as an explanatory variable for the amount used of said factor, i.e. the total monthly square meters.

the objective of the task. One of the advantages of quadratic function is its suitability to the analysis of economies of scope and incremental costs, while it allows for the estimation of marginal costs, which is the reason why it was chosen. For the long-run model, the econometric specification of the long-run total cost function is as follows (9):

$$\begin{aligned} CT &= A_0 + \sum_{i=1}^{m} \alpha_i (y_i - \overline{y_i}) + \sum_{i=1}^{n} \beta_i (p_i - \overline{p_i}) + \phi(T - \overline{T}) \\ &+ \frac{1}{2}\sum_{i=1}^{m}\sum_{j=1}^{m} \delta_{ij} (y_i - \overline{y_i})(y_j - \overline{y_j}) + \frac{1}{2}\sum_{i=1}^{n}\sum_{j=1}^{n} \gamma_{ij} (p_i - \overline{p_i})(p_j - \overline{p_j}) \\ &+ \sum_{i=1}^{m}\sum_{j=1}^{n} \rho_{ij} (y_i - \overline{y_i})(p_j - \overline{p_j}) + \sum_{i=1}^{m} \lambda_i (y_i - \overline{y_i})(T - \overline{T}) + \sum_{i=1}^{n} \mu_i (p_i - \overline{p_i})(T - \overline{T}) \\ &+ \pi (T - \overline{T})(T - \overline{T}) + \sum_{i=1}^{N} \vartheta_i D_i \end{aligned} \tag{11}$$

Where: y_i = Output i, p_i = Input i price, m = Number of outputs, n = Number of inputs, T = Temporal Trend, D_i = Firms Dummy, N = Number of firms. All the variables marked with a horizontal bar reflect the value of the entire sample mean.

The equations of expense in variable inputs consistent with the following equation:

$$G_i = p_i \cdot x_i = p_i \cdot \left[\beta_i + 2\gamma_{ii}(p_i - \overline{p_i}) + \sum_{j \neq i}^{m} \gamma_{ij} (p_j - \overline{p_j}) + \sum_{j=1}^{n} \rho_{ij} (y_j - \overline{y_j}) + \mu_i (T - \overline{T}) \right] \tag{12}$$

Where: G_i = Expense in factor i, p_i= Price for the variable inputs i, x_i = Demand derived by input i. m = Number of outputs, n = Number of inputs, T = Temporal trend.

In addition, some company *dummies* have been included to capture specific effects, as well as a temporal, linear and quadratic, cross trend with all the variables that reflect a possible technical change.

In turn, the relevant short-run model is consistent with the following expression:

$$\begin{aligned} CT &= A_0 + \sum_{i=1}^{m} \alpha_i (y_i - \overline{y_i}) + \sum_{i=1}^{n} \beta_i (p_i - \overline{p_i}) + \eta(stot - \overline{stot}) + \phi(T - \overline{T}) \\ &+ \frac{1}{2}\sum_{i=1}^{m}\sum_{j=1}^{m} \delta_{ij} (y_i - \overline{y_i})(y_j - \overline{y_j}) + \frac{1}{2}\sum_{i=1}^{n}\sum_{j=1}^{n} \gamma_{ij} (p_i - \overline{p_i})(p_j - \overline{p_j}) + \frac{1}{2}\sigma(stot - \overline{stot})(stot - \overline{stot}) \\ &+ \sum_{i=1}^{m}\sum_{j=1}^{n} \rho_{ij} (y_i - \overline{y_i})(p_j - \overline{p_j}) + \sum_{i=1}^{m} \tau_i (y_i - \overline{y_i})(stot - \overline{stot}) + \sum_{i=1}^{n} \iota_i (p_i - \overline{p_i})(stot - \overline{stot}) \\ &+ \sum_{i=1}^{m} \lambda_i (y_i - \overline{y_i})(T - \overline{T}) + \sum_{i=1}^{n} \mu_i (p_i - \overline{p_i})(T - \overline{T}) + \kappa(stot - \overline{stot})(T - \overline{T}) \\ &+ \pi(T - \overline{T})(T - \overline{T}) + \sum_{i=1}^{N} \vartheta_i D_i \end{aligned} \tag{13}$$

Where: *stot* = used amount of fixed input: total area.

This only differs from the long-run total cost equation in the linear, quadratic and cross terms that affect the only fixed factor selected -*i.e.,* total area- and will also affect the variable inputs in the respective expense equations.

$$G_i = p_i \cdot x_i = p_i \cdot \left[\beta_i + 2\gamma_{ii}(p_i - \overline{p_i}) + \sum_{j \neq i}^{m} \gamma_{ij}(p_j - \overline{p_j}) + \iota\ (stot - \overline{stot}) + \sum_{j=1}^{n} \rho_{ij}(y_j - \overline{y_j}) + \mu_i(T - \overline{T}) \right] \tag{14}$$

The method used for the simultaneous estimation of the equations system comprising the total cost equation and the respective expense equations is the estimation of systems seemingly unrelated equations. This is a recursive method by which estimated generalized least squares are applied to a set of seemingly unrelated equations which are actually related through positive or negative covariances between the error terms in the different equations at a given moment in time. This method is actually a two-stage, consistent and asymptotically efficient estimation procedure.

Both models are used to estimate deviations from the sample mean, both to avoid multicollinearity issues and to facilitate the interpretation of parameters. The estimations yielded highly similar results; these are summarized in table 4 as far as first-order parameters are concerned. As regards the sign and statistic significance of the estimated parameters, the previous table shows the good behavior in both models. All first-order coefficients carry the expected sign. In addition, all of them are statistically significant but for short-run model trend which, even though not significant, is nearly so. Nevertheless, the joint significance of all first-order parameters in the short-run model was confirmed through the Wald Test.

Marginal Costs

The mean marginal costs estimated through both models for containers (C2), general cargo (C3) and Ro/Ro cargo (C4) match the expected order and magnitudes as shown in table 4. Indeed, containers were expected to rank first in a lower-to-higher marginal cost scale, closely followed by Ro/Ro cargo and, lastly, general cargo further on behind. The main reason behind this result lies with the different rates of return reached as regards the handling of these three products.

Since there is no (product) price data available against which the marginal costs thus obtained can be verified, maximum tariffs currently applied at the Port[8], which were in force during the study period, are resorted to instead. These tariffs were grouped based on the type of cargo

[8] Spanish ports apply maximum tariff for public services regarding stowing/unstowing, loading/unloading, and reception/delivery.

involved. All estimates obtained have been verified to be below the aforementioned maximum tariff, which indicates that the marginal costs arrived at are reasonable.

Table 4. Expense, marginal costs, demands for factors and trend.

	Long-run Model		Short-run Model	
Parameter	**Estimation**	**t statistic**	**Estimation**	**t statistic**
Total cost (mean)-C1	96680	140,02	97394	138,92
Marginal cost of Containers -C2	745	28,48	684	20,72
Marginal cost of General cargo –C3	1974	14,19	2056	14,96
Marginal cost of Ro-Ro cargo –C4	1056	2,96	1139	3,051
Demand for RLC worker -C5	1,58	69,74	1,58	73,66
Demand for RLE workers-C6	2,34	45,86	2,33	49,13
Demand for intermediate consumption -C7	983	87,30	981	88,27
Demand for total area -C8	61593	106,85		
Demand for capital -C9	583266	40,61	589240	44,83
Demand for not port workers -C10	0,02	76,67	0,02	78,28
Trend -C11	-67	-1,96	-64	-1,89

As could be expected, the similarities between the results arrived at through each model as far as the marginal costs, inputs derivative demand levels, estimated expense and trends are concerned, confirm the long-run equilibrium inferred from the data. The analysis is then focused on drawing results and conclusions from the long-run model.

Table 5 shows the estimates from the final version of the long-run model, which does away with a single second-order parameter (crossing between RLE workers and Ro/Ro cargo) not significant and carrying a sign opposite to the expected one.

Table 5. Results of the estimation of the model of long term.

Parameter	Variable (1)	Estimate	Standard error	t Statistic
$C1=A_0$	**CONS**	96680,2	690,475	140,02
$C2=\alpha_{contt}$	**CONTT**	744,568	26,1409	28,4829
$C3=\alpha_{mg}$	**MG**	1973,57	139,062	14,192
$C4=\alpha_{rodt}$	**RODT**	1055,81	356,65	2,96036
$C5=\beta_{plc}$	**PLC**	1,57685	0,022611	69,7386
$C6=\beta_{ple}$	**PLE**	2,33895	0,051002	45,8603
$C7=\beta_{pi}$	**PI**	982,53	11,2547	87,2994
$C8=\beta_{pcanon}$	**PCANON**	61592,9	576,436	106,851
$C9=\beta_{pk}$	**PK**	583266	14363,4	40,6078
$C10=\beta_{pnph}$	**PNPH**	0,021919	2,86E-04	76,6747
$C11=\phi$	**T**	-67,0148	34,1904	-1,96005

Parameter	Variable (1)	Estimate	Standard error	t Statistic
C12=δ_{cdos}	CDOS	-0,068971	0,049706	-1,38758
C13=δ_{cdos}	CMG	0,408093	0,557917	0,731457
C14=δ_{cdos}	CR	4,57755	1,54726	2,95849
C15=ρ_{cplc}	CPLC	9,95E-03	7,10E-04	14,0028
C16=ρ_{cple}	CPLE	0,02	1,45E-03	13,7777
C17=ρ_{cpi}	CPI	5,818	0,511285	11,3792
C18=$\rho_{cpcanon}$	CPCANON	180,843	21,0889	8,57526
C19=ρ_{cpk}	CPK	7785,87	611,748	12,7272
C20=ρ_{cpnph}	CPNPH	2,62E-04	1,34E-05	19,6209
C21=λ_{cte}	CTE	0,120936	0,150679	0,802607
C22=δ_{mg2}	MG2	-0,518286	1,40314	-0,369375
C23=δ_{mgr}	MGR	1,15946	8,13486	0,14253
C24=ρ_{mgplc}	MGPLC	0,037099	4,60E-03	8,06544
C25=ρ_{mgple}	MGPLE	0,078918	0,01047	7,53744
C26=ρ_{mgpi}	MGPI	8,45203	2,50495	3,37413
C27=$\rho_{mgpcanon}$	MGPCANON	-109,421	120,741	-0,906247
C28=ρ_{mgpk}	MGPK	18048,7	2947,32	6,12378
C29=ρ_{mgpnph}	MGPNPH	4,48E-04	5,61E-05	8,00074
C30=λ_{mgt}	MGT	-0,469081	0,629254	-0,745456
C31=δ_{r2}	R2	-40,9608	10,3971	-3,93965
C32=ρ_{rplc}	RPLC	0,037754	0,011358	3,32395
C34=ρ_{rpi}	RPI	20,5144	6,6753	3,07318
C35=$\rho_{rpcanon}$	RPCANON	-583,417	337,467	-1,72881
C36=ρ_{rpk}	RPK	-4811,55	7599,82	-0,633114
C37=ρ_{rpnph}	RPNPH	7,67E-04	1,66E-04	4,62008
C38=λ_{rt}	RT	-0,734985	1,88866	-0,389156
C39=γ_{plc2}	PLC2	-7,20E-06	1,36E-06	-5,27695
C40=γ_{plcple}	PLCPLE	-2,11E-05	7,46E-06	-2,83304
C41=γ_{plcpi}	PLCPI	9,25E-03	2,77E-03	3,33348
C42=$\gamma_{plcpcanon}$	PLCPCANON	-0,307449	0,164174	-1,8727
C43=γ_{plcpk}	PLCPK	6,33105	2,33813	2,70774
C44=$\gamma_{plcpnph}$	PLCPNPH	1,90E-07	6,48E-08	2,93544
C45=μ_{plct}	PLCT	-0,015786	1,12E-03	-14,0831
C46=γ_{ple2}	PLE2	-2,33E-05	9,31E-06	-2,50139
C47=γ_{plepi}	PLEPI	0,028954	7,71E-03	3,75454
C48=$\gamma_{plepcanon}$	PLEPCANON	0,788301	0,477103	1,65227
C49=γ_{plepk}	PLEPK	-8,6808	5,87937	-1,47648
C50=$\gamma_{plepnph}$	PLEPNPH	1,69E-07	1,54E-07	1,09846
C51=μ_{plet}	PLET	9,91E-03	2,68E-03	3,69417
C52=γ_{pi2}	PI2	-15,0668	2,44814	-6,15439
C53=$\gamma_{pipcanon}$	PIPCANON	901,258	299,174	3,01249

Parameter	Variable (1)	Estimate	Standard error	t Statistic
C54=γ_{pipk}	PIPK	2696,68	2585,63	1,04295
C55=γ_{pipnph}	PIPNPH	4,67E-05	9,37E-05	0,497954
C56=μ_{pit}	PIT	1,24028	0,688917	1,80033
C57=$\gamma_{pcanon2}$	PCANON2	-10391,1	12917,9	-0,804397
C58=$\gamma_{pcanonpk}$	PCANONPK	-209552	157560	-1,32998
C59=$\gamma_{pcanonpnph}$	PCANONPNPH	-0,045851	7,98E-03	-5,74755
C60=$\mu_{pcanont}$	PCANONT	196,049	39,8325	4,92183
C61=γ_{pk2}	PK2	-1,33E+06	1,36E+06	-0,977757
C62=γ_{pkpnph}	PKPNPH	0,231914	0,059244	3,91454
C63=μ_{pkt}	PKT	125,511	696,051	0,180318
C64=γ_{pnph2}	PNPH2	-5,59E-09	1,41E-09	-3,97384
C65=μ_{pnpht}	PNPHT	-9,87E-05	1,54E-05	-6,41019
C66=π	T2	0,142629	0,109505	1,30249
C67=$\theta_{T.1}$	T.1	-2460,71	220,639	-11,1526
C68=$\theta_{T.2}$	T.2	-2479,14	315,09	-7,86803

(1) For a more detailed description of the variables see Annex 1.

Dependent variable: Total Expenditure	
Mean of dependent variable = 94783,3	Std. error of regression = 10802,5
Std. dev. of dependent var. = 34819,9	R-squared = 0,903733
Sum of squared residuals = 0,308070E+11	Durbin-Watson statistic =0,991747
Variance of residuals = 0,116693E+09	Corrected R-squared = 0,870825

Dependent variable: RLC Worker Expenditure	
Mean of dependent variable = 17964,1	Std. error of regression = 3989,9
Std. dev. of dependent var. = 8563,97	R-squared = 0,84924
Sum of squared residuals = 0,420269E+10	Durbin-Watson statistic = 0,667191
Variance of residuals = 0,159193E+08	Corrected R-squared = 0,842659

Dependent variable: RLE Worker Expenditure	
Mean of dependent variable = 21447,9	Std. error of regression = 7773,31
Std. dev. of dependent var. = 12515,1	R-squared = 0,613797
Sum of squared residuals = 0,159520E+11	Durbin-Watson statistic = 0,538230
Variance of residuals = 0,604243E+08	Corrected R-squared = 0,596938

Dependent variable: Non Port Worker Expenditure	
Mean of dependent variable = 10410,9	Std. error of regression = 2223,66
Std. dev. of dependent var. = 4445,35	R-squared = 0,749944
Sum of squared residuals = 0,130539E+10	Durbin-Watson statistic = 0,773278
Variance of residuals = 0,494466E+07	Corrected R-squared = 0,739029

Dependent variable: Intermediate Consumption Expenditure	
Mean of dependent variable = 24534,2	Std. error of regression = 4597,01
Std. dev. of dependent var. = 8445,03	R-squared = 0,702706

Sum of squared residuals = 0,557898E+10	Durbin-Watson statistic = 1,26826
Variance of residuals = 0,211325E+08	Corrected R-squared = 0,689728

Dependent variable: Total Area Expenditure	
Mean of dependent variable = 7071,48	Std. error of regression = 1035,59
Std. dev. of dependent var. = 2897,86	R-squared = 0,871917
Sum of squared residuals = 0,283125E+09	Durbin-Watson statistic = 0,513589
Variance of residuals = 0,107244E+07	Corrected R-squared = 0,866326

Dependent variable: Capital Expenditure	
Mean of dependent variable = 12985,4	Std. error of regression = 5212,91
Std. dev. of dependent var. = 7728,52	R-squared = 0,545660
Sum of squared residuals = 0,717404E+10	Durbin-Watson statistic = 0,391706
Variance of residuals = 0,271744E+08	Corrected R-squared = 0,525827

Certain cost-related concepts that play a relevant role in the analysis of multioutput activities can be calculated based on the estimated parameters. Specifically, the following are calculated.

Marginal costs by product and firm

Table 6 displays the results obtained and shows that all of them are statistically significant and that the same order applicable to the sample mean –higher to lower cost by products- is maintained. Furthermore, no major variability exists between them.

The marginal costs for containers (in units) are 7595 *pesetas*/unit for T.1, 8435 *pesetas*/unit for T.2 and 8425 *pesetas*/unit for T.3., all of which are reasonable figures considering that maximum tariffs are set at 12145 *pesetas*/unit.

Table 6. Marginal costs for company at the mean (ptas / ton))

Products	**Firms**	**Estimate** (Ptas/ton)	**t Statistic**
Containers	T.1.	744	28,05
	T.2.	735	28,07
	T.3.	757	28,97
General cargo	T.1.	1994	13,99
	T.2.	1915	13,96
	T.3.	2032	14,38
Ro-Ro cargo	T.1.	1117	3,089
	T.2.	1017	2,853
	T.3.	1053	2,91

Global and specific economies of scale
The global and specific economies of scale are calculated based on the estimated parameters; the results are displayed in table 7.

Table 7. Global and product-specifics Economies of Scale estimated in the average

Economies of scale	Estimate	t Statistic
Global	1,64	33,18
Containers	1,01	254,80
General cargo	1,00	251,87
Ro-Ro cargo	1,08	32,30

As shown in table 7, all results are statistically significant. Global economies of scale above one show that the average incremental cost for the mean decreases for proportional variations in all products. Specific economies of scale are very close to one for all three products.

The results by company are displayed in table 8, where global economies of scale for company T.3 are shown to be smaller than the other two –which feature similar values. As already explained, this is the largest terminal as well as the one with the greatest output levels; this is thus a case of exhaustion of economies of scale.

Table 8. Global economies of scale and for terminal

	Estimate	T Statistic
Mean	1.64	33.18
T.1	2.26	32.61
T.2	2.13	24.63
T.3	1.07	37.17

Economies of scope
Based on the estimated parameters, all relevant orthogonal partitions of the product vector are analyzed, *i.e.,* the mean production cost of all products by a single company is compared to the one that would apply if more companies were in charge of the production process:

* three companies: each one specializing in one product =ED;
* two companies: one specializing in containers and the other one offering the other two products= ED_C;

*	two companies: one specializing in general cargo and the other offering the other two products = ED_{MG};
*	two companies: one specializing in Ro/Ro cargo and the other one offering the other two products= ED_R.

Table 9 summarizes the results obtained. As shown in the table, all ED estimates are within the theoretically defined range (-1,1) and all of them are significant. The presence of different types of economies of scope reinforces the existence of global returns of scale growth even though the specific returns estimated by products remain almost constant, which is absolutely feasible given the relation between S, Si and ED.

The results in table 9 show that specialization is not advisable since joint production always carries savings as compared to specialized production. These savings are more noticeable where one single company offering all products, as compared to three companies specializing in one product each, where the joint production costs savings (at average values) would be as high as 78%.

Table 9. Economies of scope

	Estimate	**t Statistic**
ED	0,782	21,20
ED_C	0,387	20,95
ED_{MG}	0,393	21,37
ED_R	0,389	20,83

Also significant, even though not as much as the ones dealt with above, are the savings obtained by comparing the situation of a single company in charge of all products against two companies: one specializing in one product and the other manufacturing the remaining two, where the savings through joint production (at average values) would range between 38.7% and 39.3%, depending on each particular case.

Irrespective of the partition used, the savings obtained in these cases (ED_C, ED_{MG}, y ED_R) are highly similar. The reason behind this is that the only terms that depend upon the selected partition are the second-order terms representing the products within T and N-T and these are minor as compared to the first-order terms in the estimate arrived at.

7. Conclusions

There are three main reasons why a regulator will find it useful to know the cost structure. First, estimating marginal costs as well as global and specific economies of scale is an essential tool for tariff cap regulation since it provides the regulator with information on whether the application of tariffs to marginal costs -considering the economies of scale- is feasible.

Second, an economies of scope calculation provides the regulator with information on whether it is advisable to have the terminals diversified or whether they should be specialized instead, thus objectifying a decision which, when the right choice is made, inevitably carries costs savings.

Lastly, the capacity to measure the degree of subadditivity provides the regulator with a proper tool to decide the optimal port structure in terms of the adequate number of terminals. Basically, all concept costs defined help add to the amount of information available to the regulator and, accordingly, the regulator's knowledge of the reality to be regulated as well, properly guiding the latter in exercising its powers and defining the framework for regulatory action.[9]

As regards the first contribution made by cost models, this empirical study provides a first estimate of the main indicators that are relevant to any regulator. Basically, the marginal cost levels and their relative order confirm economic intuition. The lowest marginal costs are those for containers, as could be expected, followed by Ro/Ro cargo, with a marginal cost 1.4 times the marginal cost of the container and, lastly, further on behind, general cargo with a marginal cost 2.65 times the cost of the container (evaluated at the mean). The marginal cost estimates show the same behavior when estimated by company. In turn, the estimated global economies of scale are above one, which shows that the average incremental cost at the sample mean decreases on proportional variations for all products. Therefore, the application of tariffs at the marginal cost would not cover total costs. Since the service is provided by privately owned companies that are not subsidized, caps should be set above the marginal costs; a contrary solution would amount to admitting that the companies are operating at a loss. A comparison of these results to the caps in force during the sample period shows that the caps defined are always above the marginal cost estimates, the result thus being in line with the behavior of privately-owned companies[10].

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[9] For instance, a conclusion might be reached that the only feasible alternative is to have a single-terminal port. This would call for stricter regulation as a result of the lack of competition in the port. Conversely, where more than one terminal coexists on the market, there is less need for regulation, even though the regulator will still be required to make sure that the different terminals operating at the port will not act in collusion. The Buenos Aires port is clear evidence of the difficulties faced by regulators in designing the adequate port planning. Even though originally divided into six terminals, only three are currently in operation at the Buenos Aires port. For a more detailed explanation see *Trujillo and Serebrisky (2003)*.

[10] The presence of competition, to a certain extent, among the three terminals seems to show that no excessive profits are being obtained.

In regards to the second contribution, the estimates arrived at on economies of scope for all the relevant orthogonal partitions of the product vector lead to the conclusion that, in this particular case, specialization is not advisable. There are obvious savings as a result of joint production when compared either to the extreme case of three companies specializing in one product each or when compared against any partition into two companies (one of them a specialized company).

Lastly, the presence of economies of scale and economies of scope is not sufficient to conclude that the costs function analyzed is a subadditive one; this conclusion could not be reached based on the information available when drafting this article. In any event, results of scale and scope as a whole suggest that it is advisable to have the two smaller companies grow, still handling all three products. More conclusive results would necessitate a larger database so that all pertinent estimates for calculating this concept may be obtained. This investigation will continue to develop towards that goal.

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ANNEX 1.

Glossary of variables

Cons = Constant
Contt = Monthly movement of containers
MG = = Monthly movement of general goods
RODT = Monthly movement of ro-ro cargo
PLC = RLC Worker Price
PLE = RLE Worker Price
PI = Intermediate Consumption Price
PCANON = Total Area Price
PK = Capital Price
PNPH = Non Port Worker Price
T = Temporal Trend
CDOS = Crossing container with itself
CMG = Crossing container with general cargo
CR = Crossing container with ro-ro cargo
CPLC= Crossing container with RLC Worker Price
CPLE= Crossing container with RLE Worker Price
CPI = Crossing container with Intermediate Consumption Price
CPCANON = Crossing container with Total Area Price
CPK = Crossing container with Capital Price
CPNPH = Crossing container with Non Port Worker Price
CTE = Crossing container with Temporal Trend
MG2 = Crossing of general cargo with itself
MGR = Crossing of general cargo with ro-ro cargo
MGPLC = Crossing of general cargo with RLC Worker Price
MGPLE = Crossing of general cargo with RLE Worker Price
MGPI = Crossing of general cargo with Intermediate Consumption Price
MGPCANON = Crossing of general cargo with Total Area Price
MGPK = Crossing of general cargo with Capital Price
MGPNPH = Crossing of general cargo with Non Port Worker Price
MGT = Crossing of general cargo with Temporal Trend
R2 = Crossing of ro-ro cargo with itself
RPLC = Crossing of ro-ro cargo with RLC Worker Price
RPI = Crossing of ro-ro cargo with Intermediate Consumption Price
RPCANON = Crossing of ro-ro cargo with Total Area Price
RPK = Crossing of ro-ro cargo with Capital Price
RPNPH = Crossing of ro-ro cargo with Non Port Worker Price
RT = Crossing of ro-ro cargo with Temporal Trend
PLC2 = Crossing RLC Worker Price with itself
PLCPLE = Crossing RLC Worker Price with RLE Worker Price

PLCPI = Crossing RLC Worker Price with Intermediate Consumption Price
PLCPCANON = Crossing RLC Worker Price with Total Area Price
PLCPK = Crossing RLC Worker Price with Capital Price
PLCPNPH = Crossing RLC Worker Price with Non Port Worker Price
PLCT = Crossing RLC Worker Price with Temporal Trend
PLE2 = Crossing RLE Worker Price with itself
PLEPI = Crossing RLE Worker Price Intermediate Consumption Price
PLEPCANON = Crossing RLE Worker Price with Total Area Price
PLEPK = Crossing RLE Worker Price with Capital Price
PLEPNPH = Crossing RLE Worker Price with Non Port Worker Price
PLET = Crossing RLE Worker Price with Temporal Trend
PI2 = Crossing Intermediate Consumption Price with itself
PIPCANON = Crossing Intermediate Consumption Price with Total Area Price
PIPK = Crossing Intermediate Consumption Price with Capital Price
PIPNPH = Crossing Intermediate Consumption Price with Non Port Worker Price
PIT = Crossing Intermediate Consumption Price with Temporal Trend
PCANON2 = Crossing Total Area Price with itself
PCANONPK = Crossing Total Area Price with Capital Price
PCANONPNPH = Crossing Total Area Price with Non Port Worker Price
PCANONT = Crossing Total Area Price with Temporal Trend
PK2 = Crossing of Capital Price with itself
PKPNPH = Crossing of Capital Price with Non Port Worker Price
PKT = Crossing of Capital Price with Temporal Trend
PNPH2 = Crossing Non Port Worker Price with itself
PNPHT = Crossing Non Port Worker Price with Temporal Trend
T2 = Crossing of the Temporal Trend with itself
T.1 = Dummy for firm T.1
T.2 = Dummy for the firm T.2