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Determinants of the demand for maritime imports and exports

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Abstract

The main contribution of this research is to offer a theoretical explicative model and provide empirical evidence to the determinant variables which explain the behaviour of maritime imports and exports for a particular economy such as the Spanish one. Until now, maritime transport demand functions have been estimated without taking into account whether they referred to imports or exports. Moreover, the international trade literature has, from a theoretical point of view, formulated and estimated import and export demand functions in general without considering the mode of transport used.

JEL classification: L90; L92
Keywords: Maritime; Imports; Exports; Demand elasticities

1. Introduction

This paper provides an analysis of the determinants of Spanish maritime export and import functions, using as a reference a conventional model of international trade. The study focuses on the export and import of 'General Cargo'. The data employed are quarterly and cover the years 1975–1993.

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Traditionally, the mainstream of the literature on international trade assumes that there are no transport costs (see, for example, Houthakker and Magee, 1969; Khan, 1974; Bahmani-Oskooee and Alse, 1994; Marquez, 1994; Marquez and McNeilly, 1988). However, in our paper we include the maritime transport costs in seaborne trade as one more explanatory variable (Metaxas, 1971; Stopford, 1968).

As well as at international level, in Spain, some empirical works have been carried out on import and export functions such as those by Donges (1972), Mochón and Ancochea (1979), Bonilla (1978), Casado et al. (1982), Mauleón (1985), Marías (1987), Fernández and Sebastián (1989), García Solanes and Beyaert (1989), Sebastián (1991), Buisan and Gordo (1994), Mauleón and Sastre (1995). Nevertheless, none of these works consider maritime transport costs or attempt to estimate maritime import and export functions.

Antecedents of this paper are Coto-Millán (1986, 1988, 1991), in which aggregated maritime transport demand functions are considered from 1974 to 1983; Coto-Millán and Sarabia, 1993, in which the study above is updated from the period 1974–1992; and Coto-Millán and Baños-Pino, 1996, in which maritime transport demand functions are considered as aggregate derivative functions (i.e. imports plus exports) and national short sea shipping is excluded.

In order to estimate long-run relationship both for maritime exports and imports, we have used the Johansen multivariate cointegration technique and the most recent residual-based test for the null hypothesis of cointegration, developed by Shin.

The paper is organised as follows. In Section 2 the theoretical model is presented. Section 3 describes the data set that have been used. Section 4 discusses the empirical results. Finally, Section 5 provides our concluding remarks.

2. The model

In general terms, import functions are of the type

$$M = M\left(\frac{Y}{P}, \quad \frac{\mathrm{Pm}}{P}\right) \tag{1}$$

where the volume of imports in a particular country (M) depends on its monetary income (Y), the prices of imports (Pm) and the prices of domestic goods (P). The volume of imports is generally expressed in physical or real units obtained from the quotients of the monetary value by their prices. However, the prices of imports are approximated from the so-called unit value indexes, which undoubtedly present errors. One of the original findings of this work is that the use of it eliminates these errors since the physical or real units of the import and export goods are available.

Eq. (1) can be written as:

$$M = M(y, e') \quad \text{where } \frac{Y}{P} = y \quad \text{and} \quad \frac{\mathrm{Pm}}{P} = e' \tag{2}$$

where e' is the relative import price and where the expected signs are

$$\frac{\partial M}{\partial y} > 0, \quad \frac{\partial M}{\partial e'} < 0$$

The volume of maritime imports (MT) will depend on the total volume of imports (M), and on the following factors which determine competitiveness of one mode of transport compared to others, such as the prices of maritime transport services (MP), the prices of road transport services (RP), the price of rail transport services (RAP) and the distance of travel (DT). Thus:

$$\mathrm{MT} = \mathrm{MT}(M, \mathrm{MP},\ \mathrm{RP},\ \mathrm{RAP},\ \mathrm{DT}) \tag{3}$$

where it is expected that

$$\frac{\partial \mathrm{MT}}{\partial M} > 0, \quad \frac{\partial \mathrm{MT}}{\partial \mathrm{MP}} < 0, \quad \frac{\partial \mathrm{MT}}{\partial \mathrm{RP}} > 0, \quad \frac{\partial \mathrm{MT}}{\partial \mathrm{RAP}} > 0, \quad \frac{\partial \mathrm{MT}}{\partial \mathrm{DT}} > 0$$

Using expressions (2) and (3), now it is possible to write

$$\mathrm{MT} = \mathrm{MT}[M(y, e'), \mathrm{MP}; \mathrm{RP}, \mathrm{RAP}, \mathrm{DT}]$$

or

$$\mathrm{MT} = \phi(y, e', \mathrm{MP}, \mathrm{RP}, \mathrm{RAP}, \mathrm{DT}) \tag{4}$$

where the following signs are expected:

$$\frac{\partial \mathrm{MT}}{\partial y} > 0, \quad \frac{\partial \mathrm{MT}}{\partial e'} < 0, \quad \frac{\partial \mathrm{MT}}{\partial \mathrm{MP}} < 0, \quad \frac{\partial \mathrm{MT}}{\partial \mathrm{RP}} > 0, \quad \frac{\partial \mathrm{MT}}{\partial \mathrm{RAP}} > 0, \quad \frac{\partial \mathrm{MT}}{\partial \mathrm{DT}} > 0$$

In order to derive export functions, there are three approaches: the demand, supply and mixed approaches. In the demand approach, the export volume of a country (X) [1] is a function of world (or foreign) income expressed in real terms (y^*), and of the relative exports price (e^*, where $e^* = \mathrm{Px}/P^*$, Px representing the prices of the exported goods and P^* representing world prices). So, the export function can be expressed as:

$$X = X(y^*, e^*) \tag{5}$$

where the expected signs are

$$\frac{\partial X}{\partial y^*} > 0, \quad \frac{\partial X}{\partial e^*} < 0$$

In the supply approach, it is assumed that exports are really what remains when the goods aimed to supply the national market are deducted from total production. If we assume once again that the country considered is small and that international demand is perfectly elastic, then exports (X) depend on the total national production of the country (y) in real terms, an index of the use of the productive capacity (UTIC) and of the relative exports price (e^*). Accordingly

$$X = X(y, \mathrm{UTIC}, e^*) \tag{6}$$

where the following signs are expected

$$\frac{\partial X}{\partial y} > 0, \quad \frac{\partial X}{\partial \mathrm{UTIC}} < 0, \quad \frac{\partial X}{\partial e^*} < 0$$

[1] The volume of exports is generally expressed in physical or real units obtained as in the case of imports. In this case the prices of exports are approximated from the unit value indexes, which once again present errors.

The mixed approach consists of combining Eqs. (5) and (6), avoiding the extreme cases of the demand and supply approaches. The mixed approach has been used for several countries of the European Union (former EC). In this case, the most realistic supply variable is UTIC and, therefore, a mixed approach of the following type is proposed:

$$X = X(y^*, e^*, \mathrm{UTIC}) \tag{7}$$

where the expected signs are

$$\frac{\partial X}{\partial y^*} > 0, \quad \frac{\partial X}{\partial \mathrm{UTIC}} < 0, \quad \frac{\partial X}{\partial e^*} < 0$$

Once again, maritime export transport services (XT) depend on total exports (X), and freight rates of maritime transport versus other modes of transportation and distance of travel. Therefore, it is possible to write

$$\mathrm{XT} = \mathrm{XT}(X, \mathrm{MP},\ \mathrm{RP},\ \mathrm{RAP},\ \mathrm{DT}) \tag{8}$$

Using both (7) and (8), we have that

$$\mathrm{XT} = \mathrm{XT}[X(y^*, e^*, \mathrm{UTIC}), \mathrm{MP}, \mathrm{RP}, \mathrm{RAP}, \mathrm{DT}]$$

or

$$\mathrm{XT} = \psi(y^*, e^*, \mathrm{UTIC}, \mathrm{MP}, \mathrm{RP}, \mathrm{RAP}, \mathrm{DT}) \tag{9}$$

where

$$\frac{\partial \mathrm{XT}}{\partial y^*} > 0, \quad \frac{\partial \mathrm{XT}}{\partial \mathrm{UTIC}} < 0, \quad \frac{\partial \mathrm{XT}}{\partial e^*} < 0, \quad \frac{\partial \mathrm{XT}}{\partial \mathrm{MP}} < 0, \quad \frac{\partial \mathrm{XT}}{\partial \mathrm{RP}} > 0, \quad \frac{\partial \mathrm{XT}}{\partial \mathrm{RAP}} > 0, \quad \frac{\partial \mathrm{XT}}{\partial \mathrm{DT}} > 0$$

Then, it is suggested that Eqs. (4) and (9) are assumed to be as more complete versions of (2) and (5) under a functional approach of exports and imports of maritime transport services. In our case, we adopt a particular functional expression assuming that Eqs. (4) and (9) are linear in logs. [2] Thus, the equations to be actually estimated are [3]

$$\mathrm{LMT} = \beta_0 + \beta_1 \mathrm{L}y + \beta_2 \mathrm{L}e' + \beta_3 \mathrm{LMP} + \beta_4 \mathrm{LRP} + \beta_5 \mathrm{LRAP} + \beta_6 \mathrm{LDT} + u_1 \tag{10}$$

$$\mathrm{LXT} = \alpha_0 + \alpha_1 \mathrm{L}y^* + \alpha_2 \mathrm{L}e^* + \alpha_3 \mathrm{LUTIC} + \alpha_4 \mathrm{LMP} + \alpha_5 \mathrm{LRP} + \alpha_6 \mathrm{LRAP} + \alpha_7 \mathrm{LDT} + u_2 \tag{11}$$

3. The data

Data on Spanish maritime import and export transport series refer to loaded and unloaded goods (in tons) respectively, in international navigation. Such amount of goods in tons

[2] The variables are preceded by L, which means in logarithmic.

[3] These functions present many econometric problems and there is no solution for all of them at the same time. Although we employ here the latest and most modern cointegration techniques and the most robust tests, there is no doubt that there are some aggregation problems in data, simultaneity, possible errors of calculation in the observations, etc.

corresponds to the so called international maritime trade in the main Spanish ports. [4] We have also considered the rest of the Spanish commercial ports, not included in this list and being part of a group of the Comisión Administrativa de Grupo de Puertos (CAGP). The data available have made possible the following disaggregation of goods transported into three groups: 'Dry Bulk', 'Oil and Oil-products' and 'General Cargo'. The group chosen was 'General Cargo' since this sector has worked with little or no regulation of prices and services in relation to maritime transport. Therefore, MT and XT account for the million of quarterly maritime import and export tons of 'General Cargo' in Spanish economy.

Data on the Spanish real gross domestic product, y, have been obtained from Banco de España and Contabilidad Nacional Española (Bank of Spain and Spanish National Accounts).

With regard to the maritime transport service prices, MP, the average of two variables has been considered:

(a) The international dry cargo tramp time charter freight index which corresponds to the prices of the ships hired for a definite period of time and refers to further trips made both on regular lines and in 'tramp' navigation. This index, represented by FPT, has been obtained from the Norwegian Shipping News (Oslo).
(b) The dry cargo tramp trip charter freight, FPV, obtained from the General Council of British Shipping (London). Trip freight refers to the prices of hiring ships for a particular trip.

It would have been interesting to include another variable which accounted for the price of other means of transport, but the lack of reliable statistics forced us to abandon that idea. [5] As an alternative, we decided to work out dummy variables in order to capture the change observed in the modes of transport after Spain's integration into the EU. The increase in the Spanish exports to the EU has led to a considerable increase in road and railway transport from Spain to the EU with the subsequent decrease in the use of maritime transport in exports. Thus, according to data on Table 1, Spanish maritime exports to the EU countries decreased in the 1986–1993 period. Moreover, in the same period, Spanish maritime exports to other countries underwent also a slightly decrease—especially the exports to the USA, OPEC and Latin-American countries—while road and railway exports to these countries clearly increased. Spanish maritime imports from the EU underwent a decrease in their volume in the period studied from Spain's integration into the EU, for the same reasons as exports did, while imports from other countries kept on increasing in the same period.

Hence, the dummy variable which we have constructed (w) in order to obtain the substitution of maritime exports for those by land, since Spain's accession to the EU, follows the proposal carried out by Hendry and Ericsson (1991). Thus, w_t is the weighting function representing Spanish exporters' learning to the new situation.

[4] Algeciras-La Línea, Alicante, Almería, Avilés, Barcelona, Bilbao, Cádiz, Cartagena, Castellón, Ceuta, El Ferrol, Gijón, Huelva, La Coruña, La Luz and Las Palmas, Málaga, Melilla, Palma de Mallorca, Pasajes, Pontevedra, Puerto de Santa María, San Esteban de Pravia, Santa Cruz de Tenerife, Santander, Seville, Tarragona, Valencia, Vigo and Villagarcía de Arosa.

[5] The only proxy we have been able to include has been the average price of petroleum imported by the OECD countries, however, the results have proved unsatisfactory.

Table 1
Total imports and exports by groups of countries in thousands of tons

Years	1975	1980	1983	1985	1986	1988	1990	1993
Maritime exports to the EU	5089	13 215	17 929	19 574	18 957	17 849	18 965	15 319
Maritime exports to other countries	11 348	17 517	24 759	27 030	26 304	24 381	21 147	28 257
Worldwide road and railway exports	4094	5969	8274	9269	11 002	13 077	16 253	27 406
Maritime imports from the EU	22 313	18 045	16 965	17 112	16 603	15 984	18 965	19 620
Maritime imports from other countries	109 071	88 212	82 931	83 651	84 230	92 244	112 270	148 984
Worldwide road and railway imports	2958	5302	6560	7136	9314	13 682	18 065	18 335

Source: Annual Reports of Ports General Management (State Department) and Ministry of Transport.

$w_t = \{1 + \exp[k_0 - k_1(t - t_0 + 1)]\}^{-1}$ for $t = t_0$ and zero otherwise, meaning the first quarter of 1986, where t is time, t^* is the date of Spain's accession to the European Community, 1986.I, and k_0 and k_1 correspond to initial knowledge and rate of learning, respectively. We set $k_0 = 2$ and $k_1 = 1.3$, implying $w_t = 0.99$ after 3 years. Consequently, in the case of maritime exports function, in addition to the maritime transport service price, MP, we have included the following variable, which—*ceteris paribus*—results in a greater own-price elasticity instead of an intercept shift: $\mathrm{MP}^M = \mathrm{MP}\,w$.

With respect to the imports, the dummy generated (D86) is simpler, and it is based on Winters (1984) and it implies a slower adjustment. It is zero until 1986.I, when its value progressively increases in function with the number of communitary authorisations for international goods transport of land characteristics, so that it takes the annual data 0.11, 0.16, 0.23, 0.36, 0.51 and 0.71 from 1987 to 1992. Finally, it takes the value 1 for 1993. The justification of these values is as follows: value 0 from 1975 to 1986 because the maritime sector is totally regulated; values between 0 and 1 (Winters, 1984 procedure), while regulation is disappearing; and value 1 with total liberalisation of the sector.

Hence, we have added to MP the following variable which conveys the change in the slope of the maritime import function: $\mathrm{MP}^X = \mathrm{MP}$ D86.

A different dummy variable generated for imports is D89.IV. This variable takes the value 1 in the first quarter of 1989 and 0 in the rest, and accounts for the positive effect of the impact of monetary aids supplied to shipping companies by Spanish Administration for imports.

The data for e' have been obtained as the quotient of the Spanish unit value index of finished industrial non-energy goods imports (provided by the Dirección General de Política Comunitaria (DGPC)), and the Spanish non-energy industrial price index (provided by the Instituto Nacional de Estadística).

The data for e^* have been obtained as the quotient of the unit value index of Spanish non-energy industrial goods exports (provided by the above-mentioned DGPC), and the industrial price index of developed countries (provided by the OECD Economic Outlook).

As indicator of world income y^* we have used the index of the world income (series obtained from International Monetary Fund). For the UTIC variable we have used the index of the utilisation degree of the productive capacity of national business in the last three months (obtained from the OECD Main Economic Indicators).

4. Empirical results

The cointegration techniques provide a suitable framework for checking the existence of a long-run relation among the variables of our model. But beforehand we must study the stationarity properties of the data. The variables which have been considered are the following:

- LXT: Log of export 'General Cargo' in tons.
- LMT: Log of import 'General Cargo' in tons.
- Ly: Log of gross domestic product in real terms.
- LMP: Log of maritime transport service price.
- Le': Log of relative Spanish imports price of finished non-energy industrial goods.
- Le^{*}: Log of relative Spanish exports price of non-energy industrial goods.
- Ly^{*}: Log of world income.
- LUTIC: Log of utilisation degree of the productive capacity of Spanish business.

To the previous eight variables, we must add the variables w, MP^{M}, D86, MP^{X} and D89.IV defined as it was done in the previous section.

All variables (except dummy variables) are in logarithmic form and seasonally adjusted.

Given that the test to check that the variables possess a unit root or are stationary, suffer from low power and size distortions, a combination of stationarity procedures were used. To begin with we used the Phillips and Perron (1988) test, a non-parametric correction of the standard tests of Dickey and Fuller, being the null hypothesis that the variable has a unit root. In order to compliment this procedure, we have employed the test developed by Kwiatkowski et al. (1992), which proposes a Lagrange multiplier (LM) statistic to test the null of stationarity. The results of both tests, for the first difference and the levels of the variables, are presented in Table 2, where it is shown that all variables included in Eqs. (10) and (11) are I(1) or stationary in first differences, except LMT [I(0)] and Ly[I(2)] when Phillips–Perron test is applied.

Then, we must take into consideration the case that these series may be stationary around a structural break. In this way we apply the Perron (1989) innovational outlier model C to test whether a structural break has occurred in the Spanish maritime imports (and exports), since Spain's accession to the European Community in 1986. According to Perron, we consider the regression equation:

$$y_t = \mu + \theta DU_t + \beta t + \gamma DT_t^{*} + \delta D(TB)_t + \alpha y_{t-1} + \sum_{i=1}^{\infty} c_i \Delta y_{t-i} + \varepsilon_t \tag{12}$$

where $DU_t = 1$, $DT*_t = t - T_b$ if $t > T_b$ and 0 otherwise; $T_b = 1$ in 1986.I and 0 in the remainder; and $D(TB)_t = 1$ if $t = T_b + 1$ and zero in the rest. The null hypothesis imposes the following restrictions on the coefficients: $\alpha = 1$, $\beta = \gamma = 0$ and $\delta \neq 0$. Under the alternative hypothesis, we have $|\alpha| < 1$ and $\delta = 0$. The results are reported in Table 2, and the hypothesis of a unit root cannot be rejected for LMT (and LXT).

In the case of Ly_t, as Andrés et al. (1990) suggest, it is possible to consider the existence of segmented trends. In this way, if three segments are being taken (two breaks in 1985.II and 1991.II), it cannot be accepted—see Table 2—that Ly_t is I(2).

Table 2
Tests for orders of integration

Series	Unit root tests				
	PP		KPSS		Conclusion
	$Z(\Phi_3)$	$Z(t\tilde{\alpha})$	η_μ	η_τ	
Finite differences					
LMT	82.39*	−14.18*	0.04	0.03	I(0)
Ly*	28.73*	−7.58*	0.12	0.08	I(0)
LMP	31.98*	−8.03*	0.09	0.06	I(0)
LMP^M = LMP w	7.56*	−3.97*	0.18	0.13	I(0)
Le'	19.97*	−6.43*	0.16	0.10	I(0)
LUTIC	56.08*	−10.50*	0.28	0.11	I(0)
LXT	65.20*	−11.74*	0.10	0.09	I(0)
Ly	2.25	−2.16	0.23	0.17	I(0) or I(1)
Le*	44.72*	−9.41*	0.08	0.09	I(0)
LMP^X = LMP D86	57.71*	−11.07*	0.71	0.07	I(0)

Series	PP						KPSS		Conclusion
	$Z(\Phi_3)$	$Z(t\tilde{\alpha})$	$Z(t\tilde{\beta})$	$Z(\Phi_2)$	$Z(t\alpha*)$	$Z(t\mu*)$	η_μ	η_τ	
Levels									
LMT	6.83*	−3.67*	3.68*	4.83	−1.77	1.80	2.26*	0.18*	I(1) or I(0)
Ly*	2.00	−1.96	1.87	7.09	−0.75	1.57	2.52*	0.23*	I(1)
LMP	1.75	−1.86	0.92	1.31	−1.64	1.68	0.92*	0.16*	I(1)
LMP$^{\mathrm{M}}$	1.41	−1.58	1.67	1.95	−0.27	1.48	2.11*	0.31*	I(1)
Le'	0.86	−1.30	−0.17	0.61	−1.31	−1.32	0.47*	0.39*	I(1)
LUTIC	1.59	−0.66	3.70*	1.66	−0.54	0.55	0.98*	0.42*	I(1)
LXT	5.13	−3.20	0.66	3.82	−2.73	2.74*	1.09*	0.31*	I(1)
Ly	0.92	−1.09	1.90	16.80*	0.46	−0.36	2.43*	0.23*	I(1)
Le*	1.83	−1.90	−1.03	1.59	−1.58	0.01	1.22*	0.54*	I(1)
LMP^X	4.36	−0.48	2.10	5.55*	2.01	1.23	1.82*	0.61*	I(1)

Unit root test under a structural change

Series	t_α
LMT	−2.0850
LXT	−3.3872

Unit root test under two structural changes

Series	t'_α
ΔLy	−5.1432
Ly	−3.6641

Notes: *Significance at the 5% level.
$Z(\Phi_3)$, $Z(t\tilde{\alpha})$, $Z(t\tilde{\beta})$, $Z(\Phi_2)$, $Z(t\alpha^*)$, and $Z(t\mu^*)$ are the Phillips–Perron tests for the null of non-stationarity (see Perron (1988)).
η_μ and η_τ denote the Kwiatkowski et al. (1992) tests for the null of stationarity, when only a constant and a trend, respectively, appear.
Critical value for t_α at the 5% significance level is −4.24 (Perron, 1989, Table VI.B). Critical value for $t_{\alpha'}$ at the 5% significance level is −4.76 (Rappoport and Reichlin, 1989).

As far as this demand function estimation is concerned, two different problems arise. Firstly, the econometric problem of identification, taking into account that not only supply but also demand usually develop simultaneously through time, as a response to very similar variables. As regards the group of services studied here, supply comes from both Spanish and the international fleet, the latter being higher than Spanish supply. This fact means that Spanish supply exerts an insignificant influence over world prices. Since the international sector is extremely competitive, international freight can been considered as a parameter. The second problem is Spanish regulation, which can be considered as virtually non-existent. That is to say, freights are essentially international.

In order to test for cointegration, the Johansen (1988) and Johansen and Juselius (1990) multivariate procedure was employed. Johansen and Juselius develop a maximum likelihood estimation technique that has several advantages over other procedures such as the suggested by Engle and Granger (1987), because it eliminates the assumption that the cointegration vector is unique and it takes into account the error structure of the underlying process. In this way, the Johansen approach is able, not only to determine if a stable relationship exists between the variables of the model shown in Section 2, but also to test the number of cointegration vectors.

Formally, Johansen considers the p-dimensional VAR representation of x_t with Gaussian errors:

$$x_t = \sum_{i=1}^{k} \Pi_i x_{t-i} + \varepsilon_t, \quad t = 1, \ldots, T \tag{13}$$

where x_t is a $p \times 1$ vector of stochastic variables, assuming that all the x_t are at most I(1), and $\varepsilon_t \sim$ NI $(0, \Omega)$. Following from the Granger representation theorem (Engle and Granger, 1987), under the hypothesis of cointegration the VAR model can be reparametrised in equivalent error-correction form:

$$\Delta x_t = \Gamma_1 \Delta x_{t-1} + \Gamma_2 \Delta x_{t-2} + \cdots + \Gamma_{k-1} \Delta x_{t-k+1} + \Pi x_{t-1} + \varepsilon_t \tag{14}$$

The $p \times p$ matrix Π, which conveys the information about the long-term behaviour of the VAR, is the main object of our analysis. In fact, the cointegration hypothesis is formulated as restrictions on the rank of the Π-matrix. Under the null hypothesis of no-cointegration, the rank of Π is equal to zero, and under the alternative hypothesis of r cointegrating relationships, the rank of Π is r, which implies that the process Δx_t is stationary, x_t is non-stationary, but there exist r linear combinations of x_{t-k} ($\beta' x_{t-k}$) which are stationary. The matrix Π can be decomposed as $\Pi = \alpha\beta'$, where the $p \times r$ matrices α and β contain the weights with which the cointegrating relationship enter each of the equations of the VAR system and the cointegrating vectors, respectively.

The term $\beta' x_{t-1}$ is the error-correction mechanism (ECM) and it can be interpreted as the long-term static equilibrium of the system. To test the null hypothesis of at most r cointegrating vectors, Johansen (1988) proposed the trace and the maximal eigenvalue statistics. The critical value for these tests has been generated by simulation by Osterwald-Lenum (1992). In this paper, the appropriate lag length of the VAR model is based on the Schwarz criterion, in order to ensure Gaussian error terms in the vector error-correction model. Also, a small sample adjustment, as suggested by Reimers (1992), has been made in all the likelihood ratio statistics.

Although it would be better to use Johansen's procedure for all the variables involved in the system of import–export demand equations to determine cointegration relationships, however a drawback of the analysis of the multivariate cointegration model is that the difficulties of interpreting the cointegration space grow when more variables are added to the VAR system. Thus, in practice we used the Johansen technique separately in each equation, for import and export.

The results obtained from applying the Johansen methodology to the functions (10) and (11) are given in Tables 3 and 4, respectively. The trace statistics test the null that the number of cointegrating vectors is less or equal to p, $r = p(p = 1, 2, \ldots, n-1)$, against the general alternative. The maximal eigenvalue test (λ-max) is similar, except that the alternative hypothesis is explicit ($r = n$). The λ-max statistics associated with the null hypothesis that $r = 0$ are rejected but the null that $r = 1$ is not rejected (the calculated values of 21.34 and 30.71 are less than the 95% critical value of 28.14 and 34.40, respectively). The results of the trace test confirm that one can accept the hypothesis that there is at most one cointegrating vector for both equations, in respect of the set of variables specified.

According to the above results, the estimated cointegrating vector for Spanish 'General Cargo' maritime import, with the coefficient of LMT_t normalised to be unity and with with t-values in parentheses is:

Table 3
Test for cointegrating vectors ('General Cargo' maritime import)

		Maximal eigenvalue		Eigenvalue trace	
Null hypothesis $H_0{:}r$	Alternative $n-r$	Statistic	195% critical value	Statistic	95% critical value
0	5	34.91*	34.40	85.51*	76.07
1	4	21.43	28.14	52.89	53.12
2	3	18.11	22.00	32.74	34.91
3	2	12.47	15.67	15.49	19.96
4	1	3.41	9.24	3.41	9.24

Johansen ML procedure (intercepts in the cointegration relations and VAR of order 1).
Notes: r = number of cointegrating vector under the null hypothesis.
*Significant at the 5% level. Critical values are taken from Osterwald-Lenum (1992, Table 1).

Table 4
Tests for cointegrating vectors ('General Cargo' maritime export)

		Maximal eigenvalue		Eigenvalue trace	
Null hypothesis $H_0{:}r$	Alternative $n-r$	Statistic	95% critical value	Statistic	95% critical value
0	6	41.35*	40.30	121.24*	102.14
1	5	30.71	34.40	72.59	76.07
2	4	19.28	28.14	36.24	53.12
3	3	5.97	22.00	14.72	34.91
4	2	4.67	15.67	8.19	19.96
5	1	3.14	9.24	3.14	9.24

Johansen ML procedure (intercepts in the cointegration relations and VAR of order 3).
Notes: r = number of cointegrating vector under the null hypothesis.
*Significant at the 5% level. Critical values are taken from Osterwald-Lenum (1992, Table 1).

Table 5
The likelihood ratio statistics for testing weak exogeneity of each of the variables

Import equation	Ly	Le^1	LMP	LMP^M	
	0.62	0.45	0.68	0.64	
Export equation	Ly^*	Le^2	LMP	LMP^X	LUTIC
	1.57	1.36	1.61	2.97	0.65

Note: The asymmptotic distribution is $\chi^2(1)$, for which the 95% quantile is 3.84.

$$\mathrm{LMT}_t = \underset{(-6.7432)}{-12.0703} + \underset{(10.861)}{2.2591}\ \mathrm{L}y_t - \underset{(-1.861)}{0.4055}\ \mathrm{L}e^1_t - \underset{(-2.1097)}{0.0654}\ \mathrm{LMP}_t - \underset{(-2.3421)}{0.0445}\ \mathrm{LMP}^M_t \tag{15}$$

The results obtained are consistent with those in Eq. (11) and do not present many contradictions.

In the case of Spanish 'General Cargo' maritime export, the estimated long-run relationship (with t-values in parentheses) is:

$$\mathrm{LXT}_t = \underset{(7.3715)}{12.9224} + \underset{(6.2171)}{0.8022}\ \mathrm{L}y^*_t - \underset{(-2.5071)}{0.2106}\ \mathrm{L}e^2_t - \underset{(-2.9112)}{0.1834}\ \mathrm{LMP}_t - \underset{(-5.3769)}{0.0699}\ \mathrm{LMP}^X_t - \underset{(-11.3992)}{1.3139}\ \mathrm{LUTIC}_t \tag{16}$$

These results also correspond to those obtained for long-run in Eq. (11). [6]

Having estimated and established the number of the long-run relationship, the next stage would be to obtain the dynamic model estimating the short-run VAR in error-correction form. That is to say, the previous Eq. (14) describes a generally formulated reduced-form model in which the short-run dynamics, given by $\Gamma_1, \Gamma_2, \ldots, \Gamma_{K-1}$ are likely to be heavily over parameterised. The estimates of these matrices Γ are important, since they explain the variation in x_t related to the short-run. In this sense, the ECM approach does not impose that all the terms of Γ should be other than zero, and this is particularly important when the short-run effects are different from the long-run effects. For this purpose, the systems estimated with Johansen's techniques could be tested for weak exogeneity (see Johansen and Juselius, 1990). In Table 5 we have calculated the statistic to test the weak exogeneity of each of the variables Ly, Le^1, LMP, LMP^M and Ly^*, Le^2, LMP, LMP^X, LUTIC for the import and export equations, respectively. These tests are clearly not significant, and show that the single equation dynamic model for the import and export functions can be efficient.

Besides, in order to study the behaviour of the 'General Cargo' maritime import and export functions in the short-run and obtain more robust estimates of the diverse elasticities, we must take into account the cross-equation correlations between the residuals of the given equations. Thus we proceeded to estimate the system using a SURE method.

The derived preferred dynamic error correction specification for 'General Cargo' maritime import is illustrated in Table 6.

[6] Cointegration results are confirmed using the Shin (1994) approach, a residual-based test of the null of cointegration against the alternative of no cointegration. All the coefficients estimated with this methodology for the variables in Eqs. (10) and (11) are significant and very similar to those obtained by the Johansen technique. These results are available on request.

Table 6
Short-run dynamic model for 'General Cargo' maritime import

$$\Delta \mathrm{LMT}_t = -\underset{(-6.6964)^{**}}{0.7024}[\mathrm{LMT}_{t-1} - \underset{(-5.7066)^{**}}{11.6807} - \underset{(-8.9302)^{**}}{2.2253}\ \mathrm{L}y_{t-1} + \underset{(2.9725)^{**}}{0.5181}\ \mathrm{L}e^1_{t-1} + \underset{(2.0424)^{*}}{0.1464}(0.7\ \mathrm{LMP}_{t-1} + 0.3\ \mathrm{LMP}^M_{t-1})] + \underset{(2.1413)^{*}}{4.9032}\ \Delta \mathrm{L}y_t$$

Diagnostics: R^2 adjusted = 0.59; SE = 0.07; DW = 1.95;
NORM χ^2 (2) = 1.83; AR 1-5 = 0.51 [0.76]; ARCH 4 = 1.04 [0.38]

Notes: Significant levels for rejecting the null hypothesis are given in [] brackets. The numbers in parentheses beneath the coefficient estimates are the values of t ratios, where * denotes statistical significance at the 5% level and ** indicates statistical significance at the 1% level.

In this equation, none of the diagnostic tests reported are significant at the 95% critical value (the Durbin–Watson test for first-order autocorrelation, the univariate test for normality, a Breusch–Godfrey LM test for serial autocorrelation up to the fifth lag, and the ARCH test for autoregressive conditional heteroskdasticity).The coefficients of the variables in levels of this model represent long-run elasticities, whereas the coefficients on the rate of change variables are short-run elasticities. The elasticity values are in accordance with the literature and the variables signs are as expected. The coefficient of the ECM term shows that the system corrects its last-period disequilibrium by 70% a quarter. We can also observe a positive effect of the impact of monetary aids to shipping companies, from the Dirección General de la Marina Mercante (General Management of the Merchant Navy) and the Sociedad Estatal de Planes de Viabilidad (State Corporation for Viability Programmes), on EC maritime imports for the fourth term in 1989. These aids consisted on subsidies to explotation for companies with Viability Plans. Such aids probably resulted in particular falls in prices of maritime transport services during that term. However, the decrease and subsequent disappearance of the monetary aids have not altered import behaviour.

The final preferred dynamic model for 'General Cargo' maritime export is given in Table 7.

From the diagnostic statistics, the residual of the estimated equation appears to be white noise and homocedastic. It can be observed that the significant variables correspond to the expression derived from the model proposed in Section 2. The coefficient on the disequilibrium error implies

Table 7
Short-run dynamic model for 'General Cargo' maritime export

$$\Delta \mathrm{LXT}_t = -\underset{(-6.9189)^{**}}{0.7520}[\mathrm{LXT}_{t-1} - \underset{(-7.3952)^{**}}{12.1159} - \underset{(-3.1397)^{**}}{0.4758}\ \mathrm{L}y^*_{t-1} + \underset{(3.0819)^{**}}{0.2608}\ \mathrm{L}e^2_{t-1} + \underset{(2.6351)^{*}}{0.0742}(0.6\ \mathrm{LMP}_{t-1} + 0.4\ \mathrm{LMP}^x_{t-1}) + \underset{(3.5294)^{**}}{1.2581}\ \mathrm{LUTIC}_{t-1}] + \underset{(6.1811)^{**}}{0.3846}\ \Delta \mathrm{LMT}_t - \underset{(-3.2860)^{**}}{0.4115}\ \Delta \mathrm{L}e^2_t - \underset{(-2.6227)^{*}}{1.635}\ \Delta \mathrm{LUTIC}_t - \underset{(3.4451)^{**}}{0.1734}\ \Delta(0.4\ \mathrm{LMP}_t + 0.6\ \mathrm{LMP}^x_t)$$

Diagnostics: R^2 adjusted = 0.65; SE = 0.055; DW = 1.91;
NORM χ^2 (2) = 2.47; AR 1-5 = 1.29 [0.28]; ARCH 4 = 0.77 [0.54]

Notes: See Table 6.

Table 8
Income, price and cross elasticities of the sea transport demand

Variables	Long-run			Short-run		
	Income	Maritime prices	Good prices	Income	Maritime price	Goods prices
"General Cargo" exports	From 0.65[I] to 0.80	From −0.10[III] to −0.25	From −0.16 to −0.21	–	−0.16	−0.33
"General Cargo" imports	From 2.22 to 2.42	From −0.10[IV] to −0.14	From −0.40 to −0.52	5.49	−0.12	−0.43
Exports[II] (non-energy)	2.00[I]	−0.19[V]	−0.60	2.18	−0.16	−0.46
Imports[II] (non-energy)	1.66	−0.33[V]	−1.50	2.97	−0.10	−0.55

Notes: (I) Range of values for product elasticity with respect to world income.
(II) Mean value of the studies in the Spanish literature mentioned in this research.
(III) Range referred to the end of the sample. From −0.04 to 0.18 until 1986.
(IV) Range referred to the end of the sample. From −0.06 to 0.13 until 1986.
(V) Naturally, both maritime price elasticities cannot be compared with the results of other studies either in Spanish or in international literature in imports and exports, just because they do not exit; however, the results obtained here are similar to those of the studies made in Spanish maritime transport (also mentioned above), with mean values represented here with this symbol.

that 75% of any quarter is made up within the next quarter. The inelastic values of the MP variable at long and short-run were expected due to the low effect of freight variation on demand. The reason for this is that the price of transport services ranges from just 5–10% with respect to the goods transported. All variable signs are as expected, the elasticity variables are appropriate and according to previous studies. Besides we notice a structural change in the short-run price elasticity of the maritime transport services from 1986 (its value changes from 0.06 in 1986 to 0.16 in 1989).

A summary of the most remarkable results appears on Table 8.

This table shows that price and income elasticities have the expected signs and values. A more detailed explanation of these results can be found in the next section.

5. Conclusions

The main contribution of this paper is to offer a theoretical explicative model and provide empirical evidence to the determinant variables which explain the behaviour of maritime imports and exports for a particular economy.

In this work we have analysed the main factors which influence the evolution of the Spanish international maritime trade of General Cargo. To do that we have estimated maritime import and export functions with quarterly data for the period 1975.I–1993.IV.

We have applied the Johansen and Juselius multivariate techniques of cointegration in order to examine the relationship, in the long-run, between maritime exports and imports and diverse macroeconomic variables. We also highlight the significant explanatory power of the prices of maritime transport services, whose elasticity increases in time after the period of Spain's accession to the EU. Following this we applied the techniques of cointegration of Shin, obtaining similar results to the previous ones. Finally, we have specified a dynamic model for both functions.

The most remarkable results, recorded in Table 8, are the following:

- According to the empirical evidence obtained in this study, the determinants of Spanish maritime imports are national income, prices of imports and of maritime transport services.
- In a similar way, the determinants of Spanish maritime exports are world income, prices of exports and maritime transport services, and the utilisation degree of the productive capacity of Spanish business.
- Price elasticities of import and export goods transported in the long- and short-run are all lower than the unit. Those relative to exports being lower than the ones for imports.
- Price elasticities of the maritime transport services of imports and exports in the long- and short-run are all less than unity and are all lower than the price elasticities of the goods transported in the long- and short-run.
- Income elasticities of maritime imports are higher than the unit both in the short- and long-run, while those corresponding to exports are less than unity for long-run and insignificant for short-run.
- There is evidence in this work of the hypothesis of a structural change in Spanish maritime exports and imports due to the Spanish adhesion to the European Community.
- The results obtained for import estimations are similar to those obtained in other studies. However, as regards exports the following differences are observed:
  - the long-run income elasticity of exports is higher (2.00) in other studies than that corresponding to exports here (from 0.65 to 0.80);
  - the short-run income elasticity of exports is significant and high (2.18) in different studies, while it is not significant in the present study.

Such differences may be due to the measurement errors with which the series of the volume of exports is estimated from the unit value indexes, this series being annual in general; these errors are avoided in our procedure. However, making a whole assessment of the different values for import and export elasticities by using both procedures, we must say that the differences are not very important.

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