DETERMINANTS OF CONTAINER PORT CHOICE IN SPAIN

Abstract

For the economic and financial evaluation of port investment projects it is important to know the demand function of a port’s services. The objective of this study is to establish such a demand choice function for the Spanish container port services. The function is derived from the coefficients of a port choice model, for which a Multinomial Logit Model is used and of which the coefficients are estimated with regression analysis. The variables tested concern inland transport cost, ocean transport costs and broad proxy variables for quality of service. Information on container import and export flows for 2007 is from the Spanish Treasury Department.

The linear regression analysis is based on differences of utilities of alternative routings of containerised cargoes compared to those routed via the Port of Valencia. The obtained results are satisfactorily in terms of model fit. The estimated coefficients can be used to assess the impact of changes in costs of container flows routed via a port on a port’s market share. A demand choice function for the port can be derived by systematically doing so. An example is presented for the port of Valencia.

Keywords: container port competition, logit model, aggregated data, Spain

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1. INTRODUCTION

For the economic and financial evaluation of port investment projects it is important to understand the relations between port demand and the price of using a port. That is, the demand choice function of a port's services needs to be known. The objective of the study is to establish such a demand function for Spanish container port services, which is derived from the container flows routed through Spanish seaports in combination with coefficients of a Multinomial Logit model (logit model).

Choice between transport options receives a great amount of attention in particular with respect to surface transport and subsequent research has lead to an extensive development of models, of related practical applications and commercial software. Research in the maritime field started later.

Research on demand choice involving maritime transport and based on revealed preference data started with modal split studies, such as by (Winston, 1981), where maritime transport was part of a logistic chain. The focus on port choice started with (Malchow and Kanafani 2001), who tested the factors determining port choice in the US by applying a multi-nomial logit model for US exports using discrete disaggregate data. The availability of combined trade, vessel and freight rate data in the US offers a rich source of information making it possible to combine detail on cargo, port of origin and destination, ship type and size and shipping route. (Malchow and Kanafani 2004) worked it out further and show how the predicted market share for a port varies with commodity-type and carrier.

(Tiwari *et al.* 2003) used a discrete choice model where shippers choose among combinations of shipping line and port and make decisions based on shipper and port characteristics. The situation concerns the Chinese foreign trade. (Veldman and Bückmann 2003) tested port choice models for the continental and overseas hinterland of West European container ports using aggregate container flows, where type of cargo, type of container (loaded or empty) and direction of trade were disregarded. Port access costs, hinterland transport costs by mode and proxy variables for quality of service proved to be significant. (Veldman *et al.* 2005) tested similar models for a larger continental and overseas hinterland and included a variable expressing container hub port draft restrictions explicitly, which proved to be significant.

(Blonigen and Wilson 2006b) used the same rich source of US maritime statistics as (Malchow and Kanafani 2004) to test port choice for US imports using aggregate data. The level of aggregation was low resulting in a multitude of information on cargo type, trade partner and port in the US and abroad. Given these enormous of amount of data, nearly 100,000 observations, the models tested could include port efficiency data based on (Blonigen and Wilson 2006a), which measured port efficiency for a great number of US and foreign ports. (Anderson *et al.* 2009) went into more detail with 470,766 observations derived from the same statistical source on container import shipments and tested models with a great number of variables, without using port efficiency data as done by (Blonigen and Wilson 2006a).

In the context of Spain may be mentioned (Ortuzar and Gonzalez 2002), who studied inter-island passenger transport options for passenger transport comparing the market shares of air transport, high speed and normal ferry boats, and (Garcia-Menendez *et al.* 2004), who tested logit models for exports from Valencia including maritime and road transport. Later, (Garcia-

Alonso and Sanchez-Soriano 2009) studied the inter-port container traffic distribution (for imports and exports) among the biggest Spanish ports using logit models, concluding that the port-province distance is a relevant variable in the port selection process.

In this study we take the logit model proposed in (Garcia-Alonso and Sanchez-Soriano, 2009) as starting point. Our purpose is going further, reinterpreting the suggested model and studying the effect of variables such as inland and ocean transport costs in the container port choice. The analysis is done from what we could call a *port locational perspective*. That is, we analyse the actual inter-port container traffic distribution taking into account the Spanish province where each trade flow is generated. For this, we use as data source the database of Foreign Trade from the Spanish Treasury Department, which collects all the movements of cargo derived from the Spanish foreign trade taking into account the Spanish province of origin/destination of each merchandise flow. This data source allows us also to include the country of origin/destination of the container flows, so that we can adopt the cost of ocean transport. To simplify, we group countries of origin/destination of container flows in 8 sets of coherent overseas trade partner regions. Additionally, we also attempt to analyse the effect of variables related to the quality of service or the characteristics of the ports. So, we present the results obtained in the estimations of several variations of the proposed model.

The analysis includes the container ports of Algeciras, Barcelona, Bilbao, Cartagena, Castellón, Valencia and Vigo, all having an annual volume of more than 1% of the total. The container flows of 2007 are aggregated from more than a 1.6 million trade flows registered in the data base, resulting in numbers of actually observed pairs of port and trade partner region of 1984 for imports and 2211 for exports.

The study is structured as follows. Section 2 gives a description of the logit model, the port choice situation and the variables to be tested in the utility function. A description of the explanatory variables follows, which include costs and proxies for quality of service aspects. Section 3 describes the outcome of the tests of alternative models with regression analysis and the impact of cost changes on market shares and related demand choice elasticities. Finally, conclusions are drawn in Section 4.

2. THE PORT CHOICE MODEL

2.1. Model specification

2.1.1 The logit model

The choice of seaport concerns the routings of Spanish imports or exports between the gravity point of the Spanish province of import or export and the gravity point of the overseas trade partner. The logit model expresses the probability that an importer or exporter trading between one of the Spanish peninsular provinces "i" and one of the overseas trade partners "j", chooses port "k" from a set of possible ports. Per combination of province and trade partner region the probability of choosing a routing via one of the ports, can be expressed as:

$$P_{ijk}(p = k \mid p = 1 \ldots P) = \frac{e^{-Uijk}}{\sum_{p=1}^{p=P} e^{-U_{ijp}}} \tag{1}$$

where:

P_{ijk}: probability of choosing port k from all possible ports p = 1..P, for province i = 1..I and trade partner j= 1…J;

U_{ijk}: the 'utility' attached to the routing via port k for trade between i and j;
i, j and p indices

The probability P_{ijk} can be interpreted as the market share of a port k in the total of all ports serving the trade between province “i” and trade partner “j”, for either import or export. The probability P_{ijk} can be set equal to the observed market share of volume F_{ijk} of routing k in the trade between i and j.

2.1.2. The utility function

The value, which a trader attaches to routing k is measured in the utility, which can be expressed as a (linear) combination of all aspects impacting the choice between alternative ports. One of the models tested is:

$$U_{ijk} = \alpha_0^k + \alpha_1 CL_{ik} + \alpha_2 CM_{jk} + \alpha_3 Q_k \tag{2}$$

where:
CL_{ik}: inland transport cost between province i and port k;
CM_{jk}: maritime transport cost between trade partner j and port k;
Q_k: quality of service aspects for i, j and port k.

The explanatory variables CL_{ik}, CM_{jk} and Q_k are referred to as attributes. α_0, α_1, α_2 and α_3 are the coefficients of the utility function. One alternative version includes the variable of the TC_{ijk}, which is the sum of CL_{ik} and CM_{jk} and replaces these two, and another version includes dummy variables for all ports other than the base port.

2.1.3. Market share of a container routing

The relative position of one port against the other for trade pair i,j is expressed by the ratio of the probability that an importer (or exporter) chooses a routing via port k against the probability that he chooses routing p. By subsequently substituting k and p in equation (1) and dividing the resulting probabilities, the ratio becomes:

$$P_{ijk} / P_{ijp} = e^{-U_{ijk}} / e^{-U_{ijp}} = e^{U_{ijp}-U_{ijk}} \tag{3}$$

The ratio of probabilities becomes a function of the differences of their attributes, which is a convenient form. If instead of differences a ratio form would apply (this applies to the situation where it is assumed that the utility function has a multiplicative instead of a linear form) the absolute level of the attribute values should have to be known and thereby of information on all shackles of the transport chain. (Oum 1989) states that with the ratio form the choice of base routing n affects the empirical results, including own and cross elasticities of demand.

By taking the logarithm of equation 3 the model becomes convenient for estimation with regression analysis:

$$Ln(P_{ijk} / P_{ijp}) = U_{ijp} - U_{ijk} = \alpha_0 + \alpha_1(LC_{ip} - LC_{ik}) + \alpha_2(MC_{jp} - MC_{jk}) + \alpha_3(Q_p - Q_k) \tag{4}$$

where $\alpha_0 = \alpha^k{}_0 - \alpha^p{}_0$.

2.2. Flows of containerised imports and exports

The customs statistics contain information of import and export flows by province of origin and destination in peninsular Spain, the trading partner country, the province of the port of transfer in Spain[1], the mode of transport, the mode of shipment and the type, weight and value of cargo.

According to customs statistics the volume of containerised seaborne trade generated by mainland Spain and destined for any of the countries included into one of the 8 sets of overseas trade partners was 24 million tons in 2007. With 13.3 million tons exports exceed imports, which amount to 10.7 million tons. Throughput volumes of Barcelona and Valencia dominate the market, while Algeciras, located in Cadiz, Bilbao located in Vizcaya and Vigo located in Pontevedra lag much behind. Apart from said 5 ports it includes the ports of Cartagena in Murcia province and Castellón in the province with the same name. See Figure 1. The volume of the 10 port provinces not included amounts to 3% of the total. The volumes of containerised imports and exports by port province are given in Table 1

Table 1. Containerised imports and exports by port province in 2007 in 1000 tons

Port province	**Imports**	**Exports**	**Both**	**Imports**	**Exports**	**Both**
1 Alicante	87,1	86,2	173,3	0,8%	0,6%	0,7%
2 Almería	0,3	2,2	2,5	0,0%	0,0%	0,0%
3 Barcelona	3.383,8	3.407,6	6.791,4	31,5%	25,7%	28,3%
4 Cádiz	646,1	631,4	1.277,5	6,0%	4,8%	5,3%
5 Castellón	34,8	737,8	772,6	0,3%	5,6%	3,2%
6 A Coruña	5,7	2,4	8,1	0,1%	0,0%	0,0%
7 Guipuzcoa	0,1	0,8	0,8	0,0%	0,0%	0,0%
8 Huelva	0,0	2,9	2,9	0,0%	0,0%	0,0%
9 Málaga	36,7	13,5	50,1	0,3%	0,1%	0,2%
10 Murcia	68,7	344,2	412,9	0,6%	2,6%	1,7%
11 Asturias	54,5	81,1	135,6	0,5%	0,6%	0,6%
12 Pontevedra	666,5	480,5	1.147,0	6,2%	3,6%	4,8%
13 Santander	7,5	1,6	9,1	0,1%	0,0%	0,0%
14 Sevilla	28,1	162,3	190,4	0,3%	1,2%	0,8%
15 Tarragona	36,0	82,7	118,7	0,3%	0,6%	0,5%
16 Valencia	4.483,4	5.988,3	10.471,7	41,8%	45,1%	43,6%
17 Vizcaya	1.189,7	1.255,8	2.445,6	11,1%	9,5%	10,2%
Total	**10.728,9**	**13.281,2**	**24.010,1**	**100,0%**	**100,0%**	**100,0%**

Source: derived from Spanish customs data

Figure 1. Location of ports and provinces

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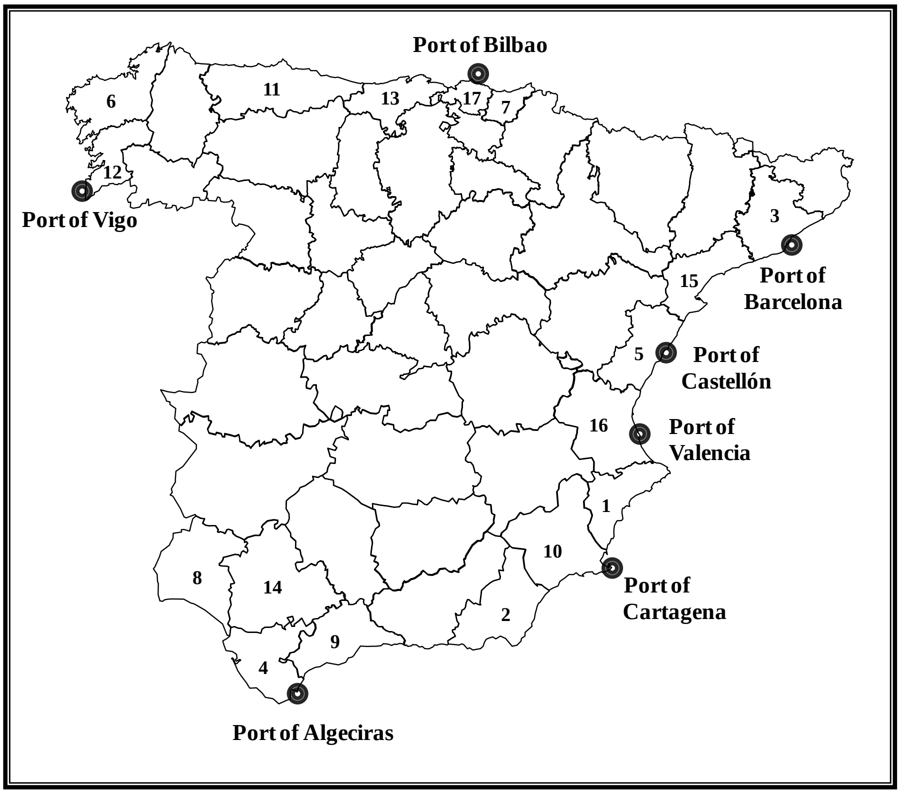
[1] We assume that the province where the customs process is realised, is where the port of transfer is located



In this study the trade partner countries as given in the customs statistics are grouped into 8 more or less coherent coastal regions that correspond with liner shipping services. The volumes of imports and exports by maritime regions are given in Table 2.

Table 2. Containerised imports and exports by overseas trade partner region in 2007 in 1000 tons

		Exports	**Imports**	**Total**
1	West Mediterranean	1.207	105	1.312
2	East Mediterranean	1.386	833	2.219
3	West/South Africa	833	420	1.253
4	Arabian Sea Area	1.757	227	1.984
5	East Asia	2.415	5.437	7.852
6	North America	2.562	1.443	4.005
7	South America EC	680	1.001	1.681
8	South America WC	271	559	830
	Total	**11.111**	**10.024**	**21.135**

Source: derived from Spanish customs data

The total volume of containerised cargoes for which inland and overseas containerised cargo flows by one of the 7 ports is known amounts to 11.1 million tons of exports and 10 million tons of imports. Given all combinations of provinces, ports and overseas regions, the maximum number of flows of imports and exports is 47 x 8 x 7 = 2,632. The model tests according to equation (4) concerns the differences of the attribute values of each port with the base port Valencia. In case the flows of the base port are zero, the denominator of the left hand side of the equation becomes zero and cannot be assessed. In this case one can either discard the observations concerned or bring in an arbitrary small value. The former would lead to a systematic omission of cases, where the port of Valencia is in a weak position, possibly leading to an over-estimation of its role. Therefore we have chosen for the latter approach by putting in a small value to both the nominator and denominator of equation 4. The above adaptations lead to a number of actually observed combinations of 1984 for imports and 2211 for exports taken from more than a 1.6 million trade operations registered in the data base.

It should be noted that port throughput volumes based on customs differ from those collected by the port authorities. (Escamilla *et al.* 2009) present a proposal to improve statistics by integrating both sources. To compare both sources for the Spanish container trades container throughput according to the Spanish Port Statistics (2007) has to be corrected by subtracting containers transhipped. These throughput volumes are assessed by taking the shares of transhipment cargo as published by (Drewry 2009) and correcting the total throughput totals for 2007 for the ports of Algeciras, Barcelona and Valencia. It appears that for all ports together the volume of Table 2 is about one third of the volume according to the port statistics. This means that our analysis is based on a sample of one third, assuming of course that port data represent the right volume.

2.3. Attributes of the logit model

2.3.1. Inland transport cost

The transport of containers between the Spanish provinces and sea ports mainly takes place by road. For the biggest container ports of Valencia and Barcelona, where rail transport has the biggest chance to be used, according to (CIM 2009) the share of road is about 95%. For other ports the share most likely is even less. The costs of trucking depend on many variables such as distance, type of truck and availability of return cargo. For this analysis we take the distance by road between the provincial gravity point and the seaport as basis and multiply it with the same price per ton-kilometre of € 0.085, which comes from DGTREN (2006) and is adapted for 2007 with information from Transport in Figures (2007).

2.3.2. Maritime transport cost

Maritime transport concerns the transport between the gravity point of the overseas regions and seaports and consists of direct shipments and shipments via transhipment ports. The cost of maritime transport is reflected in liner shipping rates which are based on shipping costs and the related demand supply situation on the liner shipping market. The costs of a round trip connecting the port of origin or destination in Spain with the port of the overseas trade partner depend on the roundtrip distance, characteristics of the ship such as size and speed, roundtrip characteristics such as number of ports of call at each coast line, port productivity and the volume of containers carried. Important also is the ratio of inbound and outbound cargoes and the position of the route in the world container shipping network. For Spain this means for instance the fact that trade links with the Far East are offered by shipping services passing Spain on their way between West Europe and the Far East and by services connecting the Mediterranean and the Far East.

The ports of Barcelona, Valencia and Algeciras are all well connected and have direct liner services with the main parts of the world. This concerns the east west trade routes connecting the major industrial centres of the world east of the Suez Canal and North America and also the north-south trade routes with Latin America and South and West Africa. Starting point of the assessment of liner freight rates for 2007 are the liner freight rates published by (Drewry 2007). These freight rate benchmarks are for full container loads and include the base ocean rate, terminal handling charges at origin and destination and fuel other surcharges. The freight rates are given for 20 ft and 40 ft containers. For the conversion into tons a TEU/box ratio of

1.6 and 14 tons per loaded TEU are applied, based on Spanish port data. Port costs are included in maritime costs and not taken explicitly.

Information of the liner shipping services as at July 2007 by (Drewry 2009) shows that Algeciras, Barcelona and Valencia are called at by all the major east-west and north-south shipping lines, while the other ports are called at by one or two services or not at all. In these cases transhipment is needed: for Cartagena and Castellon via ports in the West Mediterranean and for Bilbao and Vigo via ports in Northwest Europea. This means that full feeder costs have to be added or, if such ports are called at by one or two services, part of the feeder costs. The additional costs of feeder transport and the cost of shortsea shipping, as applies for the intra-Med trades, are based on roundtrip costs calculations.

2.3.3. Other cost and quality of service aspects

There is an extensive discussion as to what factors impact the choice of routing[2], such as transport costs, transit time, frequency of service and reliability of service. User surveys dating back to the 1980s show that quality of service aspects are important, such as (Peters 1989) and (Collison 1984). This research is refined by the use of the analytical hierarchy process (AHP) method to analyse survey data such as by (Lirn *et al*. 2003) and (Song and Yeo 2004).

(Zhang 2008) mentions that a larger hinterland of a port allows for:

1. a larger size of ships being attracted thus realising economies of ship size as described by (Jansson and Sheerson 1987);
2. higher frequencies of service resulting in Mohring effects as described by (Scherer 1980) and (UNITE 2003);
3. stronger roles as load centres;
4. better availability of third party logistic service providers and
5. more value added clusters as described by (de Langen 2004).

Taken together these effects can be referred to as hub port effects.

Above-mentioned user surveys include competition aspects at a detailed sometimes operational level as it applies to specific ports in combination with operators. They are useful for operators to strengthen their market share by improving their competitive edge. Our analysis is at a more abstract level and disregards the performance of individual operators. Instead it concentrates on cost parameters derived from the average performance of port and liner shipping operators, such as the port's place in the liner shipping network and economies of ship size.

The basic costs are those featuring in transportation planning models on modal split and route choice and include transport costs, transit time, frequency of services and all quality of service aspects such as service reliability impacting port choice as experienced by operators and users and producers and which are included in the utility function. Transit time is not included as it is practically proportional to transport costs, while precise information is lacking. Service reliability is not included as it averages out between operators.

Important, however, are the so called Mohring effects as noted by (Scherer 1980). Users of transport facilities impact the situation of other users. In the negative case, e.g. when the activity of one user causes extra costs for others, we talk of congestion costs. In the positive case, when users' activities improve the welfare situation of other users we talk about the

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[2] Defined here as the door-to-door shipment of imports and exports including land transport, maritime transport and transfer in ports

‘Mohring effect’. The project UNIfication of accounts and marginal costs for Transport Efficiency (UNITE, 2003), is a project under the Fifth Framework package by the European Commission, where a great amount of attention is paid to the quantification of Mohring effects through case studies concerning passenger and freight transport. Logit models were used in particular with respect to freight transport.

Mohring effects are related to frequency of service or headway[3]. At the level of a route the frequency can be calculated as the average of number of sailings per unit of time. At the level of a port, being linked by more than one route and being served by more than one shipping line, the frequency can be equated to the average over all routes and services. This average comes close to Mohring effects measuring quality of service aspects related to the level of trade.

The Mohring variable is expressed by 1 minus the inverse of container throughput of the ports in 500,000 tons, where throughput concerns both import, export and transhipment containers.

Table 3. Mohring variable

	Port	**Mohring index**
1	Algeciras	0,9882
2	Barcelona	0,9803
3	Bilbao	0,9155
4	Cartagena	0,0476
5	Castellon	0,6232
6	Valencia	0,9846
7	Vigo	0,7943

Source: Spanish Port Statistics (2007) and (Drewry 2009)

3. MODEL TESTING

3.1. Results of regression analysis

The port choice models are tested for both imports and exports, with as explanatory variables inland costs (LC) and maritime costs (MC), total costs (TC) being the sum of inland costs and maritime costs and further Mohring or, more general, hub-port effects (Mo). The test are done for a model including an estimate of the intercept (“with intercept”) and for a model forcing the intercept to be zero (“without intercept”). If the intercept differs significantly from zero, this means that there is a positive or negative preference for the base port k compared to all other ports according to equation 4.

The basic model includes the variables LC, MC and Mo. The results presented in line 1 of Table 4 show that the coefficients differ significantly from zero with high t-values for both exports and imports. The goodness of fit according to r-square is with 0.377 for exports and 0.352 for imports not high. It means that for exports 38% of the variation is explained by the model and for imports 35%. Note that this is not unusual for port choice models. (Blonigen and Wilson 2006a) measured r-square values of about 10% for their models, while (Veldman and Buckmann 2003) measured values ranging from 11% to 64% for the models on continental hinterland flows.

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[3] Headway is also referred to as inter-arrival time. Frequency of calls per year equals 365/headway

For both exports and imports the absolute values of the coefficients for LC is greater than for MC, but are rather close. This suggests that port choice is more sensitive for variations in LC than for MC, while they are both expressed in the same monetary units, i.e. EURO per ton. The measurement of costs, however, is not so accurate that we can state that a EURO spend at sea is valuated less than one spend at land transport.

The value of the intercept is greater than zero and statistically significant. This means there is a preference to use the port of Valencia being the base port in the equations (3) and (4). This difference is not explained by the model and is discussed hereafter. The Mohring variable is clearly significant indicating that Mohring and related hub-port effects are relevant.

The model with TC, as the sum of LC and MC, is adopted for the assessment of the demand choice function. The model tests for imports and exports presented in the lines 2 of Table 4 show that this variable plays a clear role, resulting in marginally lower r-square values. Comparison with the model of line 1 shows that the values of the resulting coefficients are closer to those of LC than of MC.

Table 4. Results of statistical analysis (t-values between parentheses)

Nº	**Intercept**		**LC**		**MC**		**TC**		**Mo**		**r-square**	**Nº obs.**
						Exports						
1	3,66	(13,6)	-0,133	(-21,8)	-0,126	(-6,3)	-	-	15,4	(29,3)	0,377	2211
2	3,62	(14,8)	-	-	-	-	-0,133	(-22,2)	15,4	(30,3)	0,377	2211
						Imports						
1	5,20	(16,4)	-0,161	(-22,5)	-0,109	(-5,6)	-	-	15,7	(25,0)	0,352	1984
2	4,88	(16,7)	-	-	-	-	-0,155	(-22,7)	15,3	(25,0)	0,350	1984

To get insight in the relative position of the ports as far as inland costs and maritime costs are concerned, while disregarding Mohring effects, the models presented in line 1 were also tested without intercept by adopting port specific dummy variables according to:

$$Ln(P_{ijk} / P_{ijp}) = \alpha_1 (LC_{ip} - LC_{ik}) + \alpha_2 (MC_{jp} - MC_{jk}) + \alpha_3 D_3 + \alpha_4 D_4 + \alpha_5 D_5 + \alpha_6 D_6 + \alpha_7 D_7 + \alpha_8 D_8 \quad (5)$$

The dummy variables D_3 to D_8 indicate whether or not a shipment is routed via one of the ports other than base port k = Valencia. With the test results in Table 5 the dummy variables of the ports are indicated with the first three letters of the ports' name.

Regression analyses are done for models with inland and maritime costs separately and taken together. The r-square values are with about 0.73 considerably higher than for the models with the Mohring variable and without dummy variable, which are in the range of 0.35 to 0.38.

The results show that the coefficient values of most dummy variables differ significantly from zero. In all except one case the coefficient value is negative indicating that the port's market share according to inland and maritime costs has to be corrected in downward direction. In other words the port of Valencia gets more than only based on inland and maritime costs. This applies both for import and export. The only positive value is for the port of Barcelona in case of exports, where the sign of the coefficient is positive, but differs not significantly from zero. In other words the market shares of Valencia and Barcelona do not differ much on the basis of their costs characteristics.

Table 5. Results of statistical analysis including port dummy variables

	Exports				Imports			
	coefficient	**t-value**	**coefficient**	**t-value**	**coefficient**	**t-value**	**coefficient**	**t-value**
Intercept	0	n.a.	0	n.a.	0	n.a.	0	n.a.
LC	-0,13	-22,9	-	-	-0,17	-24,4	-	-
MC	-0,11	-6,5	-	-	-0,04	-1,7	-	-
TC	-	-	-0,13	-22,8	-	-	-0,17	-23,72
DAlg	-6,50	-16,1	-6,36	-16,1	-3,79	-7,8	-4,35	-9,18
DBar	0,62	1,6	0,60	1,6	-3,53	-7,6	-3,61	-7,73
DBil	-3,51	-6,6	-3,73	-9,6	-7,23	-11,1	-4,59	-9,46
DCar	-15,82	-31,8	-16,54	-42,4	-18,17	-28,8	-17,14	-35,42
DCas	-12,70	-25,6	-13,42	-34,6	-17,18	-27,3	-16,14	-33,52
DVigo	-6,06	-11,1	-6,31	-14,6	-8,85	-13,3	-6,33	-11,61
R-square	0.735		0,735		0.731		0,727	
Nº obs.	2211		2211		1984		1984	

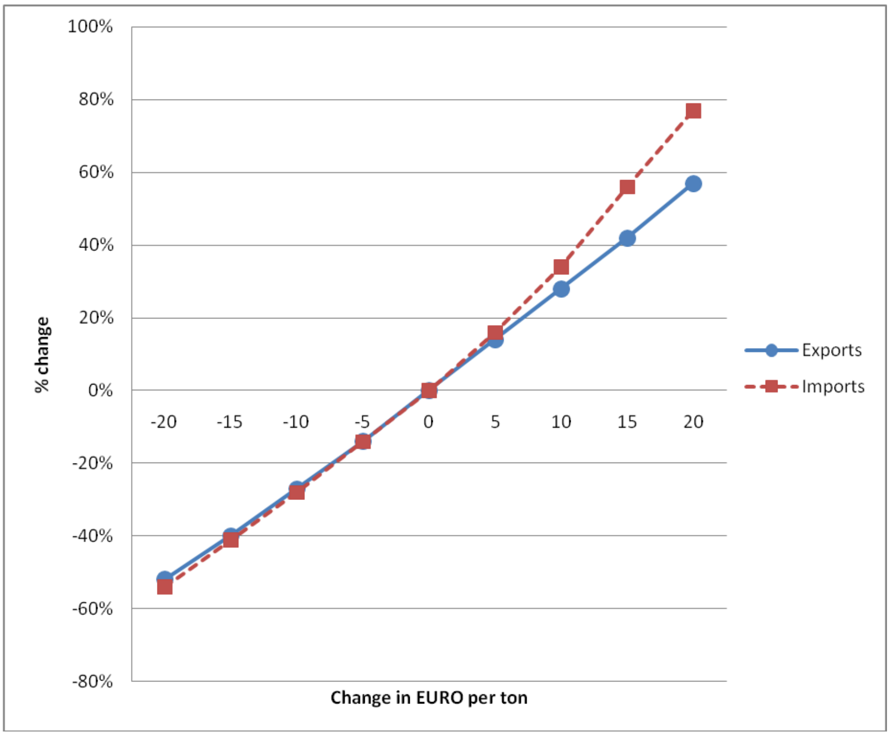
3.2. Impact of cost changes on market shares

For interventions in ports such as by investments in infrastructure, superstructure or pricing it is important to know how such measures impact the market share of a port. The impact of an increase in costs per ton of all containerised cargoes routed through a port can be assessed by increasing the cost of the routings passing the port compared to the cost of all other routings. By increasing or decreasing the costs of the port *k* compared to all other ports, containers are rerouted and port *k'*s market share will decrease or increase.

The impact of cost changes on the market share of a routing is simulated for both imports and exports using the coefficient of total costs as given in line 2 of Table 4. We take equation (4) as starting point and include a term of the total cost differences TC, replacing the separate terms of inland costs LC and maritime costs MC. As a result of an increase in total costs of $\Delta TC = €\ 1$, the term $\alpha_1\ (TC_{iip}\text{-}TC_{iik})$ changes with an amount of $\alpha_1 x\ 1 = \alpha_1 = -0.133$ in case of exports and with an amount of $\alpha_1 x\ 1 = \alpha_1 = -0.155$ in case of imports. For values of $\Delta TC = €\ 2$ the changes are 2 x 0.133 = -0.266 for exports and 2 x 0.155 = -0.310 for imports, and so on for ΔTC = 3, 4 etcetera. Instead of taking the market ratios according to the model, i.e. P_{ijk}/P_{ijp}, we use the observed market ratios as starting point, i.e. F_{ijk}/F_{ijp}, where F_{ijk} and F_{ijp} are the actual trade flows as used for the regression analysis.

As an example, we can calculate the market share of Valencia (as this one was the port that was taken as reference to calculate the ratio of probabilities) for variations of ΔTC ranging from € -20 per ton to € +20 per ton. The volume of cargoes routed through Valencia varies as given in Figure 2, which represents the demand choice function for Valencia.

Figure 2. Market share of Valencia for variations of ΔTC



4. CONCLUSIONS

For the economic and financial evaluation of port investment projects it is important to understand the relations between port demand and the price of using a port. That is, the demand choice function of a port's services needs to be known.

In a first step a logit model is tested. The obtained results are satisfactorily in terms of model fit. They show that the analysed variables play an important role in the inter-port container traffic distribution in Spain. All coefficients are statistically significant and the model with dummy variables for ports explains almost three quarters of the variation of flows routed through the Spanish container ports. The coefficient of the variable related to land transport cost is slightly greater than the one related to maritime cost. This suggests that an extra EURO spend on land transport costs has a slightly greater impact on port choice than one spend on maritime transport costs.

In a second step the estimated coefficients are used to assess the impact of changes in costs of container flows routed via a port and thereby on its market share. A demand choice function for this port is derived by systematically doing so. The demand function is based on the port choice model having the sum of inland and maritime costs as one of the explanatory variables. An example is presented for the port of Valencia.

The outcome of the model tests allow us to state that the location of a port, both in terms of origin and the destination of its traffic is a key factor to explain the observed container port choice in Spain. It remains for future research to strengthen the model by including other variables such as an indicator of the inland container transport balance, a split of the inland cost variables in a distance dependent and independent part as appeared successful in studies on container port choice in the north-west European continent or testing a two phase port choice - coastline choice first and port choice second - by applying a nested logit model as appeared to be successful for US container imports. Insight in port competition can be further deepened by assessing the complete table of elasticities and cross-elasticities for all ports.

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