Testing port choice models using physical and monetary data: a comparative case study for the Spanish container trades

Abstract

Transport costs are useful explanatory variables in port choice research. Nevertheless, the availability of such information usually poses a problem. Thus, the formulation of an alternative approach, to be used as a proxy of these variables, would be desirable. The objective of this study is to improve the analysis of container port choice using logit models by adopting physical non-monetary indicators based on maritime distance and ship size. The statistical tests of logit models on port choice using these new variables is compared with the result of using cost variables for the same dataset of choice positions. The statistical outcome is such that it allows us to present this approach as a contribution to the literature on port choice modeling.

1 Introduction

For the economic and financial evaluation of port projects it is important to know the impact of these interventions on port market shares. Port choice models such as logit models give explicit relationships between port routing costs and market shares so that demand choice functions can be derived. Of these costs maritime costs are often difficult to collect so that estimates have to be made. This publication presents an alternative approach and shows how physical data based on ship size and distance can be an alternative for the use of costs.

The world-wide network of container liner services is becoming more fine-meshed and with this the number of different routings offered per pair of flows between hinterland and foreland regions. This increase is a reflection of the world-wide economic growth and continuous restructuring of global supply chains. The increase of routing options, each using a particular port, implies more competition between ports and thereby a need for adequate tools of analysis, as noted by Robinson (Robinson 2002). Therefore port choice issues are part of the literature on port competition and competitiveness, and it is useful to give the application of Multinomial Logit (logit) models a place within it.

As far as we know, statistical analyses of port choice using logit models based on revealed preferences started about a decade ago with Malchow and Kanafani ((Malchow and Kanafani 2001), (Malchow and Kanafani 2004)). The nascent literature of statistical tests on port choice using logit models consists of about a dozen of publications (Paixao Casaca, Carvalho, and Oliveira 2010), most of which include elements important to understand the approach of this study.

The specification of the models tested varies with study focus, availability of data, level of aggregation, statistical estimation method and geographical setting. Malchow and Kanafani studied the combined choice of shipping line and port for US exports with data based on 4434 shipments. They had detailed information on commodity type and used maritime distance, inland distance, headway (inter-arrival time), ship size and probability of last port of call as main attributes of the utility function, which proved to be statistically significant. The wealth of information on commodity type and geography was at the cost of accuracy of the variables used to approximate in particular maritime costs. More recently, Anderson *et al.* (Anderson, Opaluch, and Grigalunas 2009) used 470,766 flows between US inland destinations and overseas origins routed through 10 ports in the US to test nested logit models on choice of coast line firstly and subsequently the choice of port. The choice of coast line was captured by geographical dummy variables, so that they could avoid to explicitly include the costs of landbridge routing options. The model attributes for port choice included amongst other the maritime costs (sea freight), time at sea, trucking time and trucking distance. The model is output based to serve as a tool for market share prediction.

The studies on port choice in the US demonstrate the availability of a great amount of information, say it at some effort, on container flows between inland destinations, overseas port of origins and the US port of transfer and also of information on maritime costs. For other countries such information is often not available, has to be constructed on the basis of assumptions, or the related attribute in the utility function has to be simply omitted. Some of the earliest and most important works outside the U.S. concern Chinese and Taiwanese ports. For instance, Tiwari *et al.* (Tiwari, Itoh, and Doi 2003) studied the combined choice of shipping line and port of transfer for Chinese imports and exports and used data of a survey of 1033 shipments. The attributes of their logit model do not include maritime costs and instead concer physical approximations such as maritime distance, inland distance, physical indicators related to the port's size and productivity and various dummy variables. Nir *et al.* (Nir, Lin, and Liang 2003) also applied a logit model for the choice of one of three ports in Taiwan based on a survey of 309 container shipments. Model attributes included inland transport costs and time, port specific dummy variables and shipping service variables such as service frequency. They did not adopt maritime costs as attribute, most likely as they considered the differences of these costs with respect to the three routing options, to be negligible.

Veldman and Garcia-Alonso also contributed to enlarge the analysis of port choice in the Spanish case using logit model in previous works. Veldman *et al*. (Veldman, Bückmann, and Saitua 2005) studied the combined choice of six container ports and three inland transport modes for containerized imports and exports of continental West Europe using 943 inland transport flows. Logit model attributes include inland transport costs by mode, transit time, maritime costs and indicators for quality of service. The data on container flows and costs were constructed by combining different statistical sources of containerized imports and exports by ports, modes of transport and countries. Model parameters were estimated with regression analysis based on differences of attributes as discussed by Oum (Oum 1989). Similarly, Veldman and Gopkalo (Veldman and Gopkalo 2010) studied port basin choice for containerized imports and exports of Russia. Russian customs statistics provide information of containerized flows between inland regions and trade partner countries and of the port basin of transfer including ports of transfer in Russia proper and in neighboring transit countries. The logit model attributes used were inland transport costs and time and maritime transport costs and time and assessed on the basis of various publications on sea freight. Logit model parameters were estimated for 150 flows of imports and 144 flows of exports with regression analysis based on differences of attributes. Veldman *et al* (Veldman, Garcia-Alonso, and Vallejo-Pinto 2011) also studied port choice on the basis of Garcia-Alonso and Sanchez-Soriano. (Garcia-Alonso and Sanchez-Soriano 2009) studied port choice in Spain using distance between inland provinces and ports as attribute in the logit model. (Veldman, Garcia-Alonso, and Vallejo-Pinto 2011) analyzed 2211 containerized export flows and 1984 import flows of Spain transferred via 7 different ports. Spanish customs statistics provide information on containerized flows between Spanish inland regions and trade partner countries and port of transfer in Spain. The attributes used were inland transport costs, maritime transport costs and indicators for port quality of service. This last publication is used as reference to compare the results obtained from the new model proposed here and referred to as ’previous’ study.

We are of the opinion that to test logit models on port choice in the ideal situation costs are to be included. From the literature review, however, it can be stated that the assessment of maritime transport costs poses a problem. To overcome this, we construct a linkage between maritime costs and indicators of costs through physical data derived from the economies of ship size models. The latter models are related to work by Jansson and Shneerson (Jansson and Shneerson 1987), Cullinane and Khanna (Cullinane and Khanna 1999) and Veldman (Veldman 2011), while the coefficients used are taken from the latter.

Section 2 describes generalized costs and non-monetary cost indicators and the relation between both based on the outcome of economies of ship size models. Section 3 gives a comparison of the logit model tested in earlier research using costs as attributes and the proposed port choice models using non-monetary indicators. The structure of the container flows routed through Spanish ports is shown in Section 4. In Section 5 the non-monetary indicators are used to test port choice models with regression analysis and the results are compared with those of earlier test results using maritime cost variables. Finally in Section 6, conclusions are drawn on the use of the models for the assessment of the impact of port interventions on port market shares.

2 From costs to physical, non-monetary indicators at trade level

Information on shipping costs (i.e. the sea freight or tariff from the point of view of the user of shipping services) is available for certain countries only. Notable exceptions are the availability of freight rate data in Latin America (Wilmsmeier and Hoffmann 2008), and the United States (Anderson, Opaluch, and Grigalunas 2009). For Spanish maritime trades such information is not available. We, therefore, apply an approximation based on the main elements of the underlying structure of maritime transport costs.

To approximate total maritime transport costs (MC) per roundtrip of a mainline service we assess the costs of the time ships spend at sea and the costs of the time ships spend in port, each multiplied by the related daily costs. The maritime transport costs are determined by the size of ships involved, the sailing distance, the number of ports of call, the volume carried in relation to the ship's carrying capacity, the load degree, and port productivity. Maritime transport costs can be expressed as a function of the size and design service speed of the ships involved, as is shown in (1):

$$\mathrm{MC}(\mathrm{S},\mathrm{V}) = \mathrm{TS}(\mathrm{S},\mathrm{V})\ \mathrm{CAS}(\mathrm{S},\mathrm{V}) + \mathrm{TP}(\mathrm{S},\mathrm{V})\ \mathrm{CIP}(\mathrm{S},\mathrm{V}) \tag{1}$$

Where:

$\mathrm{TS}(\mathrm{S},\mathrm{V})$: time spend at sea in days,

$\mathrm{TP}(\mathrm{S},\mathrm{V})$: time spend in port in days,

$\mathrm{CAS}(\mathrm{S},\mathrm{V})$: cost per day at sea,

$\mathrm{CIP}(\mathrm{S},\mathrm{V})$: cost per day in port,

S: carrying capacity in TEU,

V: service speed in knots.

The time ships spend at sea depends on the roundtrip distance and the sailing speed of ships. Generally applies: the greater a ship, the greater the design service speed. This means that bigger ships have to spend less time at sea, or at least the same amount of time. The daily cost at sea includes capital, labor and fuel costs, and relates to the size of the ship, the service speed of ships, the engine power and crew costs, which all show economies of ship size resulting in economies of ship size for the time ships spend at sea.

The time ships spend in port includes a fixed time element related to entering and leaving the port and preparing for loading and unloading and a variable time element related to cargo handling. The daily costs in port include the same costs as when steaming except the fuel costs of the ship's main engine. The variable time element depends on the amount of cargo handled, which depends on the size of the ship and the trade specific load degree. The time of cargo handling depends on the number of cranes working the ship, and this is more or less proportional to the length of a ship. One can state that in broad terms the length of a ship is proportional to the capacity of the ship to the power one third. This means that the time ships spend loading and unloading increases with the size of the ship with a power of one third.

In general terms, maritime costs per round trip per TEU can be expressed as a function of ship size, speed and roundtrip distance, which functions are proportional to the actual costs. Information on daily costs and operational performance of container transport as presented here after is taken from Veldman (Veldman 2011) to be referred to as the previous study. For a comparable analysis see also Cullinane and Khanna (Cullinane and Khanna 1999).

2.1. Elasticity values of production factor cost

The costs including capital, labor and fuel costs are expressed as multiplicative functions of ship size and speed and the elasticity values applied here are taken from the previous study. This also applies to the elasticity values of the operational performance used in the section hereafter.

Capital related costs are based on the ship's price. Annual capital costs are set equal to the capital recovery factor (annuity) based on the interest rate and the ship's economic lifetime, where the interest rate is the weighted average of the return on equity and interest on loans. The ship's price can be expressed as function of the ship's size and speed or size only according to (2):

$$P = \alpha_0 S^{\alpha_1} V^{\alpha_2} \tag{2}$$

Where the price P is a function of size S (expressed in TEU) and design service speed V (in knots). A higher speed, ceteris paribus, requires a greater engine power resulting in higher building costs. The Greek letter symbols concern the model parameters, and are estimated with regression analysis of the model in log-linear form. The result of the regression analysis shows that the elasticity value of the ship's price (and thereby of the capital related cost) is 0.726, and for the vessel speed is 0.0235. For size only the coefficient value is 0.766. For the calculations hereafter we apply the latter.

Labor related costs depend on the size of the ship's crew, the nationality of the crew and the ship's voyage patterns. Small ships deployed in coastal shipping may have smaller crews and thereby lower costs of labor. These aspects have little to do with a ship’s size. This implies that the elasticity value, according to equation (3), equals zero.

$$L = \varepsilon_0 S^{\varepsilon_1} \tag{3}$$

Fuel costs relate to a ship’s engine power. To attain a certain speed the engine power is less than proportional to ship size, which advantage is often traded off against higher speed. The equation can be expressed as (4):

$$kW = \gamma_0 S^{\gamma_1} V^{\gamma_2} \tag{4}$$

Where engine power measured in kilowatt (kW) is expressed as a function of ship size and speed. The regression analysis of container ships gives values of the elasticity of 0.607 for ship size and 2.215 for the ship’s speed.

2.2. Elasticity values of operational performance

Bigger container ships tend to have a higher design service speed and the following multiplicative relationship (5) appears to do fine for the speed:

$$V = \beta_0 S^{\beta_1} \tag{5}$$

For containerships there is a positive relationship between ship size and speed. For the total fleet of containerships the elasticity with respect to speed is 0.167.

The time spent in port depends on the cargo handling speed, which can be expressed as (6):

$$H = \varepsilon_0 S^{\varepsilon_1} \tag{6}$$

Where handling speed *H* per ship per day is the number of containers loaded and unloaded. The handling speed depends on factors such as crane productivity, the number of cranes working the ship simultaneously and the distribution of containers over the holds. As the speed is assessed over all ports called at on a roundtrip, some averaging takes place. Statistical measurements are scarce and generally limited to the situation of a particular port or terminal. (Jansson and Shneerson 1987) assumed that across all ports on a roundtrip cargo handling productivity is proportional to the number of cranes handling a ship, which is proportional to a ship’s length. Over a whole fleet of ships the length of a ship is proportional to its size according a power of one third. This implies an elasticity value of one third. We summarize the results in table 1.

Insert table 1 about here

2.3 Proposed physical, non-monetary indicators

On a roundtrip the time spend at sea (TS) can be expressed as a function of the roundtrip sailing distance, twice the distance inbound and outbound in nautical miles (2xD), and ship size *S* and equals the roundtrip distance divided by the sailing speed of the ships, as it is shown in (7):

$$TS = \frac{2D}{V} = \frac{2D}{(\beta_0 S^{\beta_1})} \propto DS^{-\beta_1} \propto DS^{-0.167} \tag{7}$$

This indicates that the time spent at sea is proportional to the roundtrip distance and to the size of ship to the power $-\beta_1$, which is -0.167 (from table 1). For the bigger ships the time spent at sea therefore is shorter, given the same roundtrip distance.

The time spent in port (TP) can be expressed in a similar way as a function of the size of ship, the load factor (*LF*: number of containers handled in TEU on a roundtrip divided by the size in TEU) per roundtrip and the cargo handling speed (8):

$$TP = LF\frac{S}{H} = LF\frac{S}{(\varepsilon_0 S^{\varepsilon_1})} \propto S^{(1-\varepsilon_1)} \propto S^{0.667} \tag{8}$$

This indicates that the time spend in port is proportional to the size of ship with a power, which is 0.667 ($1-\varepsilon_1$). The time spent in port increases with the size of ships.

In the equations 2, 3 and 4, capital, labor and fuel costs are expressed as a function of ship size and speed. Total costs therefore are the sum of three multiplicative functions with ship size elasticity values of 0.766 for capital costs, 0 for labor costs and 0.606 for fuel costs, which are proportional to engine power. The elasticity values are all less than one which means that for each production factor economies of scale exist with respect to daily costs, so that they also exist for all factors taken together and that the average is somewhere in between the highest and lowest value.

The summed daily costs at sea and in port are assessed for the range of ships from 1000 to 10,000 TEU. For the sake of convenience it is assumed that the summed data can be forced in a multiplicative relationship. The resulting elasticity values are estimated by using ship size as the explanatory variable, which leads to elasticity values of 0.884 for daily costs at sea and 0.730 for daily costs of time spend in port. The cost of the time spent at sea, as a function of roundtrip distance and ship size becomes (9):

$$\mathrm{Cost\ at\ sea} = \mathrm{TS(S,V)\ CAS(S,V)} \propto \mathrm{D\ S^{-0.167} S^{0.884}} \propto \mathrm{D\ S^{0.717}} \tag{9}$$

To arrive at the costs per TEU carried, the cost has to be divided by the volume of containers loaded and unloaded, which is the product of ship size TEU and load factor *LF*. This results in (10):

$$\text{Cost at sea per TEU} \propto \text{D}\ \text{S}^{(0.717-1)} \propto \text{D}\ \text{S}^{-0.223} = AS \qquad (10)$$

The cost of the time spent in port become (11):

$$\text{Cost in port} = \text{TS}(\text{S},\text{V})\ \text{CIP}(\text{S},\text{V}) \propto \text{S}^{0.667}\text{S}^{0.630} \propto \text{S}^{1.297} \qquad (11)$$

Cost in port per TEU carried results when dividing by the volume of containers loaded and unloaded and results in (12):

$$\text{Cost in port per TEU} \propto \text{S}^{(1.297-1)} \propto \text{S}^{0.297} = \text{IP} \quad (12)$$

The results demonstrate the existence of economies of ship size for the costs of the time ships spend at sea and the diseconomies of ship size for the time they spend in port.

2.4 Quality of service aspects

In the previous study we used a quality of service index at the level of the ports and refer to it as Hub-port index and is based on the following reasoning. User surveys dating back to the 1980s such as Peters (Peters 1989) and Collison (Collison 1984) show that quality of service aspects are important. This research is refined by the use of the analytical hierarchy process method to analyse survey data such as by Lirn et al. (Lirn, Thanopoulou, and Beresford 2003) and Song & Yeo (Song and Yeo 2004).

Zhang (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 (Jansson and Shneerson 1987);
2 higher frequencies of service resulting in Mohring effects as described by Scherer (Scherer 1980) and UNITE (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 (Langen 2004).

To include these effects in the previous study a Hub port indicator was applied and is expressed by 1 minus the inverse of container throughput of the ports in 500,000 tons, where throughput concerns both import, export and transshipment containers.

Insert table 2 about here

3. Comparison of port choice models: non- monetary indicators versus generalized costs

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 central port of the overseas trade partner region. The logit model expresses the probability that an importer or exporter, the cargo router, 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 (13):

$$P_{ijk}(p = k|p = 1 \dots P) = \frac{e^{-U_{ijk}}}{\sum_{p=1}^{P} e^{-U_{ijp}}} \qquad (13)$$

Where:

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

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

i, *j*,*k* 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*.

The concept of *utility* of an alternative of routing represents its value for the cargo router, and can be expressed as a linear combination of all aspects impacting the choice among different alternatives. We test two comparable utility functions. The one including non monetary indicators becomes (14) and is referred to as proposed new model:

$$U_{ijk} = \alpha_0^k + \alpha_1 D_{ik} + \alpha_2 AS_{jk} + \alpha_3 IP_{jk} + \alpha_4 FD_{kj} + \alpha_5 Q_k (14)$$

Where:

D_{ik}: inland transport distance between province *i* and port *k*;

AS_{jk}: ‘at sea’ index for trade partner *j* and port *k* (see equation (10);

IP_{jk}: ‘in port’ index for trade partner *j* and port *k* (see equation (12);

FD_{jk}: feeder port dummy for trade partner *j* and port *k*; 1 id feeder transport is needed; 0 otherwise;

Q_k: quality of service aspects for port *k*, referred to as Hub-port index.

The explanatory variables D_{ik}, AS_{jk}, IP_{jk} FD_{jk} and Q_k are referred to as attributes and α_0, α_1, α_2 α_3 α_4 and α_5 are the coefficients of the utility function.

Equation (15) corresponds with the previous model based on maritime transport costs and was tested by Veldman et al. (Veldman, Garcia-Alonso, and Vallejo-Pinto 2011) as:

$$U_{ijk} = \alpha_0^k + \alpha_1 LC_{ik} + \alpha_2 MC_{jk} + \alpha_3 Q_k \tag{15}$$

Where:

LC_{ik}: inland transport cost between province *i* and port *k*;

MC_{jk}: maritime transport cost between trade partner *j* and port *k*;

Q_k: quality of service aspects for port *k*, referred to as Hub-port index

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 (13) and dividing the resulting probabilities, the ratio becomes (16):

$$\frac{P_{ijk}}{P_{ijp}} = \frac{e^{-U_{ijk}}}{e^{-U_{ijp}}} = e^{\left(U_{ijp} - U_{ijk}\right)} \tag{16}$$

The ratio of probabilities becomes a function of the differences of their attributes, which is a convenient form. By taking the logarithm of (16) from (14) and (15), the model becomes convenient for estimation with regression analysis (17) and (18):

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

(17)

$$Ln\left(\frac{P_{ijk}}{P_{ijp}}\right) = U_{ijp} - U_{ijk} = \alpha_0 + \alpha_1(D_{ip} - D_{ik}) + \alpha_2(AS_{jp} - AS_{jk}) + \alpha_3(IP_{jp} - IP_{jk}) + \alpha_4(FD_{jp} - FD_{jk}) + \alpha_5(Q_p - Q_k) \qquad (18)$$

Where $\alpha_0 = \alpha_0^k - \alpha_0^p$.

The coefficients of the two variants, (14) and (15), according to equations (17) and (18) are tested with regression analysis. The variables are listed in table 3 under the heading ‘previous model’ and ‘proposed new model’ for the non-monetary indicators. Instead of using the Hub-port index it is possible too to apply port specific dummy variables related to $\alpha_0 = \alpha_0^k - \alpha_0^p$. For the comparison we focus on the model with the Hub-port index.

Insert table 3 about here

4 The database: the statistics of the Spanish foreign trade

Spanish customs statistics contain annual information of import and export flows by province of origin and destination in peninsular Spain: mode of transport, characteristics of the cargo (type, weight and value) and trading partners. In this paper we are focusing on flows of 2007 because our aim is to compare the results obtained from the new model with those derived from a previous one, based on the flows distribution actually observed this year among the main container ports in Spain (Algeciras, Barcelona, Bilbao, Cartagena, Castellón, Valencia y Vigo).

According to the statistics, the volume of containerized seaborne trade generated by the main provinces (for foreign trade by sea) of the mainland Spain was 24 million tons in 2007. With 13.3 million tons, exports exceed imports, which amount to 10.7 million tons. The volumes of containerized imports and exports by port province are given in table 4 (see their location by their number in figure 1). The volume of the 10 port provinces not included amounts to 3% of the total.

Insert table 4 about here

Insert figure 1 about here

In this study, as in the previous one, the trade partner countries as given in the customs statistics are grouped into eight coastal regions, which correspond with end regions of liner shipping services. The total volume of containerized cargoes through the analyzed Spanish container ports is 11.1 million tons of exports and 10 million tons of imports. The detail of the volumes of imports and exports by foreland region are given in table 5.

Insert table 5 about here

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 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 customs data base. For a deeper knowledge of data, see (Veldman, Garcia-Alonso, and Vallejo-Pinto 2011).

The information on maritime distances between Spanish ports and the gravity points of the foreland regions is from BP World-wide marine distance tables and the corresponding information of ship size and applicability of feeder ships is from CI-Online.

5 Results of the regression analysis

With regression analysis we test the statistical significance of the proposed non monetary indicators and compare it with the results of the models with cost data as published in the previous study. The non monetary indicators have three components, the At Sea Index (10), the In Port Index (12) and the Feeder Dummy. Both models further have a Hub-port index to include quality of service aspects, such as Mohring effects. The disadvantage of this variable is that it depends on the port's market share, so that market predictions have to be done in an iterative manner. An alternative is to apply a model without the Hub-port dummy, which is replaced by a dummy variable for each port.

The results of the previous study using cost data instead of non monetary indicators are given in the columns 2 and 3 of the tables 6 and 7. Columns 4 and 5 present the estimated coefficients of the new indicators. They have the right sign and the t-values show that the coefficient values for all variables differ significantly from zero. The R-square values are 0.430 for containerized exports and 0.393 for containerized imports, which are rather normal for this type of models, and even higher than with the previous model. So the comparison shows that the model is at least as good as the one with costs. Columns 6 and 7 show the results of the new model using port specific dummies variables instead of the Hub port-index. Compared with the model without dummy variables the result is better in terms of R-square: 0.507 against 0.43 for exports and 0.448 against 0.393 for imports. The dummies for all ports differ significantly from zero.

These results of the statistical tests of the new logit models show that for the situation with Spanish container trades they do well compared to models using maritime costs as variable. This, presumably, also says something about the accuracy of maritime transport costs constructed from sometime incomplete sources.

Insert table 6 about here

Insert table 7 about here

6 Conclusions

Port choice models based on logit models can be an important tool for the assessment of the impact of interventions in ports. As shown in the previous study, logit models having cost variables as attributes in the utility function have the advantage that demand choice functions can be derived by simulating the impact of cost changes on market shares. In the practice of port planning, however, information on maritime costs is often not available or has to be constructed with great effort.

In this study it is shown that alternative indicators can be constructed approximating the actual maritime costs and which can be used for logit model testing. The results of the regression analyses of the logit models show that for Spanish imports and exports the coefficients of the physical indicators such as the ‘at sea index’ and the ‘in port index’ appear to differ significantly from zero. It also appears that in terms of R-square the outcome of the previous study using monetary data is certainly not better.

Our conclusion is that port interventions leading to the accommodation of bigger ships on certain trades and increased port productivity can be translated into a change in value of the logit model attributes such as the ‘at sea index’ and the ‘in port index’. Thus, the impact of port interventions on port market shares can be assessed by applying the coefficients estimated for these variables and by simulating the impact of changes in attribute values on port market shares. These calculations can be used to support the economic evaluation of port projects by comparing the market shares for the situation with and without the project.

Finally, with respect to the evaluation of port interventions it can be concluded that in the ideal situation the information of logit models is to be tested with cost data. Nevertheless, where no information on maritime costs is available and where coefficient values of logit model attributes such as the ‘at sea index’ and the ‘in port index’ have been estimated, the latter can be used for the assessment of the project impact as a good proxy. In both situations the coefficients may also be used, in the practice of port planning, for the assessment of the project impact for other ports. In these cases of course, a well balanced judgment is needed to justify the transferability of the values on the basis of existing similarity of the choice position of the ports concerned.

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References

Anderson, Christopher M, J J Opaluch, and T A Grigalunas. 2009. “The demand for import services at US container ports.” *Maritime Economics and Logistics* 11 (2): 156-185.

Collison, F M. 1984. “Market Segments for Marine Liner Service.” *Transportation Journal* 24 (2): 40-54.

Cullinane, Kevin, and Mahim Khanna. 1999. “Economies of Scale in Large Container Ships.” *Journal of Transport Economics and Policy* 33 (2): 185-208.

Garcia-Alonso, Lorena, and Joaquin Sanchez-Soriano. 2009. “Port selection from a hinterland perspective.” *Maritime Economics and Logistics* 11: 260-269.

Jansson, Jan, and Dan Shneerson. 1987. *Liner Shipping Economics*. Ed. Chapman and Hall Ltd. London: Chapman and Hall Ltd. London.

Langen, Peter De. 2004. “Governance in Seaport Clusters.” *Maritime Economics and Logistics* 6 (2) (June 1): 141-156. doi:10.1057/palgrave.mel.9100100.

Lirn, T C, H Thanopoulou, and Anthony K.C. Beresford. 2003. “Transhipment Port Selection and Decision-making Behaviour: Analysing the Taiwanese Case.” *International Journal of Logistics: Research and Applications* 6 (4): 229-244.

Malchow, M, and A Kanafani. 2001. “A disaggregate analysis of factors influencing port selection.” *Maritime Policy and Management* 28 (3): 265-277.

———. 2004. “A disaggregate analysis of port selection.” *Transportation Research. Part E* 40 (4): 317-337.

Nir, A S, K Lin, and G S Liang. 2003. “Port choice behaviour from the perspective of the shipper.” *Maritime Policy and Management* 30 (2): 165-173.

Oum, Tae Hoon. 1989. “Alternative Demand Models and Their Elasticity Estimates.” *Journal of Transport Economics and Policy* 23 (2): 163-187.

Paixao Casaca, Ana C., S. Carvalho, and M. Oliveira. 2010. Port choice in the European short sea shipping market: the view of point of port authorities. In *IAME 2010 Annual Conference Proceedings*.

Peters, Hans Jürgen. 1989. *SeaTrade, Logistics and Transport*. The World Bank.

Robinson, R. 2002. “Ports as elements in value-driven chain systems: the new paradigm.” *Maritime Policy and Management* 29 (3): 241-255.

Scherer, Frederic M. 1980. *Industrial Market Structure and Economic Performance*. Ed. Rand McNally College. Chicago: Rand McNally College.

Song, Dong-Wook, and K T Yeo. 2004. “A Competitive Analysis of Chinese Container Ports Using the Analytic Hierarchy Process.” *Maritime Economics and Logistics* 6 (1): 34-52.

Tiwari, P, H Itoh, and M Doi. 2003. “Shipper´s port and carrier selection behaviour in China: a discrete choice analysis.” *Maritime Economics and Logistics* 5 (1): 23-39.

UNITE. 2003. UNIfication of accounts and marginal costs for Transport Efficiency. Project funded by the EC under the Fifth Framework Transport RTD. Framework Programme (1998-2002) in the thematic programme Competitive and Sustainable Growth.

Veldman, Simme. 2011. On the ongoing increase of containership size. In *Advances in Maritime Logistics and Supply Chain Systems*, ed. Ek Peng Chew, Loo Hay Lee, and Loon Ching Tang, 201-228. Singapure: World Scientific Publishing Company Pte, Ltd.

Veldman, Simme, Ewout H Bückmann, and Rafael Nistal Saitua. 2005. “River Depth and Container Port Market Shares: The Impact of Deepening the Scheldt River on the West European Container Hub-Port Market Shares.” *Maritime Economics and Logistics* 7 (4) (December 1): 336-355. doi:10.1057/palgrave.mel.9100142.

Veldman, Simme, Lorena Garcia-Alonso, and José Ángel Vallejo-Pinto. 2011. “Determinants of container port choice in Spain.” *Maritime Policy and Management* 38 (5) (September): 509-522.

Veldman, Simme, and Olga Gopkalo. 2010. A Model on Port Basin Choice with Russian Container Trade. In *International Forum on Shipping, Ports and Airports (IFSPA) 2010: Integrated Transportation Logistics: From Low Cost to High Responsibility*, 409-420. Chengdu (Sichuan, China).

Wilmsmeier, Gordon, and Jan Hoffmann. 2008. “Liner Shipping Connectivity and Port Infrastructure as Determinants of Freight Rates in the Caribbean.” *Maritime Economics & Logistics* 10 (1-2) (March 1): 130-151.

Zhang, Anming. 2008. The impact of hinterland access conditions on rivalry between ports. Discussion paper 2008-8. Joint Transport Research Centre, OECD and ITF. Joint Transport Research Centre, OECD and ITF.