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DETERMINANTS OF MARITIME TRANSPORT COSTS. A PANEL DATA ANALYSIS FOR LATIN AMERICAN TRADE

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Abstract

This paper analyses the determinants of transport costs for intra-Latin American trade over a period of six years (1999-2004). The data refer to yearly disaggregated (SITC 5 digit level) maritime trade flows on 277 trade routes. With this data set, a transport costs equation is estimated using linear regression analysis in a panel data framework. The first contribution to the literature is to exploit the greater variability present in our data and to control for unobservable heterogeneous effects. The second is to investigate the influence of open registries on the variability of maritime transport costs. Three groups of explanatory variables are considered. Firstly, time-varying variables: use of open registries and trade imbalance. Secondly, variables related to liner shipping network structures: number of liner services, shipping opportunities, deployed ships and deployed TEUs. Finally, product related variables such as volume of shipment, value of product and special characteristics of the cargo (i.e. refrigerated cargo). The results will allow us to quantify the effect of the explanatory variables on international maritime transport costs and to compare the obtained elasticities with previous cross-section analysis. In particular, estimating the impact of the use of open registries on transport cost is a new contribution in this field that could provide policy makers with valuable information to be used in the implementation of economic policies.

KEYWORDS: International Transport Costs Maritime Trade Latin America Sectoral Data Time Series Open Registries Competitiveness liner shipping network structure

JEL classification: F10, F14

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1. INTRODUCTION

The world we live in today has been shaped by a tremendous increase in international trade and investment flows, and by the relocation of industrial activities in countries providing lower labour costs. This trend towards globalization has, at least partially, its origins on the rapid development of transportation and information technologies across countries. There is little agreement, however, on the main causes and consequences of the globalization process.

In this paper we focus on the role that maritime transport costs play in this global context and more specifically, we investigate the determinants of these costs for intra Latin American trade over a period of six years. Only recently the economic literature has investigated the determinants of maritime transport costs. Clark, Dollar and Micco (2002) indicate that geographical factors, transport insurance, transport conditions (i.e. refrigerated transport), trade imbalances, economies of scale, containerised transport, number of maritime lines, port efficiency and anti-competition legal and practical restrictions, are affecting transport costs. Sánchez, Hoffmann, Micco, Pizzolitto, Sgut and Wilmsmeier (2003) demonstrate that efficiency of port infrastructure also influences transport costs. Their analysis is based on quantitative port performance measures. Hoffmann (2001) studies the determinants of port efficiency and finds that not only infrastructure, but also institutional, administrative and political factors are influencing international transport costs. Wilmsmeier and Pérez (2005) analyse the effect of liner shipping network conditions on transport costs from different regions to South America. They show a decreasing effect of maritime services supply on transport cost and investigate to what extent the structure of the deployed fleet for directly connected regions contributes to the level of transport costs.

Other studies refer to alternative transport modes. For instance, Micco and Serebrisky (2004) analyse the determinants of air transport costs. Distance, unit values, trade imbalance, airport infrastructure, government effectiveness and regulatory quality are important determinants of air transport costs. Product unit value coefficients are higher than those obtained for maritime and road transport pointing towards the importance of transport insurance, whereas distance coefficients are lower than those obtained for other modes of transport. Martínez-Zarzoso and Nowak-Lehmann (2007) analyse door to door transport costs determinants of Spanish exports to Poland and Turkey. Their results show that the main determinants for short-sea-shipping transport costs are the quality of service and the transportation conditions, whereas the main determinants for road transport costs are transport conditions, distance and transit time. Most of these investigations used data for a single year and based their analysis on cross-section regressions.

In this paper we update and extend the abovementioned research on the determinants of maritime transport costs in two directions. First, we analyse the consistency of the variables used previously in the literature by using a richer data set, containing transport costs data for intra Latin American sectoral trade over the period 1999-2004. This unbalanced panel allow us to control for unobservable heterogeneous effects.

Second, we investigate the influence of open registries on the variability of maritime transport costs. To our knowledge this has not been done previously. As minor additions, we also aim to measure the impact of external developments such as economic crisis on maritime transport costs and to provide some hints on what shipping policies could be used to lower maritime transport costs in order to promote competitiveness in Latin America. Finally, we are able to disentangle the transport costs variable into pure freight costs and insurance costs, in our econometric model.

The structure of the paper is as follows: Section 2 reviews previous studies concerning the measurement of transport costs. Section 3 describes the data, specifies the model and the hypotheses to be tested. Section 4 discusses the empirical results and Section 5 concludes.

2. TRANSPORT COSTS: MEASUREMENT AND DETERMINANTS

One of the main difficulties in analysing transport costs is that of obtaining reliable data. In the recent economic literature there have been several attempts to measure transport costs directly or indirectly. Some authors used cif/fob[1] ratios as a proxy for shipping costs (Baier and Bergstrand, 2001, Limao and Venables, 2001; Radelet and Sachs, 1998). Since most importing countries report trade flows inclusive of freight and insurance (cif) and exporting countries report trade flows exclusive of freight and insurance (fob), transport costs, including insurance costs can be calculated as the difference of both flows for the same aggregate trade. However, Hummels (2001) showed that importer cif/fob ratios constructed from IMF sources are poor proxies for cross-sectional variation in transport costs and such a variable provides no information about the time series variation. Ogueldo and Mcphee (1994) also doubted the usefulness of cif/fob ratios from IMF sources as a proxy of transportation costs.

Hummels (2001, 2007) used data on transport costs from various primary sources including shipping price indices obtained from shipping trade journals (Appendix 2 in Hummels, 2001); air freight prices gathered from survey data; and freight rates (freight expenditures on imports) collected by customs agencies in United States, New Zealand and five Latin-American countries[2].

In addition to cif/fob ratios reported by the IMF, Limao and Venables (2001) used shipping company quotes for the cost of transporting a standard container (40 feet) from Baltimore to sixty-four destinations. The authors pointed out that it is not clear how the experience of

[1] Cif stands for "cost, insurance and freight"; fob stands for "free on board."
[2] Chile, Argentina, Brazil, Uruguay and Paraguay.

Baltimore can be generalised. Martínez-Zarzoso, García-Menendez, and Suárez-Burguet (2003) used data on transportation costs obtained from interviews with logistic operators in Spain. They found import elasticities with respect to transport costs similar in magnitude to those found by Limao and Venables (2001).

Micco and Perez (2001) used data from the U.S. Import Waterborne Databank (U.S: Department of Transportation), where transport cost is defined as "the aggregate cost of all freight, insurance and other charges (excluding U.S. import duties) incurred in bringing the merchandise from the port of exportation to the first port of entry in the U.S.". Sánchez et al (2003) analysed data on maritime transport costs obtained from the International Transport Data Base (BTI). They focussed on Latin American trade with NAFTA.

Each of the above-mentioned research shows that the common perception that transport costs are unimportant is wrong; they are neither small nor uniform across goods and transport modes. In the empirical application of this paper we aim to add further evidence concerning the importance of transport costs. In order to do so, we use freight rates per ton obtained from the BTI[3]. Data from the BTI for freight rates are exclusive of loading costs. The main difference between these data and those reported by the IMF is that the BTI data on imports at cif and fob prices, freight rates and insurance costs are obtained from the same reporting country. Since information is collected using identical methodology, the data are more reliable than the IMF rates. A second advantage is that we have disaggregated data at 5 digit level SITC[4]. We use the same source as Hoffmann (2001) and Martínez-Zarzoso and Suárez-Burguet (2005) but for different trade flows. In accordance with the related empirical

[3]The International Transport Data Base (BTI, "Base de datos de Transporte Internacional") was created by the United Nations Economic Commission for Latin America and the Caribbean (ECLAC) in 2000 in order to facilitate research in the areas of trade and international transport. In addition to the typical trade data that is commonly published for example by COMTRADE (http://unstats.un.org/unsd/comtrade/), the BTI includes, inter alia, information about the mode of transport, the country of departure, the freight and the insurance paid for international transport. Further information is available upon request from g.wilmsmeier@napier.ac.uk.

[4] SITC: Standard International Trade Classification.

literature, the variables selected to explain maritime transport costs are: geographical factors, transport conditions (i.e. refrigerated transport), economies of scale, containerised transport, number of maritime lines, shipping opportunities, ship characteristics, use of open registries, and port operating schemes (Clark, Dollar and Micco, 2004; Martínez-Zarzoso and Nowak-Lehmann, 2007; Márquez-Ramos, Martínez-Zarzoso, Pérez and Wilmsmeier (2007); Wilmsmeier and Pérez, 2005).

3. DATA, HYPOTHESES AND MODEL SPECIFICATION

3.1. Data

The freight rate data are disaggregated at five-digit level (SITC). This level of detail was chosen to avoid aggregation bias resulting from mixing heterogeneous product categories. As mentioned in the previous section, the basic source of information is the International Transport Database (BTI) from ECLAC. This database compiles information on import and export of 21 countries[5] in Latin America and the Caribbean, representing a total of 277 maritime trade routes over a period of six years (1999-2004). The BTI gives information on the actual freight rates per ton paid for the export of a certain good between countries i and j excluding loading costs. One limitation of the data is that the series is annual, therefore, variations throughout a specific year cannot be allocated to a specific point in time and seasonality cannot be controlled for. However, an advantage is that the data represent individual shipments and are not based on means.

In order to make the freight rate data comparable over time, the freight rate series and the product values are all deflated with the US GDP implicit price deflator.[6] The US GDP implicit price deflator can be used as an approximation for the national price deflators since

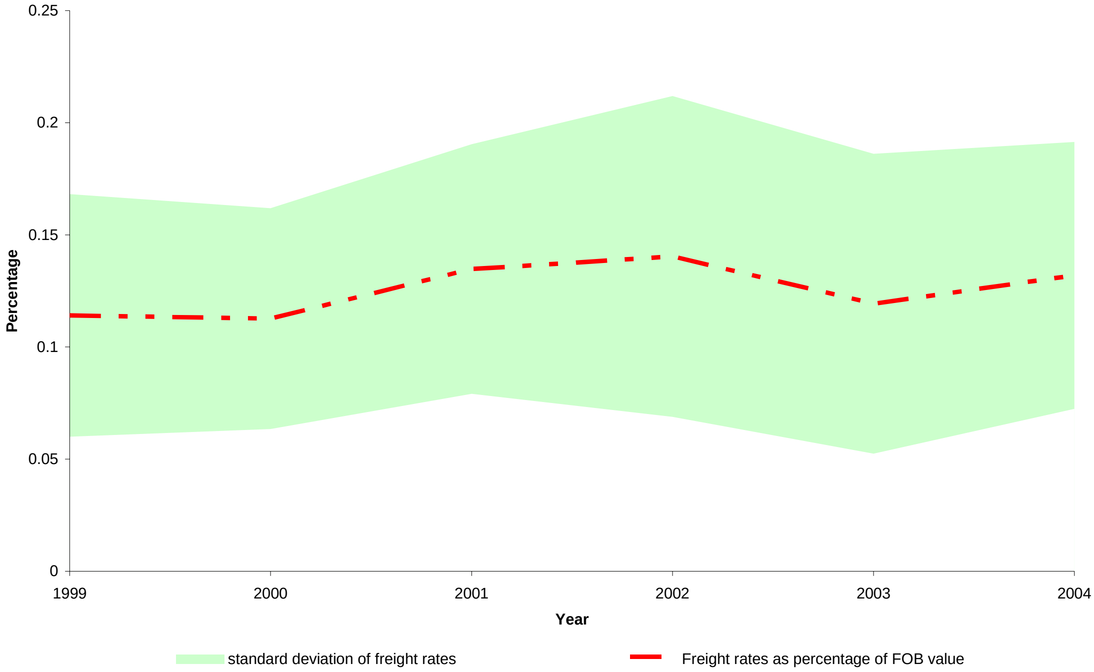
[5] Argentina, Belice, Bolivia, Brazil, Chile, Colombia, Costa Rica, Ecuador, El Salvador, French Guiana, Guatemala, Guyana, Honduras, Mexico, Nicaragua, Panama, Paraguay, Peru, Suriname, Uruguay, Venezuela

[6] The US Deflator is obtained from the GPO Access, a service from the U.S. Government Printing Office available in: www.gpoaccess.gov.

all freight charges are paid in USD and no other specific transport price deflators are available. Data on connectivity such as fleet deployment, average ship sizes in services, capacity in services, number of shipping lines, and shipping opportunities between ports of country i and j have been calculated from liner schedules and Containerisation International[7].

Figure 1 shows the evolution of maritime transport cost as percentage of the product value over time. The figure shows that the burden of transport costs in relation to the product value on imports has been slightly increasing and reached a peak in 2002, when the economic crisis struck the regional economies.

Figure 1 – International transport costs development and level of variation in maritime intra Latin America Trade



Source: Own elaboration
Note: Information based on International Transport Database (1999-2004). Includes transport costs on 277 maritime trade routes in Latin America for the period from 1999 to 2004. Excludes the products classified as SITC 3.

The increase of the share of transport costs as a percentage of product value at this point in time can probably partly be explained by the fact that port services in several ports (i.e. Buenos Aires) were bound to the dollar during the period of devaluation (Sánchez and

[7] Containerisation International Yearbook, various years, www.ci-online.co.uk.

Wilmsmeier, 2006). This implies a relative increase of port costs in the total costs. The increase of ad-valorem freight rates in 2004, following the reduction in 2003, could partly be explained by the high demand for shipping services in Asia, which lead to a significant redeployment of ships outside the region. Furthermore, an increase in the variation of transport costs during 2001 and 2002 is observed, probably due to the differential impact of the economic crisis in different countries.

3.2. Model Specification

In this section we present a reduced form model of maritime freight rates for Latin American exports. It is assumed that exported commodities are produced in the country of export and then shipped, at a cost, to the import markets where the goods are sold. As a result of the shipping margin, the price paid by consumers in the destination exceeds the price received by producers. Since the shipping margin depends on competitive conditions in the shipping industry, similar to Clark et al. (2004) the shipping firms are assumed to be profit-maximizing identical firms and behave as Cournot competitors. Within this framework, a simple constant-elasticity pricing equation can be derived from a fully specified general-equilibrium model (Francois and Wooton, 2001). The pricing equation relates the price of shipping commodity k (disaggregated at 5-digit level of the SITC classification) in year y from port i in Latin America to destination port j, TC_{ijkt}, to the marginal cost of this service, mc(i,j,k,t), and a profit magin term, ψ (i,j,k,t),

$$TC_{ijkt} = mc(i, j, k, t)\psi(i, j, k, t) \qquad (1)$$

Marginal costs and profit margin depend on transport service conditions, infrastructural variables of origin, transit and destination countries, external factors such as the development of the charter market and oil prices, the degree of competition existing in the market and factors inherent to the characteristics of the commodity to be transported. Assuming a multiplicative functional form, the marginal cost equation is given by,

$$mc_{ijkt} = \varphi_k \chi_t W_{ijkt}^{\alpha_1} Q_{ijkt}^{\alpha_2} TEU_{ijt}^{\alpha_3} D_{ij}^{\alpha_4} INS_{ijkt}^{\alpha_5} \qquad (2)$$

Where χ is a dummy variable referring to year t and φ_k is a dummy variable referring to product k, W_{ijkt} denotes the value per weight ratio (USD per ton) in year t, Q_{ijkt} is the volume of transaction between port *i* and *j* in year t, TEU_{ijt} denotes volume of TEU deployed in the import region in year t, which represents a proxy for the market size. D_{ij} denotes the maritime distance between country i and j, INS_{ijkt} denotes the insurance cost paid for product k transported between country i and j in year t. The profit margin equation is given by,

$$\psi_{ijkt} = \gamma_k F_{ij}^{\alpha_6} NB_{ijt}^{\alpha_7} LSNS_{ijt}^{\alpha_8} \qquad (3)$$

where γ_k is a dummy variable referring to product k that can be a proxy of the different transport elasticities across sectors, F_{ij} denotes the use of a ship running an open registry flag, NB_{ijt} denotes negative trade imbalances. $LSNS_{ijt}$ denotes liner service market structure between origin and destination in year t.

Substituting equations (2) and (3) taking natural logs and adding an error term we derive the empirical model to be estimated as:

$$\ln TC_{ijkt} = \delta_k + \chi_t + \alpha_1 \ln W_{ijkt} + \alpha_2 \ln Q_{ijkt} + \alpha_3 \ln TEU_{ijt} + \alpha_4 \ln D_{ij} + \alpha_5 \ln INS_{ijkt} + \alpha_6 \ln F_{ij} + \alpha_7 NB_{ijt} + \\ + \alpha_8 LSNS_{ijt} + \mu_{ijk} \qquad (4)$$

where $\delta_k = \varphi_k + \gamma_k$ and ln denotes natural logarithms and μ_{ijk} is the error term which is assumed to be identically and independently distributed.

The empirical model specified by equation (4) will be used to test a number of hypotheses:

Hypothesis 1. Distance versus Liner Service Network Structure (LSNS). Distance has been used as a "classic" determinant for transport costs in prior studies. We argue that the role of distance has been overrated in prior analyses. Distance can be a proxy for transit time, since time related costs, such as fuel and manning, rise with distance, but do not reflect the relation of trading partners in the transport network. We argue that maritime transport costs can be referred to as market driven, therefore, a measure that represents the Liner Service Network Structure could be a better determinant for transport costs. The measure introduced representing the Liner Service Network Structure is derived from principal components analysis, which allows us to control for the multicollinearity between the numerous variables representing this structure. Our measure includes the following individual variables: Shipboard capacity, number of services, number of deployed vessels, shipping opportunities and average ship size on the individual routes.

Hypothesis 2. Role of Open Registries. Open registries have been addressed in several contexts, such as maritime safety. To our knowledge, however, their role as a determinant of transport costs has not been investigated so far. Our hypothesis is that the use of open registry flags is mirrored in reduced transport costs.

Hypothesis 3. Consistency of Determinants. The impact of the commonly-accepted determinants of transport costs could be time variant. Therefore, the stability over time of the estimated coefficients will be tested.

Hypothesis 4. Influence of External Developments. External influences such as development of charter rates and bunker fuel and external shocks (in the present study the economic crisis in Argentina, Brazil and other Latin American countries in 2002), are also potential determinants of the general development of transport costs and have to be taken into account when comparing the level of transport costs over time.

The validity of Hypothesis 1 implies that $\alpha_8 > \alpha_4$ in Equation 4 and that the explanatory value of the adjusted R^2 should be greater, when liner service market structure, instead of distance, is used as a single explanatory variable.

The testing of Hypothesis 2 is motivated by the discussion on the role of flag states and the differences in flag registers (Sánchez, Hoffmann and Talley, 2005). An important issue for the success of flag states is lower register costs. We argue that these lower costs are reflected in the average transport costs, when ships having an open registry flag are used.

Hypothesis 3 could be tested by estimating cross-section regressions for each year and testing for the equality of the estimated coefficients over time. Alternatively, a single model with time-variant coefficients can be estimated for the overall period.

Finally, Hypothesis 4 is tested comparing the sign, magnitude and significance of the estimated coefficients for the yearly dummies, which are used to control the presence or absence of external shocks.

4. EMPIRICAL EVIDENCE

4.1.Main Results

The final data base includes 275337 observations. Incomplete data and outliers are excluded from the empirical analysis. Each observation corresponds to a given transaction, k[8]. As explained above, equation (4) is estimated to study the determinants of maritime transport cost per ton of exports on 277 trade routes in Latin America during the period 1999-2004. In order to evaluate the effect of single explanatory variables on transport costs, the regressors were progressively included in the estimated models. Tables 1-4 show our final results.

In order to test **Hypothesis 1** the first set of regression includes only the variables D_{ij} and $LSNS_{ijt}$ (Table 1) in Equation (4). The obtained results show that Liner Service Network Structure explains 8% of the variability of transport costs (Model D), whereas distance explains only 5.9%. In addition, the Liner Service Network Structure has a higher impact on transport costs than geographical distance, when both variables are introduced. Moreover, the

[8] Descriptive statistics are presented in the Appendix.

variation of the estimated coefficients in Models A-D for distance (Model A, 0.52; Model C and D, 0.28) indicates that the structure of Liner shipping networks is a good proxy to measure the impact of network characteristics and that distance can rather be used as an explanatory variable for time related effects such as bunker fuel use and manning.

Table 1 – Regression results – Distance and Liner Shipping Network Structure

Model /Determinants	A	B	C	D
(Constant)	0.8471 (27.2752)	2.7677 (76.9494)	4.9443 (2435.8408)	2.7047 (73.1581)
$Distance_{ij}$	0.5225 (131.2053)		0.2788 (60.6081)	0.2799 (61.0133)
Liner Shipping Network Structure (LSNS) $_{ij}$		-0.2224 (-100.7571)	-0.2928 (-154.9450)	-0.2284 (-103.538)
2000				0.0855 (8.8942)
2001				0.0895 (9.911)
2002				0.0014 (0.1553)
2003				-0.086 (-9.7692)
2004				0.1881 (21.7867)
R^2	0.059	0.080	0.092	0.100
F	17214.842	24007.964	14000.757	4377.322
Number of observations	275338	275338	275338	275338

Notes: significant at 1%, 5% and 10%. T-statistics are given in brackets. The dependent variable is the freight rate per ton of transporting good *k* from the exporting country *i* to the importing country *j* in natural logarithms. All explanatory variables, excluding LSNS and dummies, are also in natural logarithms. Models A-D were estimated by OLS. The estimation uses White's heteroscedasticity-consistent standard errors. Panel data are for the year 1999-2004.

Table 2 shows the results obtained when the full model is estimated. The progressive introduction of additional explanatory variables increases the explanatory power of the model from 8.7% to 54.5%. For all models, the estimated parameters have the expected signs and are statistically significant at conventional significance levels.

A central new finding of this study is the impact of open registries on transport costs as proposed in **Hypothesis 2**. Following the argumentation that open registries involve lower costs for shipping lines, we introduced a dummy variable, which takes the value of one, if the cargo is exported by a ship running an open registry flag[9], zero otherwise. The obtained results, shown in columns H to J in Table 2, indicate that exports on ships running an open registry flag are in average 3.3 to 4.1% lower in costs than exports using ships of other flags. Hoffmann et al (2005) questioned whether the system of open registries is unfavourable for developing countries. Our findings indicate that exporters in Latin America benefit from open registries, since the introduced dummy has a negative impact on transport costs, which could lead to an increase of the competitiveness of their products in the destination countries.

Table 2 – Main Regression results – Panel data

Model	**E**	**F**	**G**	**H**	**I**	**J**
(Constant)	4.9119 (640.2068)	5.7479 (122.4308)	5.8599 (123.6967)	3.1554 (74.0065)	3.1279 (72.5746)	0.9491 (17.3776)
Liner Service Network Structure (LSNS)	-0.2984 (-157.2829)	-0.2934 (-168.0744)	-0.2895 (-164.5303)	-0.3146 (-203.3938)	-0.3149 (-203.415)	-0.2706 (-160.6286)
Reefer cargo		0.1244 (7.9536)	0.1226 (7.8399)	0.3639 (26.4742)	0.368 (26.7092)	0.3478 (25.4231)
Volume of shipment (ln)		-0.2031 (-377.6849)	-0.2032 (-378.0479)	-0.1117 (-196.1308)	-0.1115 (-195.1599)	-0.1115 (-196.5493)
TEU deployed (ln)		-0.0469 (-12.4549)	-0.0549 (-14.4908)	-0.0926 (-27.8211)	-0.0901 (-26.6835)	-0.0480 (-14.0576)
Open registry			-0.0627 (-17.1921)	-0.0399 (-12.4604)	-0.041 (-12.7648)	-0.0335 (-10.5156)
Product Value (ton) (ln)				0.3783 (286.5149)	0.3786 (286.4237)	0.3757 (286.1964)
Negative Trade Imbalance					-0.015 (-4.3536)	-0.0229 (-6.727)
Distance (ln)						0.2135 (64.1718)
Year 2000	0.0511 (5.292)	0.0508 (6.3164)	0.0565 (7.0213)	0.0853 (12.0685)	0.0829 (11.7049)	0.0878 (12.4782)
Year 2001	0.065 (7.1589)	0.0291 (3.9085)	0.035 (4.6961)	0.0811 (12.3811)	0.0783 (11.897)	0.0822 (12.5762)
Year 2002	-0.0211 (-2.3343)	-0.0721 (-9.7152)	-0.0649 (-8.7395)	0.0154 (2.3588)	0.0131 (2.003)	0.0152 (2.341)
Year 2003	-0.1072 (-12.1258)	-0.1876 (-25.4253)	-0.1725 (-23.2244)	-0.0618 (-9.4597)	-0.0647 (-9.8568)	-0.0707 (-10.8537)
Year 2004	0.1689 (19.4421)	0.0192 (2.6035)	0.0314 (4.2362)	0.1012 (15.5526)	0.0976 (14.8749)	0.086 (13.2027)
R^2	0.0879	0.400	0.401	0.539	0.540	0.545
F	4426.603	20419.525	18426.791	29208.992	26778.235	25404.278
Number of observations	275337	275337	275337	275337	275337	275337

Notes: T-statistics are given in brackets. The dependent variable is the freight rate per ton of transporting good *k* from the exporting country *i* to the importing country *j* in natural logarithms. All explanatory variables, excluding LSNS and dummies, are also in natural logarithms. Models E-J were estimated by OLS. The estimation uses White's heteroscedasticity-consistent standard errors. Panel data are for the year 1999-2004.

[9] For further details on the issue open registries classifications see Hoffmann, Sánchez, Talley (2005).

We find evidence that lower crewing costs for open registries might be reflected in the freight charges, in line with the questions arising in Hoffmann et al (2005). Our results indicate that shippers in Latin America directly benefit from the use of open registry flags.

With respect to the rest of explanatory variables, results in Models E-J (Table 2) show that the Liner Service Network Structure (LSNS) variable has the expected negative sign and is significant. This indicates that a greater number of shipping opportunities, with bigger vessels, a greater number of deployed ships and of competing shipping lines reduces transport costs significantly.

Models F-J (Table 2) include a dummy for goods transported in refrigerated containers. The transport of refrigerated cargo has a positive effect on the dependent variable and the results show that refrigerated cargoes involve charges between 12% and 37% higher than non-refrigerated cargo. These findings are comparable to earlier studies (Hoffmann, 2001 and Martínez-Zarzoso and Nowak-Lehmann, 2007) and reflect the higher costs incurred by reefer containers due to different handling requirements and energy consumption on board. Our results also indicate that the unit-value of the cargo has a significant impact on transport costs. Models G-J indicate that a 10% increase in cargo value per ton increases average transport costs by 3.7%. These findings reflect that within the region "traditional" tariffs, where shipping companies distinguish between different commodities, are still in use. In particular, if goods are of very high value, the freight rate may effectively be charged irrespectively of weight and measurement on an ad- valorem basis.[10]

Additionally, models E-J support the existence of economies of scale in shipments that have a reducing effect on transport costs. Based on our results, a 10% increase in the volume of a shipment implies a 1.1% reduction in transport costs, indicating that shipping lines will

[10] Based on interviews with shipping lines on pricing strategies and Herman de Meester, European Community Shipowner's association.

probably give lower freight rates to high volume shippers. It also indicates a great variability in the transport costs offered for the same service depending on the volume exported and points towards the existence of a certain negotiation margin between agents.

In models F-J the variable "TEU deployed" is introduced. It has the expected negative sign and is significant. The TEU deployed in a region at a certain point in time, can be seen as a proxy for the market size of maritime transport in a specific region[11]. According to Model J, a 10% increase in TEU deployed in a region has an average reducing impact on transport costs of 0.48%. This can be interpreted as economies of scale that can be realized in greater markets.

Real distance from port to port is significant and has the expected sign. Longer distances increase maritime transport costs. The estimated distance elasticity is 0.21, This is in line with elasticities found in earlier studies. Hoffmann (2001) shows elasticity slightly higher, between 0,23 and 0,28, for intra-Latin American maritime trade. Hummels (1999) estimates the distance coefficient as between 0,2 and 0,3 for different commodities.

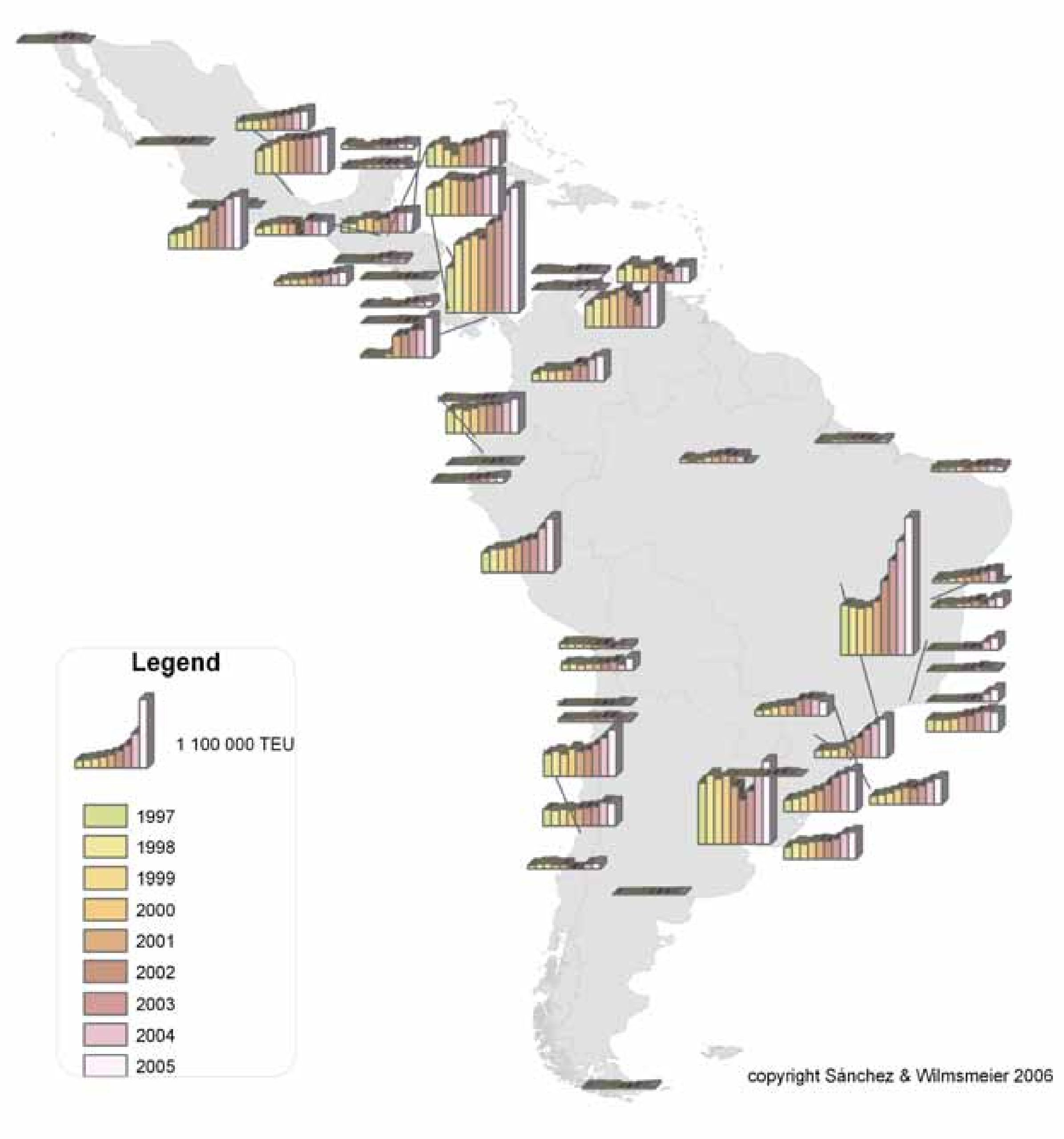
The trade imbalance variable (introduced in models I and J) is significant and has the expected sign. As expected, it displays a negative sign, implying that in a situation where a country exports less than it imports from a trade partner (trade imbalance will be negative), freight rates will tend to be lower due to the low percentages of capacity use on return routes used in the vessels deployed in services linking the two countries and due to the high degree of competition between lines to attract those lower traffic volumes.

In order to test **Hypothesis 3**, Model (H) was also estimated for each single year (Table 3). The estimated coefficients for LSNS, Reefer cargo, Volume of shipment, Open registries, Product Value, are very stable over time and are always significant at the 1% level. Only the variable TEU deployed change significantly over time, showing an unexpected positive sign

[11] Shipping regions in this case are defined as follows: WCSA, ECSA, NCSA, CA, Caribbean.

in the year 2000, and negative sign but variable magnitudes for the years 2001-2004. In order to investigate this variable effect of market size over time, Figure 2 shows the evolution over time of container port movements in Latin American Ports. 1997-2005. The figure clearly depicts the general tendency of container market growth and additionally shows the specific effects on container trade of the economic crisis in 2002, especially in Buenos Aires.

Figure 2–Container Port Movements in Latin American Ports, 1997-2005



Source: Sánchez and Wilmsmeier (2006).

In relation to **Hypothesis 4** we introduce year-dummy variables to test for the change of transport costs against the base year 1999. All dummies display significant t-values. The results of the panel data estimation show that transport costs have changed significantly in comparison to the base year 1999. We can observe that transport cost have risen between 7.8% and 8.8% in the years 2000 and 2001 (in comparison to 1999) due to external factors that are common for all trading partners. However, the increase was significantly less in 2002, in this year transport costs were only around 1.1 to 1.5% higher than in 1999, which implies a reduction in comparison to the previous year (2001). In 2003 freight rates were in average around 6% lower than 1999.

Table 3 – Regression results – Variation over time

Model H	2000	2001	2002	2003	2004	Beta Variation
(Constant)	1.0995 (3.2063)	3.7449 (40.3298)	3.3398 (32.9927)	2.1728 (23.5247)	4.921 (50.8405)	
Liner Service Network Structure (LSNS)	-0.2978 (-67.4306)	-0.297 (-83.7837)	-0.3266 (-89.7157)	-0.342 (-98.0692)	-0.3119 (-93.5095)	0.045
Reefer cargo	0.3493 (9.1403)	0.3339 (10.5656)	0.3425 (11.181)	0.3885 (12.2255)	0.378 (11.6771)	0.0546
Volume of shipment	-0.1141 (-71.3933)	-0.1105 (-81.8456)	-0.1098 (-82.7084)	-0.1199 (-98.7432)	-0.1028 (-89.3716)	0.0171
TEU deployed	0.0756 (2.8152)	-0.133 (-18.7326)	-0.115 (-14.8)	-0.0249 (-3.5524)	-0.2156 (-29.5771)	0.2912
Open registry	-0.0632 (-6.4943)	-0.0226 (-2.9231)	-0.0256 (-3.437)	-0.0789 (-12.0537)	-0.0421 (-6.6238)	0.0563
Product Value (ton)	0.374 (150.090)	0.3778 (125.2856)	0.392 (129.0764)	0.3876 (133.2642)	0.3695 (132.8041)	0.0225
R^2	0.541	0.543	0.572	0.555	0.511	
F-Change	6509.765	9437.127	10950.618	12044.932	11894.836	
Number of observations	33169	47726	49192	57957	68337	

Notes: T-statistics are given in brackets. The dependent variable is the freight rate per ton of transporting good *k* from the exporting country *i* to the importing country *j* in natural logarithms. All explanatory variables, excluding LSNS and dummies, are also in natural logarithms. All Models were estimated by OLS. The estimation uses White's heteroscedasticity-consistent standard errors. Panel data are for the year 1999-2004.

Given the yearly structure of the data, this can be due to time lagged-effects of the economic crisis. In 2003 export volumes using maritime transport picked up again. The effect of the devaluation of the Argentinean peso and other currencies in the region against the dollar can also be seen as an external factor affecting transport costs.

In 2004 freight rates are between 8.5 and 10.1% higher than 1999, which is also a significant increase in comparison to the previous year 2003. This effect can probably be attributed to the "China effect", which leads to a significant redeployment of ships from Latin America to Asia, which led to a significant shortage of shipping capacities in LAC.

4.2. Robustness

A series of robustness tests follows. First, model (4) is estimated for Brazilian imports. To be precise, of the 275337 that enter in the panel regressions, 32737 concern a single importer, Brazil. With this issue in mind, the transport cost equation was estimated including the same explanatory variables as in model J in Table 1. However, since LSNS and distance are highly correlated for a single importer, they are added separately in columns 1 and 2 of Table 4. The results show that the year dummies are negative and statistically significant at the one percent level. A reason could be that port efficiency in Brazil has increased over time and therefore, holding the other explanatory variables constant, transport costs are lower in the latest years of the sample than in 1999. In addition, the coefficient of the variable "volume of shipments" is slightly higher than for the complete sample, showing that Brazil is able to exploit economies of scale in transport more than other LA countries.

Second, model (4) is estimated only for those shipments for which we have separate information about insurance costs. The sample is reduced to 209901 observations. Two regressions are estimated. Model 3 shows the result of the baseline regression, comparable to model F in Table 1. The estimated coefficients are highly significant and reasonably similar to those in model F.

Model 4 shows the results when two variables are added: insurance costs and a dummy that takes the value of one when the importing port is a landlord port. The estimated coefficients of the two added variables are highly significant and show the expected signs. A higher insurance increases transportation costs. We could think of two hypotheses that could help explain this outcome. On the one hand, this could be associated with port insecurity, a higher insurance could be paid when the product is transporter between more insecure ports. On the other hand, higher value added goods could have higher insurance costs and also higher transport costs. If transport costs in Landlord ports are really lower, as we assume, there could also be a relationship between insurance costs and port operator models. The results open up the question whether Service and Tool ports in Latin America are potentially less safe and therefore imply higher costs for the shippers.

Finally, we restricted the sample to the product categories that are containerised. Most of the estimated coefficients showed similar magnitudes and the same signs as in model F (Table 2). The inclusion of sectoral dummies at 3digit SITC also did not change the main results.

Table 4. Robustness tests

	Brazil		**Insurance >0**	
	Model 1	**Model 2**	**Model 3**	**Model 4**
(Constant)	5.1644 (19.719)	0.5169 (1.8311)	0.3772 (7.5562)	0.1619 (2.128)
Liner Shipping Network Structure (LSNS)	-0.2104 (-60.0914)	-	-0.3042 (-160.0601)	-0.3026 (-155.4661)
Reefer	0.4291 (18.7554)	0.4605 (19.7591)	0.2423 (13.572)	0.2416 (13.5359)
Volume of shipment (ln)	-0.145 (-78.1027)	-0.1445 (-76.31)	-0.0937 (-120.1636)	-0.0937 (-120.1812)
TEU Deployed	-0.1552 (-9.0138)	-0.1268 (-7.2282)	0.0098 (2.9599)	0.0243 (4.7751)
Open registry	0.0091 (0.9303)	0.0068 (0.6796)	-0.0327 (-9.0832)	-0.0299 (-8.1188)
Product Value (ton)	0.2791 (71.3338)	0.2682 (67.4893)	0.2946 (132.3014)	0.2949 (132.3562)
Distance$_{ij}$		0.5469 (47.6964)	0.2305 (61.4701)	0.2336 (60.8452)
Y2000	-0.0099 (-0.7207)	-0.0077 (-0.5497)	0.0821 (9.0927)	0.0853 (9.4107)
Y2001	-0.0633 (-4.755)	-0.0622 (-4.5868)	0.0673 (7.6032)	0.0684 (7.7235)
Y2002	-0.06 (-4.741)	-0.0651 (-5.0455)	0.0028 (0.3167)	0.0041 (0.4612)
Y2003	-0.0384 (-2.7911)	-0.0475 (-3.3942)	-0.0796 (-9.2445)	-0.0762 (-8.8068)
Y2004			0.0911 (10.6939)	0.0908 (10.6584)
SEGURLN			0.1124 (60.9468)	0.1122 (60.7727)
IDUMLA				-0.0211 (-3.7524)
R^2	0.503	0.484	0.554	0.554
F	3312.407	3070.291	19948.788	18539.029
N	32737	32737	209901	209901

Notes: T-statistics are given in brackets. The dependent variable is the freight rate per ton of transporting good *k* from the exporting country *i* to the importing country *j* in natural logarithms. All explanatory variables, excluding connectivity and dummies, are also in natural logarithms. Models 1-4 were estimated by OLS. The estimation uses White's heteroscedasticity-consistent standard errors. Panel data are for the year 1999-2004.

5. CONCLUSION

This paper analyses the determinants of maritime transport costs for intra-Latin American trade over the period 1999-2004. With this aim, a transport costs model is specified and estimated in a panel data framework.

Four hypotheses were tested. Firstly, we analysed the relative importance of geographical distance and liner service network structure on maritime transport costs. The results indicate that the more central a trade route is located in the maritime liner service network the lower the average transport costs. This opens the important discussion on the "cost" of being peripheral. The elasticities found show that the impact of being peripheral in the maritime network is higher than the impact of distance. Network peripheral countries pay higher prices for transporting their exports, especially when they trade with other peripheral countries. Countries that are both peripheral in the maritime network and distant from other export markets face higher freight rates. Location is an important issue in Latin America, given the insular geographic character of the Caribbean and given that countries on the west and east coast of South America are located at the endpoint of the maritime network. The development of a hierarchical network, with growing importance of transhipment centres in Panama, Callao (Peru) or Manta (Ecuador) and of some intermediary ports on the east coast in Brazil, might leave certain regions in even more peripheral positions. We found evidence on higher transport costs for their exports, which implies a reduction in competitiveness in comparison to exporters in more central locations.

Secondly, we analysed the impact of open registries. The results indicate that the use of open registries significantly reduces transport costs. This negative impact on transport costs is consistent with small variations over the period 1999-2004. This opens further discussion on the role of flags of convenience, also raised by Hoffmann, Sánchez and Talley (2005). These findings also imply that a shipper might take into account certain risks using services that use flags of convenience to reduce their shipping costs. These findings can be seen as a first step to analyse this impact in more depth, differentiating also the effect of secondary registries and the perception of associated risks.

Thirdly, we tested for the stability of the estimated coefficients over time. Our results indicate that for most of the explanatory variables the estimated elasticities vary only slightly over time. Therefore, the cross sectional modelling approaches presented by Micco and Perez, Hummels (2001), Sánchez et al (2001), Wilmsmeier et al (2006) in prior studies are consistent over time.

Finally, we analysed the impact of external shocks on maritime transport costs. On the one hand, our findings indicate that the economic crisis of the year 2002 has some negative effects on freights in the following year, 2003. On the other hand, the increase in freight rates in 2004 could be attributed to the "China effect", which leads to a significant redeployment of ships from Latin America to Asia and to a significant shortage of shipping capacities in LAC.

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APPENDIX

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation	Variance
LSNS	347 572	-1.52	1.68	.0110	1.00077	1.002
Distance (ln)	896 980	5.37	8.97	7.6999	.76871	.591
Port Infrastructure (Export Infrastructure)	347 572	-1.90	1.27	.0024	.99622	.992
Port Infrrastructure (Import Country)	347 572	-1.02	3.12	-.0085	1.01206	1.024
Transport costs per ton deflated (ln)	687 306	-8.04	18.01	5.0829	1.09605	1.201
Product value per ton (ln)	897 652	-6.63	19.73	8.1061	1.44984	2.102
Volume of shipment (ln)	897 652	-6.91	13.78	-.1192	3.00451	9.027
Valid N (listwise)	275 338					