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MARITIME CONNECTIVITY AND TRADE

POLICY ISSUES IN INTERNATIONAL TRADE AND COMMODITIES
RESEARCH STUDY SERIES No. 70

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MARITIME CONNECTIVITY AND TRADE

by

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Abstract

Connectivity is a crucial determinant of bilateral exports. This paper presents an empirical assessment of the relationship between maritime connectivity and exports in containerizable goods during the period 2006-2012. Based on a unique dataset empirical investigations unequivocally show that lacking a direct maritime connection with a trade partner is associated with lower values of exports. Estimates point to a range varying from minus 42 per cent to minus 55 per cent. When assessing the effect of the number transhipments necessary to connect country pairs, any additional transhipment is associated with a 20 to 25 per cent lower value of exports. Results further suggest that in the absence of a bilateral connectivity indicator the impact of bilateral distance on bilateral exports is likely to be over-estimated.

Keywords: Maritime Transport, Sea Distance, Containerizable Trade, Trade Costs

JEL Classification: C61, F1, L91

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Any mistakes or errors remain the authors' own.

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Executive Summary

Access to foreign markets is a critical determinant of export performance. In technical literature foreign market access is seen as representing the foreign market potential of a country and relates inter alia inversely to bilateral transport costs.

The existence of a direct maritime connection has also been recognized to play an important role in determining trade costs. However, little theoretical and empirical attention has been devoted to its impact on bilateral exports. The lack of comprehensive evidence on the relationship between maritime connections and bilateral exports is due to the lack of data to a large extent.

The objective of this paper is to fill this gap by using novel information on maritime connections for a sample of 178 countries collected over the 2006-2012 period. Some basic statistical analysis reveals that over the whole period on average about 14 per cent of country pairs are connected directly, about 11 per cent need a single transhipment, about 36 per cent two transhipments and about 28 per cent three transhipments. This is to say that about 61 per cent of country pairs are connected with no more than two transhipments and around 90 per cent with no more than three transhipments.

This paper is a first assessment of the impact of the nature of maritime connections on bilateral exports of containerizable goods using a comprehensive set of country pairs observed over several years. Although a causal relationship remains difficult to identify, our estimates suggest that the absence of a direct connection is associated with a drop in exports value varying between 42 and 55 per cent depending on the underlying empirical specification. Results also indicate that any additional transhipment is associated with a drop in exports value varying between 20 and 25 per cent. We also find evidence that the relationship between bilateral exports and the number of transhipments necessary to transport containerizable goods between two countries is likely to be non-linear. These results suggest that the quality of maritime connectivity is likely to be a preponderant determinant of foreign market access.

By definition landlocked could not enjoy any direct connection with any trade partner but contiguous countries. The above results provide an estimate of the handicap in terms of export value landlocked countries have to face on top of the impact of the quality of transit transports.

High transport costs continue to constitute the greatest impediment to LDCs' trade competitiveness, equitable access to global markets. The improvement of the quality of maritime connectivity should be at the core of any strategy aiming at stimulating exports and promoting the participation of the domestic economy in global chains of production. Such improvement could only contribute to the reduction of transport costs.

Intervening efficiently on maritime connectivity is certainly not an easy task. Several options exist and their respective desirability could only reflect country specific characteristics. However, investing in infrastructures would be vital in all options. This would require a financial effort most countries are not able to bear alone. International cooperation and partnerships is thus crucial. International cooperation and partnerships could take the form of establishing strategies aiming at creating incentives for shipping companies to serve destinations which are not necessarily profitable in first place. For instance, it could consist in granting companies serving "remote" countries some preferential access to major maritime hubs around the world.

1. INTRODUCTION

Maritime transport is at the core of international trade in merchandises. Around 80 per cent of volume of goods exchanged in the world are transported via sea (UNCTAD, 2008). The predominance of maritime transport is explained to a large extent by an exponential intensification of containerized transport services. Thanks to containerization and the global liner shipping network, small and large exporters and importers of finished and intermediate containerizable goods from far away countries can trade with each-other, even if their individual trade transaction would not economically justify chartering a ship to transport a few containers from A to B. Thanks to regular container shipping services and transhipment operations in so-called hub ports, basically all countries are today connected to each other. A recent empirical study confirmed the "… effects of the Container Revolution on World Trade" (Bernhofen et al., 2013). As far as North-North trade is concerned the authors found a cumulative (concurrent plus lag effects) average treatment effect of containerization over a 20 year time period amount to 790 per cent. The cumulative effect of bilateral GATT membership is found to raise trade by an average of 285 per cent, which is less than half the cumulative effect of full containerization.

Despite a growing participation of developing countries in seaborne trade,[1] evidence on maritime connections suggests that, except for few of them such as China, they may have not reached their full potential. Fugazza and al. (2013) using a novel dataset find that the average number of direct maritime connections, meaning without involving any transhipment of the transported goods between the country of origin and their destination, is half for developing countries that it is for developed ones.

Recent literature has emphasized the importance of transport costs and infrastructure in explaining trade and access to international markets. Different empirical strategies have been used to produce estimates of the overall level of transport costs and eventually of their impact on the exchange of goods. Several studies used the ratio between imports CIF and imports FOB to proxy transportation costs, the so-called cif/fob ratio (e.g. Baier and Bergstrand 2001, Hummels and Lugovskyy 2006). Estimates vary essentially with the level of product aggregation. A reasonable average estimate of such ratio computed based on total imports CIF and FOB at the country level ranges between 6 per cent and 12 per cent. At more disaggregated product levels their dispersion increases. Approximations of CIF/FOB ratios are higher for developing than for developed regions. UNCTAD estimates that in the last decade, freight costs amounted 6.4 per cent for developed countries' imports as compared to 10.6 per cent for Africa (UNCTAD, 2011).

Based on the estimation of a gravity model using US data, Anderson and Van Wincoop (2003) found that transport costs correspond to an average ad valorem tax equivalent of 21 per cent. These 21 per cent include both directly measured freight costs and a 9 per cent tax equivalent of the time value of goods in transit. Using a similar empirical approach, Clark and al. (2004) estimates reveal that for most Latin American countries, transport costs are a greater barrier to U.S. markets than import tariffs. They also find that ports efficiency is an important determinant of shipping costs.

Arvis and al. (2013) recent work is an extension of Jacks et al. (2011) contribution. As such, it represents the most comprehensive country-level analysis of trade costs and their components up to date. Their database includes 178 countries and covers the 1995-2010 period. Estimates of trade costs are inferred from the observed pattern of production and trade across countries. Results indicate that maritime transport connectivity and logistics performance are very important determinants of bilateral trade costs: UNCTAD's Liner Shipping Connectivity Index (LSCI) and the World Bank's Logistics Performance Index (LPI)[2] are together a more important source of variation in trade costs than geographical distance, and the effect is particularly strong for trade relations involving the South.

[1] Between 1970 and 2010, developing countries´ share in the volume of seaborne exports rose from just 18 per cent to 56 per cent of the world´s total (UNCTAD, 2013).

[2] The World Bank's Logistics Performance Index (LPI) and UNCTAD's Liner Shipping Connectivity Index (LSCI) both aim in different ways to provide information about countries' trade competitiveness in the area of transport and logistics.

The existence of a direct maritime connection has also been recognized to play an important role in determining trade costs. However, little theoretical and empirical attention has been devoted to its impact on bilateral exports. The nature of maritime connections is usually treated as a component of an aggregate trade costs function in standard theoretical models and its impact is tariff-like. The available empirical evidence is limited and remains piecemeal. For instance, Wilmsmeier and Hoffmann (2008) findings based on a sample of 189 freight rates of one company for the Caribbean show that trade routes with only indirect services (i.e. including transhipments) induce higher transport costs. Their estimates suggest that transhipment has the equivalent impact on freight rates as an increase in distance between two countries of 2,612 km.

The lack of comprehensive evidence on the relationship between maritime connections and bilateral exports is due to the lack of data to a large extent. The objective of this paper is to fill this gap by using novel information on maritime connections for a large sample of countries collected over the 2006-2012 period. It is a first attempt to assess the impact of the nature of maritime connections between any pair of countries on their bilateral exports of containerizable goods. Although a causal relationship remains difficult to identify, our estimates suggest that the absence of a direct connection is associated with a drop in exports value of 55 per cent in our reference specification. Results also indicate that any additional transhipment is associated with a drop in exports value of 25 per cent. We also find evidence that the relationship between bilateral exports and the number of transhipments necessary to transport containerizable goods between two countries is likely to be non-linear.

The rest of the paper is organized as follows. Next section presents the data and reviews some descriptive statistics. Section 3 discusses the empirical strategy implemented to retrieve the impact of maritime connectivity on containerizable trade. Results are shown in section 4. The last section discusses possible policy implications and concludes.

2. DATA

We first present the main characteristics of our data and then some descriptive statistics which helped identifying our empirical strategy.

The database

Empirical investigation is based on a unique dataset described in Fugazza and al. (2013). The shortest maritime liner shipping routes between any pair of countries are reported for a reference sample of 178 countries for 6 years over the 2006-2012 period. Information for the year 2007 is missing unfortunately. Computed maritime liner service distances are retrieved using an original database containing all existing direct liner service connections between pairs of countries and the corresponding sea distance between the two countries' respective main container ports.[3] If a connection is qualified as "direct" it implies that there is no need for transhipment in a third country. However, the ship will usually call at other ports en route. The information on the existence or not of a direct connection is retrieved from the UNCTAD's Liner Shipping Connectivity Matrix (LSCM). The information contained in the latter database is obtained annually, in the month of May, through Lloyds List Intelligence. The data covers the reported deployment of all containerships at a given point in time. This methodology allows for comparisons over time, as the "sample" is always complete.

However, the scope of the activities and countries covered, as well as the measurement approach, are rather different. In spite of these differences, both indexes are statistically positively correlated, with a partial correlation coefficient of +0.71. Information concerning UNCTAD's LSCI is available in UNCTAD's Review of Maritime Transport. A detailed description and data of the World Bank, LPI is available via the website http://www.worldbank.org/lpi.

[3] Sea distance between pairs of countries represents the distance separating each coastal country's main port(s). In the cases of some large countries with several coast lines (e.g. USA, Canada et al) the main port retained varies according to the trade partner considered.

Shortest routes are obtained by solving for the shortest path problem in the frame of the graph mathematical theory applying a modified version of the Dijkstra (1959) algorithm. In the identification of the shortest route, direct connections are always privileged. This is to say that in case two options are available for moving from point A to point B, the option with the smallest number of transhipments would be chosen even if the corresponding maritime distance that has to be travelled is the longest of the two options. Moreover, we limit the number of transhipments to four (six in the case the origin and destination countries are landlocked). Larger figures could be obtained but would probably not reflect realistic route choices from a logistical point of view.

Three novel variables are then retained from the previous computations: a dummy variable that assumes the value 1 if at least one direct service between the two countries exists and 0 otherwise, a variable indicating the number of transhipments necessary to connect any pair of countries and, the effective maritime distance to be covered between any pair of countries. Note that only in the case of a direct maritime connection, the effective (computed) maritime distance coincides with the sea distance mentioned above. Note also that information on the number of transhipments necessary to connect any pair of countries is symmetric: if two transhipments are necessary to move containers from country C to country D, then the same number of transhipments is necessary to move containers in the opposite direction from D to C.

Amongst the 178 countries of the sample 33 are landlocked. While landlocked countries have by definition no direct access to liner shipping services, they do of course also trade with overseas trading partners, making use of their neighbouring countries seaports. Land-locked countries are assigned a maritime distance which corresponds to the sum of two distances: the distance to the container port in the transit country through which the largest share of overseas trade passes and, the computed maritime distance between the transit country and any reachable destination. We implicitly assume that transportation on road and transportation on sea have comparable effects on transport costs. We further implicitly assume that transhipment from road/rail to sea has the same impact on transport costs than transhipment from sea to sea. These assumptions may not be the most appropriate. Moreover, road transport costs may also vary from country to country as well as cost related to transhipment operations. As a consequence we will adopt an econometric strategy, described precisely below, that accounts explicitly for country specific characteristics and would thus minimize any possible bias related to the above assumptions.

Table 1
Top and bottom fifteen countries: average number of transhipments

Top 15	*Mean*	*Bottom 15*	*Mean*
GBR	0.73	RWA	3.15
FRA	0.79	MWI	3.15
BEL	0.84	ZMB	3.15
DEU	0.87	BOL	3.16
NLD	0.88	ISL	3.16
ITA	0.92	TKM	3.20
ESP	0.93	NER	3.20
CHN, HKG SAR	0.95	BLZ	3.23
CHN	0.97	SVK	3.31
USA	0.98	HUN	3.31
KOR	1.07	BLR	3.32
MYS	1.11	NRU	3.42
SGP	1.13	MLI	3.53
CHN, TWN Prov. of	1.19	MDA	3.62
JPN	1.29	ARM	4.10

Some descriptive statistics

Straightforward computations provide interesting insights into the structure of the global liner shipping network. Over the whole period on average about 14 per cent of country pairs are connected directly, about 11 per cent need a single transhipment, about 36 per cent two transhipments and about 28 per cent three transhipments. This is to say that about 61 per cent of country pairs are connected with no more than two transhipments and around 90 per cent with no more than three transhipments.[4] The maximum number of transhipments obtained is 6. This might be unrealistic in some circumstances. However, only 10 per cent of our observations are related to more than three transhipments and almost all of them involve either one landlocked or two landlocked countries. An alternative resolution of our algorithm includes a constraint limiting the maximum number of transhipments to 3 (+1 for landlocked countries). This alternative variable together with the corresponding maritime distance are used as robustness check variables. We note that the two maritime distances are strongly correlated and show a coefficient of pairwise correlation close to 0.98. Looking at the average number of connections at the country level over the whole period of time as reported in table 1 (left quadrant) we observe Great Britain is the country with the smallest average number of transhipments, followed by France, Belgium, Germany and three other EU countries. This ranking could be the result of a strong intra-EU trade effect. Nevertheless even when trade relationships with other EU members are not included those European countries stay amongst the top ten country list. The other countries amongst the top fifteen are the USA and seven East Asian countries. There is again clear intra-regional effect within the latter group of countries. The right quadrant of table 1 contains the corresponding bottom fifteen countries. The geographical composition is more heterogeneous and all continents are represented. The bottom list is not only made of landlocked countries and small island states.

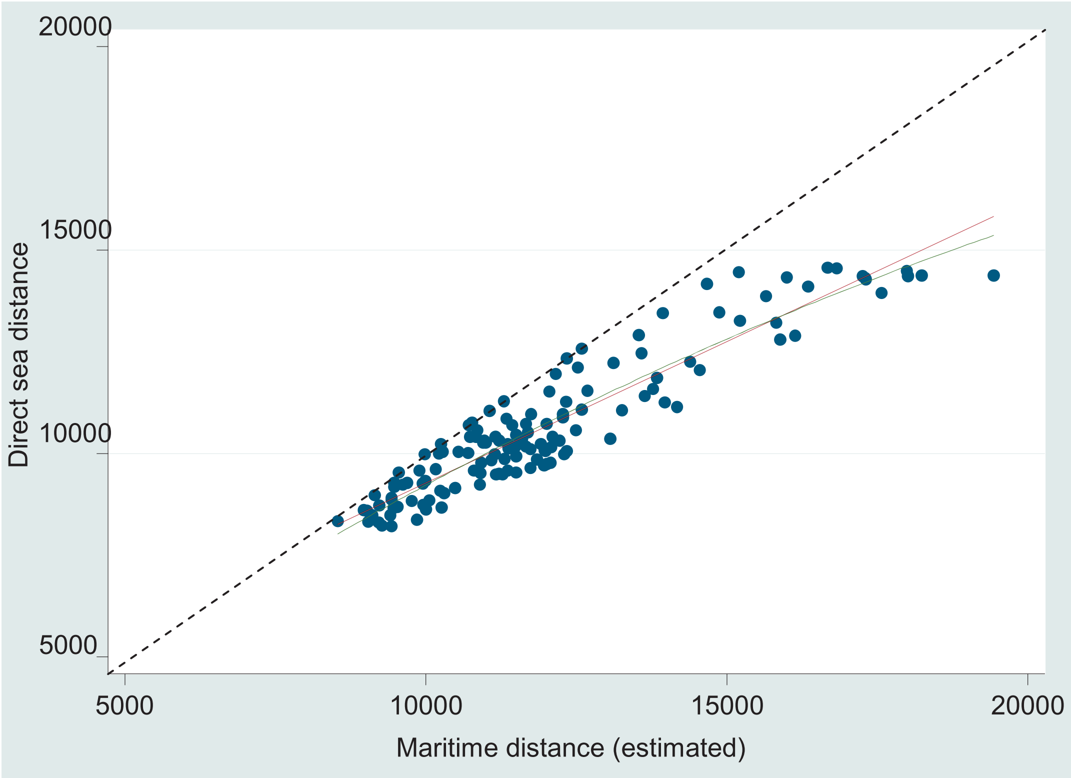
The direct sea-distance and the shortest connection distance with transhipment are expected to be strongly correlated. The maritime distance with transhipment(s), however, tends to increase with respect to sea distance as the latter increases. This is shown in figure 1. Points on the 45 degree line represent direct connections as the computed effective distance (including transhipments) and the sea distance by definition coincide. However, the question of whether maritime distances with transhipment and the associated number of transhipments are correlated does not have an obvious answer. The linear and quadratic fit lines reported in figure 2 both suggest that the two measures are only weakly correlated. Here all direct connections are excluded, but even when using the whole sample the two distance measures remain only weakly correlated.

The above findings highlight two important features that should be accounted for in any empirical analysis of determinants of containerized trade. Standard measures of distance (sea or as the-crow-fly distances) are underestimated in the case of non-direct connections, meaning for more than 85 per cent of the observations. As a direct consequence, the impact of distance on bilateral exports is expected to be over-estimated when standard measures are adopted. The existence or not of a direct connection and the very number of transhipments necessary to reach any export destination are also expected to affect trade and not necessarily independently of the impact of effective maritime distance. In other terms, distance as such may not fully reflect the incidence of transport costs and it should be considered together with the number of transhipments in assessing the impact of transport costs on bilateral exchanges.

[4] These percentages are slightly different from earlier analysis (UNCTAD, 2013) because in this paper our data base includes land-locked countries, which are connected to the global shipping network through their neighbouring transit countries.

Figure 1

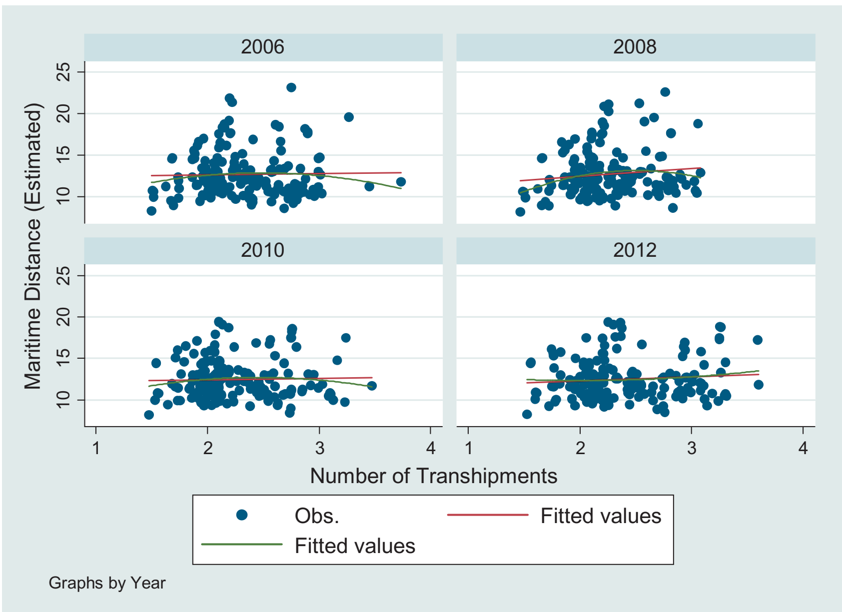
Direct sea distance and maritime (estimated) distance with transhipments



Note: The red line represents the linear fit of the relationship and the green line its quadratic fit. The dashed line is the 45 per cent line.

Figure 2

Maritime distance (estimated) and number of transhipments (country averages)



Note: The red line represents the linear fit of the relationship and the green line its quadratic fit.

3. EMPIRICAL STRATEGY

The identification of direct connections and the definition of the number of transhipments necessary to connect any country pair and the computation of the corresponding effective maritime distance for a sample of 178 countries during 6 years could help refining the assessment of the impact of trade costs on bilateral trade determinants. A clear causal relationship nevertheless could be difficult to identify as the possible influence of endogeneity issues related to either reverse causality/simultaneity or omitted variables or both may not be fully excluded.[5]

Endogeneity and the reference sample

A direct connection between two countries is clearly a factor of higher potential trade. However, the existence of a direct connection between two countries may not exist if the demand for goods produced in one or the other country is not large enough. The issue of reverse causation could be at work and the underlying intuition is almost obvious. However, several specialized contributions show that the establishment/interruption of a direct connection is not an immediate process in most circumstances.[6] Several elements could explain the existence of direct transport services between two countries independently of current relative demand conditions. Most obvious ones are historically high levels of trade, sufficiently good port infrastructures and the geographical location with respect to major maritime routes and regional maritime hubs. Not surprisingly, they are also expected to be important determinants of current trade values and as such are included in our empirical model. The former element is reflected in current demand conditions and time invariant characteristics inherent to trade partner countries. The last two elements are varying only gradually across time and could be controlled for by country and time specific effects. The inclusion of variables able to reflect the influence of the three elements above allows us to avoid or at least minimize possible omitted variables biases.

However, the treatment of reverse causation/simultaneity may remain only partial in this context. Several empirical strategies could be implemented in order to treat specifically simultaneity. Instrumental variable estimation is amongst the most efficient ones. Unfortunately good instruments for the existence of a direct connection are not easily identifiable. We could not think of any which would not be more or less strongly related to our dependent variable. Due to the very small number of trade relationships where a change in connectivity status is observed during the 2006-2012 period a strategy based on first differentiation in the wake of Baier and Bergstrand (2007) for instance is not really conceivable. Identification could be based at best on no more than 9 per cent and at worst on about 3 per cent of observations constituting the sample for our benchmark specifications. This limited variability prevents us for contemplating other difference in difference type of approaches potentially able to treat simultaneity explicitly. One of these strategies could consist in using as the comparative sample those trade relationships affected by changes in direct connections in other countries. However, this group represents no more than 6 per cent of the reference sample which annihilates any reasonable room for precise identification.

A major element explaining the restricted variability in connectivity observed for our reference sample could be the relatively short period of time covered. As the data collection process is exclusively forward oriented and will probably remain as such as no historical series exist besides those maintained by UNCTAD. Keeping all these constraints in mind, we believe that the core empirical strategy adopted in this paper and the set of robustness checks implemented explore all reasonably feasible directions to contain the incidence of endogeneity bias in our estimates.

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[5] Endogeneity however plagues any estimates obtained using any version of the gravity model. As stated in Bladwin and Taglioni (2006) "…the gravity model is not a model in the usual sense – it is the regression of endogenous variables on endogenous variables…".

[6] See *inter alia* Notteboom (2004), Wilmsmeier and Notteboom (2009) and Ducruet and Notteboom (2012).

The empirical model

Our focus being maritime connectivity, we take as our dependent variable trade in goods which are highly containerizable or its natural log depending on the estimated specification. As mentioned previously the volume of trade transported via sea represents about 80 per cent of world trade volume. In this study our reference unit is not volume but value. We have that on average the value of trade that can be transported via sea has been increasing steadily from 50 per cent of total trade in 2006 to more than 54 per cent in 2012. Pairwise correlation between the series of total exports and exports which are highly containerizable is about 0.93 and is highly significant.

The empirical model we adopt is the standard gravity model of international trade augmented by the inclusion of our maritime connection variables. Our benchmark specification is given by,

$$\ln\left(X_{jkt}\right) = \alpha_0 + \alpha_1 Border_{jk} + \alpha_2 Language_{jk} + \alpha_3 Colony_{jk} + \alpha_4 \ln\left(maritime\_dist_{jkt}\right)$$
$$+ \alpha_5 RTA + \alpha_6 transhipment_{jkt} + \alpha_7 \ln(GDP_{jt}) + \alpha_8 \ln(GDP_{kt}) + \alpha_9 I_{it} + \alpha_{10} I_{jt} + \alpha_{11} I_t + \varepsilon_{ijt}$$

The dependent variable ln(*X*) is the natural logarithm of total exports from country *j* to country *k* and recorded during year *t*. Explanatory variables include some standard gravity variables. Namely we have dummies for the existence of a common border (*Border*), a common language (*Language*) and a dummy indicating whether the trade partner was or was not a colony of the source country (*Colony*). Our distance variable *maritime_dist* represents the effective maritime distance separating country j from country k and is computed as described previously. We include an *RTA* dummy indicating whether the trade relationship is or is not preferential. The latter dummy is also expected to account for any possible impact of preferential trade agreements on transport costs. The natural logarithm GDPs of the origin and destination countries are also included to account for aggregate demand and supply conditions. We consider three different versions for the *transhipment* variable. The first version is a dummy variable which assumes the value 1 if a direct service exists at all, and 0 if not. The second version reports the number of transhipments necessary to connect any pair of countries computed applying the Dijkstra's algorithm in the frame of the graph mathematical theory. In the latter case we also estimate a specification that includes the square of the number of transhipments variable. This is to reflect the possibility of observing decreasing marginal transhipment costs. Exporter and importer specific and time invariant effects are controlled for by the inclusion of exporter and importer fixed effects. The inclusion of these sets of fixed effects should minimize the incidence of possibly omitted variables that are expected to be time invariant and country specific. For instance and importantly, the position of any country with respect to major maritime routes is likely to be accounted for by these sets of country fixed effects. Global and year specific shocks are absorbed by year fixed effects.

4. RESULTS

4.1. CORE SPECIFICATIONS

To start with we consider the whole sample in a cross section. We take average values over the reference period for all continuous variables. GDP variables are not included as we control for exporter and importer fixed effects. As to the RTA dummy variable and the transhipment variable in its binary version, they are both set to one if they take that value at least once over the reference period. Note that choosing any other rule in terms of value allocation would not affect significantly the results. Results are reported in table 2. Column (1) shows results obtained using a standard specification where the distance variable corresponds to the direct sea distance between major ports. Column (2) still does not include any transhipment variable but is based on calculated effective maritime distance and not direct sea distance. Column (3) refers to the specification including the binary version of our transhipment variable. Column (4) reports estimates using the number of transhipments as our indicator of maritime connectivity. Column (5) further includes the square of the number of transhipments. The first two columns indicate that all coefficients can be significantly affected by the choice of the bilateral distance used in the regressions. For instance, the impact of bilateral distance is significantly larger in column (1) and the RTA variable coefficient is significantly smaller. Coefficients and in particular that of the bilateral distance variable, are further affected by the inclusion of a maritime connectivity variable as can be seen from column (3) to (5). When using the direct sea distance measure or when using its effective measure but without any transhipment variable, the impact of bilateral distance appears to be overestimated. A one per cent increase in distance is associated with a 1.3 per cent decrease in bilateral exports when using the direct sea measure of bilateral distance compared to a 1.1 decrease when using the calculated effective measure of maritime distance instead. The figure drops to -0.92 and -0.88 per cent with the binary transhipment variable and the number of transhipments variable respectively. Estimated coefficients further suggest that the absence of a direct connection is associated with a 64 per cent lower value of exports and any additional transhipment is associated with a 31 per cent lower value of exports. However, the impact on bilateral exports of transhipment appears to be decreasing as we obtain a positive coefficient for the number of transhipments squared variable.

Table 3 reports results obtained using the original structure of the data. GDP variables are thus reintroduced. From a qualitative point of view patterns are similar to those observed for table 2 results. Without controlling for extensive margin of maritime connection that is the number of transhipments, the impact of maritime distance appears to be over-estimated. It is even more over-estimated when using direct sea distance. In the former case the elasticity of bilateral exports with respect to effective maritime distance is -1.16 and it is -1.34 in the latter. When controlling for maritime connectivity, the elasticity drops to -1.01 when including our binary transhipment variable and and to -0.98 when including our transhipments count variable. Differences between distance (log of) coefficients are always significant. The sensitivity of the RTA dummy coefficient is remarkably affected by the use of our measure of effective maritime distance instead of the measure of direct sea distance. The estimated coefficient increases from 0.7 to 0.88 and the variation is statistically significant. After controlling for maritime connectivity, the estimated coefficients slightly decrease to about 0.84. The difference however is not statistically significant.

Results reported in column (3) show that the absence of direct connection is associated with a fall in bilateral exports value by 55 per cent. When assessing for the impact of the total number of transhispments necessary to reach the final destination, results indicate that any additional transhipment translates into a fall in exports value of about 25 per cent. Again we find that the relationship between bilateral exports and the number of transhipments may not be linear and is represented by a strictly convex function.

Both table 2 and table 3 point to the importance of controlling for the extensive margin of maritime transport. The inclusion of a precise measure of effective bilateral maritime distance and that of a variable qualifying the nature of the bilateral maritime connection reduces significantly the impact of bilateral distance on the value of bilateral exports. This is to say that trade costs may not be properly accounted for when using direct geographical distances.

Table 2
Benchmark regressions (Cross section)

	(1)	(2)	(3)	(4)	(5)
LN(maritime_distance)	-1.299[a]	-1.100[a]	-0.929[a]	-0.880[a]	-0.879[a]
	(0.0213)	(0.0211)	(0.0213)	(0.0231)	(0.0229)
Language	0.961[a]	1.114[a]	1.071[a]	1.064[a]	1.062[a]
	(0.0393)	(0.0399)	(0.0391)	(0.0394)	(0.0391)
Colony	0.768[a]	0.690[a]	0.554[a]	0.602[a]	0.559[a]
	(0.100)	(0.106)	(0.103)	(0.101)	(0.102)
Border	0.420[a]	0.821[a]	0.594[a]	0.797[a]	0.656[a]
	(0.147)	(0.152)	(0.144)	(0.141)	(0.142)
RTA	0.885[a]	1.110[a]	1.035[a]	1.064[a]	1.028[a]
	(0.0454)	(0.0456)	(0.0448)	(0.0448)	(0.0447)
Transhipment			-1.020[a]		
			(0.0384)		
Transhipments_Number				-0.309[a]	-0.797[a]
				(0.0155)	(0.0322)
Transhipments_Number_2					0.134[a]
					(0.00832)
Exporter FE	Yes	Yes	Yes	Yes	Yes
Importer FE	Yes	Yes	Yes	Yes	Yes
Observations	24760	24760	24760	24760	24760
R^2	0.806	0.809	0.813	0.812	0.814
Adjusted R^2	0.804	0.806	0.811	0.809	0.811

Note: Robust standard errors in parentheses: [c] $p < 0.10$, [b] $p < 0.05$, [a] $p < 0.01$.

Table 3
Benchmark regressions (Panel)

	(1)	(2)	(3)	(4)	(5)
LN(maritime_distance)	-1.343[a]	-1.157[a]	-1.014[a]	-0.981[a]	-0.970[a]
	(0.0191)	(0.0199)	(0.0199)	(0.0209)	(0.0208)
Language	0.960[a]	1.134[a]	1.088[a]	1.086[a]	1.078[a]
	(0.0374)	(0.0383)	(0.0377)	(0.0379)	(0.0377)
Colony	0.781[a]	0.683[a]	0.598[a]	0.625[a]	0.602[a]
	(0.0896)	(0.0950)	(0.0929)	(0.0913)	(0.0919)
Border	0.392[a]	0.814[a]	0.664[a]	0.795[a]	0.720[a]
	(0.128)	(0.134)	(0.129)	(0.127)	(0.127)
LNGDPX	0.287[a]	0.324[a]	0.318[a]	0.307[a]	0.310[a]
	(0.0358)	(0.0362)	(0.0361)	(0.0362)	(0.0361)
LNGDPM	0.795[a]	0.820[a]	0.810[a]	0.800[a]	0.803[a]
	(0.0352)	(0.0355)	(0.0353)	(0.0354)	(0.0353)
RTA	0.698[a]	0.879[a]	0.834[a]	0.847[a]	0.830[a]
	(0.0363)	(0.0374)	(0.0368)	(0.0368)	(0.0367)
Transhipment			-0.796[a]		
			(0.0319)		
Transhipments_Number				-0.253[a]	-0.573[a]
				(0.0117)	(0.0243)
					0.0879[a]
Transhipments_Number_2					(0.00569)
Exporter FE	Yes	Yes	Yes	Yes	Yes
Importer FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes
Observations	125632	125632	125632	125632	125632
R^2	0.779	0.771	0.775	0.774	0.775
Adjusted R^2	0.779	0.770	0.774	0.773	0.774

Note: Robust standard errors in parentheses (clustered by country-pair). [c] $p < 0.10$, [b] $p < 0.05$, [a] $p < 0.01$.

4.2. ROBUSTNESS CHECKS

Various robustness checks are undertaken. As already mentioned, we could not implement any satisfactory and statistically validated instrumentalization of our transhipment variables. We then opt for a set off robustness checks able to limit as much as possible the influence of endogenity. We start with the inclusion of a larger set of fixed effects. We then restrict our sample to trade relationships for which no change in transhipment conditions have been observed over the whole period. We further consider the use of an alternative maritime connectivity variable. Finally we treat the high incidence of zeros in the matrix of bilateral trade.

Fixed effects and consecutive years

We enlarge the set of fixed effects by including exporter fixed effects and importer fixed effects interacted with time fixed effects. Results are reported in the first three columns of table 4. Columns (1) to (3) are the direct counterpart of columns (3), (4) and (5) respectively in table 3. Coefficients of variables present in both tables are only affected at the second or third decimal. We also included country pair fixed effects as an additional check. However, due to the low variability in the transhipment variables, their impact is to a large extent absorbed by the set of country-pair fixed effects.

As mentioned previously information for the 2007 is missing. We excluded the year 2006 from our sample in order to consider only consecutive years. Results, not reported, remain practically unchanged with respect to our benchmark specification.

Steady connections

In order to isolate as much as possible our estimates from a simultaneity bias, we drop from our reference sample those trade relationships where a change in connection status (direct versus non-direct) has been observed over the period under investigation. When considering the number of total transhipment as our connectivity related explanatory variable we drop all trade relationships whose number of transhipments necessary to connect the underlying pair of countries have changed. As already discussed, observations dropped represent less than 3 per cent of observations of the reference sample in the former case. In the latter case, the percentage is about 9 per cent. Results are reported in the last three columns of table 4. Exporter and importer fixed effects interacted with time fixed effects are considered for the ease of comparison with the first three columns of the table which can be seen as reference ones in light of findings commented in the previous sub-section.

Results are in line with corresponding ones obtained for the whole sample. In other words, even by generating a possible selection bias, which could also cause endogeneity, results are comparable with those obtained in our reference estimations. The little variance in estimated coefficients across samples may suggest that, as discussed previously, simultaneity does not appear to be a major issue.

Table 4
Extended fixed effects

	(1)	(2)	(3)	(4)	(5)	(6)
LN(maritime_distance)	-1.016[a]	-0.979[a]	-0.971[a]	-1.019[a]	-0.972[a]	-0.977[a]
	(0.0202)	(0.0213)	(0.0212)	(0.0208)	(0.0225)	(0.0225)
Language	1.085[a]	1.082[a]	1.075[a]	1.099[a]	1.076[a]	1.069[a]
	(0.0380)	(0.0381)	(0.0380)	(0.0392)	(0.0404)	(0.0403)
Colony	0.603[a]	0.628[a]	0.607[a]	0.576[a]	0.589[a]	0.573[a]
	(0.0936)	(0.0919)	(0.0926)	(0.0957)	(0.0935)	(0.0943)
Border	0.654[a]	0.783[a]	0.710[a]	0.619[a]	0.693[a]	0.617[a]
	(0.130)	(0.127)	(0.128)	(0.131)	(0.127)	(0.128)
RTA	0.856[a]	0.868[a]	0.852[a]	0.823[a]	0.833[a]	0.826[a]
	(0.0378)	(0.0377)	(0.0377)	(0.0387)	(0.0396)	(0.0395)
Transhipment	-0.790[a]			-0.823[a]		
	(0.0322)			(0.0345)		
Transhipments_Number		-0.258[a]	-0.571[a]		-0.302[a]	-0.633[a]
		(0.0121)	(0.0247)		(0.0144)	(0.0303)
Transhipments_Number2			0.0872[a]			0.104[a]
			(0.00590)			(0.00844)
Exporter FE*Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Importer FE*Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	125632	125632	125632	121481	114017	114017
R^2	0.779	0.778	0.779	0.779	0.784	0.785
Adjusted R^2	0.775	0.774	0.775	0.775	0.780	0.781

Note: Robust standard errors in parentheses (clustered by country-pair). [c] $p < 0.10$, [b] $p < 0.05$, [a] $p < 0.01$.

Table 5
Poisson regressions

	(1)	(2)	(3)	(4)	(5)	(6)
LN(maritime_distance)	-0.460[a]	-0.450[a]	-0.447[a]	-0.499[a]	-0.448[a]	-0.500[a]
	(0.0128)	(0.0126)	(0.0126)	(0.0130)	(0.0126)	(0.0129)
Language	0.201[a]	0.237[a]	0.236[a]	0.219[a]	0.240[a]	0.222[a]
	(0.0367)	(0.0364)	(0.0364)	(0.0358)	(0.0364)	(0.0358)
Colony	0.279[a]	0.202[a]	0.201[a]	0.191[a]	0.195[a]	0.188[a]
	(0.0424)	(0.0427)	(0.0425)	(0.0433)	(0.0427)	(0.0434)
Border	0.433[a]	0.436[a]	0.444[a]	0.386[a]	0.440[a]	0.383[a]
	(0.0384)	(0.0377)	(0.0377)	(0.0367)	(0.0377)	(0.0367)
LNGDPX	0.353[a]	0.354[a]	0.352[a]	0.354[a]	0.354[a]	0.355[a]
	(0.0938)	(0.0925)	(0.0927)	(0.0923)	(0.0924)	(0.0921)
LNGDPM	0.621[a]	0.621[a]	0.620[a]	0.623[a]	0.621[a]	0.624[a]
	(0.0965)	(0.0959)	(0.0965)	(0.0927)	(0.0960)	(0.0924)
RTA	0.520[a]	0.443[a]	0.438[a]	0.404[a]	0.434[a]	0.402[a]
	(0.0325)	(0.0325)	(0.0324)	(0.0316)	(0.0324)	(0.0316)
Transhipment		-0.610[a]				
		(0.0272)				
Transhipments_Number			-0.271[a]	-0.264[a]	-0.513[a]	-0.482[a]
			(0.0113)	(0.0113)	(0.0316)	(0.0417)
Transhipments_Number^2					0.0940[a]	0.0881[a]
					(0.00984)	(0.0146)
Exporter FE	Yes	Yes	Yes	Yes	Yes	Yes
Importer FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	201189	201189	201189	201189	201189	201189
pseudo R^2	0.950	0.951	0.952	0.953	0.952	0.953
ll	-8.87811e+09	-8.54299e+09	-8.52911e+09	-8.29563e+09	-8.49761e+09	-8.27951e+09

Note: Robust standard errors in parentheses (clustered by country pair). [c] $p < 0.10$, [b] $p < 0.05$, [a] $p < 0.01$.

Maximum number of transhipments

As mentioned above, the maximum number of transhipments allowed for is six. Without mentioning landlocked countries such as Georgia or the Republic of Central Africa, countries such as Denmark or Germany according to our computations could need up to 6 transhipments to reach some destination. As from a logistic point of view this may seem unrealistic, we redefined our maritime connectivity variable by imposing a more stringent constraint in terms of the maximum number of transhipments in the solution of our algorithm. Namely the number of transhipments cannot be larger than 3 for non-landlocked countries and no larger than four for landlocked ones. No more than 11 per cent of total observations are affected by this new constraint. No dramatic changes are observed in terms of effective maritime distance. Econometric estimations are shown in table 5. We do not report the specification where the binary maritime connectivity variable is used as estimated coefficients are only slightly modified compared to those shown in column (3) of table 3. This is not surprising in view of the strong correlation that exists between the two calculated maritime distances.

Generally speaking although all coefficients are affected, differences with respect to benchmark estimates are not dramatic. For instance, any additional transhipment translates into a fall in exports value of about 22 per cent. This could have been expected as the upper bound of the number of transhipment has been limited while the overall maritime distance has been modified only slightly. This combination of features also explains why the coefficient on maritime distance has increased in absolute value. Once again, the inclusion of interactions between exporter and time fixed effects and between importer and time fixed effects, as reported in columns (2), (4) and (6), do not affect the results. A perhaps important remark relates to the significant change in the estimated coefficient of the RTA dummy. It is systematically smaller than its counterpart of table 3. This is to say that when the number of transhipment is limited, we observe an amplification of the maritime distance effect together with a reduction of that of the existence of an RTA. This is not necessarily surprising as all measures are determinants of transport costs and they do not act independently from each other.

Columns (5) and (6) show cross-country estimates. Patterns described above are also obtained in this framework.

Zeros

The prevalence of zeros and asymmetric flows in the matrix of bilateral exports are well-documented stylized facts. Our database is no exception. Thirty eight per cent of all potential export relationships are not active. Amongst these 38 per cent, 12 per cent are characterized by a zero in both export directions and the remaining 26 per cent by a zero in one or the other direction. Opting for a log-linearized empirical model is not fully compatible with the existence of zeros in trade data. We imposed a truncation of the sample (that is, elimination of zero-trade pairs) as solution in our reference estimations. Nevertheless such truncation could bias significantly estimated coefficients. We thus implement the Poisson pseudo-maximum likelihood (PPML) estimator introduced by Gourieroux Monfort and Trognon (1984) and shown in Santos Silva and Tenreyro (2006) to deal appropriately with both the presence of zero exports observations and heteroskedasticity. The choice of the latter approach and not that of Helpman and al. (2008) is motivated by the fact in the latter consistent estimation of the structural parameters is only possible under the assumption that all random components of the model are homoscedastic.[7] This would be in clear contrast with available evidence. Results are reported in table 5. Columns (3) and (5) report estimates obtained with our restricted number of transhipments variable. Coefficients are not readily interpretable as it was the case in our log-linear model. Coefficients on dummy variables, while holding the other variables constant in the model, represent the difference in the logs of exports between the two categories identified by the dummy. The incidence rate ratio is the exponential of the coefficients. Estimates are not dramatically

[7] See Santos Silva and Tenreyro (2014) for a detailed discussion.

different from those obtained in our log-linear model based on intensive margin observations exclusively. For instance, as regarding our transhipment variable, column (2) estimates indicate that exports value is 46 per cent lower when there is no direct connection. Results in column (4) and (5) show that any additional transhipment is associated with a fall in exports value by 23 to 23.5 per cent depending on the maximum number of transhipments allowed for. Estimates for the RTA dummy when including any transhipment variable correspond to 55 per cent higher exports against the 41 per cent obtained in the reference estimation. As the distribution of our dependent variable is displaying signs of overdispersion we run two additional sets of regressions. Both assume that bilateral exports follow a negative binomial distribution. However, the negative binomial MLE may predict fewer zeros for a given mean than the observed number of zeros. Then, the second set of regressions also explicitly accounts for the over incidence of zeros which could be a cause of overdispersion. In that we follow Burger, van Oort and Linders (2009) who show that the problem of overdispersion and of excessive zeros can be addressed appropriately by zero inflated negative binomial MLE. Results are reported in table 6 and table 7 respectively. Results reveal differences in estimated impacts which are much more pronounced than those observed for the Poisson regressions. This is particularly the case for classical gravity variables. Being part of the same trade agreement is associated with an about 240 per cent higher value of bilateral exports. Differences are to a great extent smaller in the case of our transhipment variables. Estimated coefficients indicate that the absence of a direct connection is associated with a 42 per cent lower value of bilateral exports. Any additional transhipment is associated with an about 20 per cent lower value of bilateral exports. The zero-inflated negative binomial regression generates two separate models and then combines them. A logit model is generated for the zero cases, predicting whether or not the export relationship is active. We consider three different set of explanatory variables to be considered for the zero predicting model. The first set contains all explanatory variables of the non-zero- inflated negative binomial model and is behind the estimates of table 7. In the second set exporter and importer fixed effects are dropped. The last set is comparable to the second one except for the inclusion of some additional country and time specific variables. All of them reflect some the geographical characteristics of the country. Results are only marginally affected by the set of explanatory variables included. The overdispersion parameter is found to be significantly different from zero at the 97 per cent confidence level and is about 5 in all specification. This is likely to indicate that the Poisson distribution may not be the most appropriate. Moreover the Vuong z-statistic being always significantly positive, the zero inflated variant of the Negative Binomial estimator is preferable.

Table 6
Negative binomial regressions

	(1)	(2)	(3)	(4)	(5)	(6)
LN(maritime_distance)	-1.374[a]	-1.259[a]	-1.196[a]	-1.337[a]	-1.179[a]	-1.338[a]
	(0.0175)	(0.0185)	(0.0201)	(0.0207)	(0.0196)	(0.0207)
Language	1.320[a]	1.299[a]	1.301[a]	1.226[a]	1.291[a]	1.223[a]
	(0.0346)	(0.0349)	(0.0348)	(0.0353)	(0.0349)	(0.0353)
Colony	0.922[a]	0.878[a]	0.873[a]	0.916[a]	0.869[a]	0.915[a]
	(0.0704)	(0.0709)	(0.0698)	(0.0706)	(0.0703)	(0.0707)
Border	1.719[a]	1.603[a]	1.655[a]	1.470[a]	1.611[a]	1.448[a]
	(0.137)	(0.142)	(0.143)	(0.147)	(0.144)	(0.147)
LNGDPX	0.0417	0.0496	0.0492	0.0507	0.0441	0.0505
	(0.0968)	(0.0968)	(0.0967)	(0.0978)	(0.0966)	(0.0978)
LNGDPM	0.679[a]	0.667[a]	0.637[a]	0.646[a]	0.639[a]	0.650[a]
	(0.0992)	(0.0978)	(0.0975)	(0.0964)	(0.0970)	(0.0964)
RTA	0.926[a]	0.891[a]	0.891[a]	0.757[a]	0.872[a]	0.754[a]
	(0.0321)	(0.0317)	(0.0317)	(0.0314)	(0.0317)	(0.0314)
Transhipment		-0.545[a]				
		(0.0287)				
Transhipments_Number			-0.195[a]	-0.212[a]	-0.409[a]	-0.337[a]
			(0.0138)	(0.0130)	(0.0256)	(0.0321)
Transhipments_Number^2					0.0497[a]	0.0390[a]
					(0.00678)	(0.0105)
Exporter FE	Yes	Yes	Yes	Yes	Yes	Yes
Importer FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
N	201189	201189	201189	201189	201189	201189
pseudo R^2	0.086	0.086	0.086	0.087	0.086	0.087
ll	-1275803.1	-1275443.7	-1275407.3	-1274375.8	-1275268.4	-1274353.1

Note: Robust standard errors in parentheses (clustered by country pair). [c] $p < 0.10$, [b] $p < 0.05$, [a] $p < 0.01$.

Table 7
Zero-inflated negative binomial regressions

	(1)	(2)	(3)	(4)	(5)	(6)
LN(maritime_distance)	-1.004[a]	-0.879[a]	-0.847[a]	-0.975[a]	-0.837[a]	-0.970[a]
	(0.0131)	(0.0135)	(0.0141)	(0.0150)	(0.0140)	(0.0150)
Language	1.148[a]	1.116[a]	1.121[a]	1.044[a]	1.104[a]	1.036[a]
	(0.0276)	(0.0278)	(0.0277)	(0.0279)	(0.0278)	(0.0280)
Colony	0.805[a]	0.761[a]	0.760[a]	0.797[a]	0.761[a]	0.801[a]
	(0.0522)	(0.0526)	(0.0520)	(0.0523)	(0.0523)	(0.0525)
Border	1.577[a]	1.442[a]	1.490[a]	1.355[a]	1.446[a]	1.322[a]
	(0.0785)	(0.0805)	(0.0802)	(0.0817)	(0.0805)	(0.0818)
LNGDPX	0.125	0.138c	0.129	0.138c	0.131	0.135c
	(0.0820)	(0.0816)	(0.0818)	(0.0827)	(0.0815)	(0.0823)
LNGDPM	0.663[a]	0.662[a]	0.634[a]	0.647[a]	0.646[a]	0.653[a]
	(0.0720)	(0.0706)	(0.0709)	(0.0704)	(0.0703)	(0.0706)
RTA	0.922[a]	0.877[a]	0.885[a]	0.770[a]	0.865[a]	0.794[a]
	(0.0242)	(0.0238)	(0.0240)	(0.0239)	(0.0239)	(0.0238)
Transhipment		-0.606[a]				
		(0.0206)				
Transhipments_Number			-0.197[a]	-0.209[a]	-0.469[a]	-0.434[a]
			(0.00965)	(0.00930)	(0.0196)	(0.0244)
Transhipments_Number^2					0.0734[a]	0.0747[a]
					(0.00587)	(0.00832)
Exporter FE	Yes	Yes	Yes	Yes	Yes	Yes
Importer FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
N	201189	201189	201189	201189	201189	201189
ll	-1248838.2	-1247483.0	-1248168.6	-1247012.7	-1247678.2	-1247305.9

Note: Robust standard errors in parentheses (clustered by country pair). [c] $p < 0.10$, [b] $p < 0.05$, [a] $p < 0.01$.

5. CONCLUDING REMARKS

Despite the importance of trade costs as drivers of exchanges of merchandise goods between countries and of the geographical pattern of economic activity contributions to their understanding remain piecemeal.

This paper is a first assessment of the impact of the nature of maritime connections on bilateral exports of containerizable goods using a comprehensive set of country pairs observed over several years. Two variables, new to the gravity literature, are used to qualify the nature of maritime connections: a variable indicating the existence or not of a direct maritime connection (i.e. the existence of at least one operational shipping service) between two countries, and a variable resulting from an optimization algorithm indicating the number of transhipments necessary to connect two countries, including landlocked ones.

Our estimates suggest that the absence of a direct connection is associated with a drop in exports value varying between 42 and 55 per cent depending on the underlying empirical specification. Results also indicate that any additional transhipment is associated with a drop in exports value varying between 20 and 25 per cent. We also find evidence that the relationship between bilateral exports and the number of transhipments necessary to transport containerizable goods between two countries is likely to be non-linear. A causal relationship remains difficult to identify. We recognize that the existence of direct connection between two countries is expected to rely heavily on the intensity of their exchanges. We also recognize that the sensitivity of an established direct transport service to changes in demand on either side is expected to depend on the location of each country with respect to major maritime routes. This is to underline the otherwise possible existence of hysteresis in direct connections which are not necessarily sections of major maritime routes. We believe however that the inclusion of country fixed effects and demand related variables such as GDP does contribute to limit the incidence of a possible omitted variable bias. Reverse causality between bilateral exports and the existence of direct transport services cannot be excluded although we believe its scope is minor in our empirical set up.

Traditionally sea distance is assumed to be among the main determinants of freight rates and thus also of the trade competitiveness of countries. Our findings indicate that in the presence of an indicator of bilateral maritime connectivity, even under its simplest form, the impact of maritime distance clearly diminishes. The impact of other standard gravity variables is also significantly affected by the inclusion of such indicator.

Our results suggest that the quality of maritime connectivity is likely to be a preponderant determinant of foreign market access and eventually export performance. They provide for instance an estimate of the handicap in terms of export value landlocked countries have to face on top of the impact of the quality of transit transports.

LDCs and their development partners have set recently an ambitious goal of doubling the share of LDCs' exports in global exports by 2020. The development partners have agreed to realize timely implementation of duty - free quota - free market access, on a lasting basis, for all LDCs, with simple, transparent and predictable rules of origin; and the reduction or elimination of arbitrary or unjustified non-tariff barriers and other trade-distorting measures. However, these measures may not be sufficient. Our results indicate that the improvement of the quality of maritime connectivity should be at the core of any strategy aiming at stimulating exports. Such improvement could only contribute to the reduction of transport costs which continue to constitute the greatest impediment to LDCs' trade competitiveness.

Intervening efficiently on maritime connectivity is certainly not an easy task. Several options exist and their respective desirability could only reflect country specific characteristics. However, investing in infrastructures would be vital in all options. This would require a financial effort most countries are not able to bear alone. International cooperation and partnerships is thus crucial. International cooperation and partnerships could also take the form of establishing strategies aiming at creating incentives for shipping companies to serve destinations which are not necessarily profitable in first place. It could also take the form of granting companies serving "remote" countries some preferential access to major maritime hubs around the world.

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