Transport Costs in International Trade

by

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1 Introduction

Transport costs are one of the major components of trade costs along with tariffs, non-tariff measures and distribution costs. The cost of transportation in international trade can be defined as all shipping expenses of internationally traded good from origin point to destination point. It acts as a major determinant in location choice and clustering of economic activity. High cost of transportation of components makes production process slow and costly and force economic agents to operate at locations with good transport access, such as large international ports.

A usual way of modeling transportation cost is to relate it linearly with distance, as in Samuelson's iceberg cost function (Samuelson, 1952). While this

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approach allows transport costs to be neatly incorporated into trade model, it cannot fully explain relationship between costs and distance. Many empirical studies have found that transport costs tend to initially increase at decreasing rates with growing trade volume, but start decreasing at some point due to scale economy. This inverse U-shape relationship cannot be captured by distance alone.

Transport costs depend on many factors such as modes of transportation, infrastructure and geographical location. In addition, transportation cost for developing countries are much higher. Obviously, simple transport cost model as a function of distance cannot account for this complex and changing relationship between costs and their determinants.

In this paper I propose a new approach to measure transport cost taking into account so-called transport density. The transport density can be broadly interpreted as an efficiency of transportation network and infrastructure. Suppose that a route between two countries has a short distance. Taking apart economic incentives of comparative advantage, a large number of shippers will be attracted to use this route, which in turn stimulates infrastructure and transport development on the route[1]. However, absence of direct connection and existence of various geographical barriers like bad climatic conditions, mountainous terrain, or poor infrastructure and law enforcement, even between conveniently located economies creates dispersion of economic activity.

Inspiration came from the "shortest-path-problem", which is simply a

[1] Issue of transport density has been previously discussed by economic geographers. Tabuchi (1998) and Helpman (1998) noted that with the reduction of transportation cost, increase in transport density can lead to congestion, and increase in urban cost. While, Takatsuka and Zeng (2004) argue that technological improvement in transportation industry leads to decrease in urban costs, which implies a positive relationship between two costs..

minimization of distance between countries. The number of shortest paths between two countries is an approximate estimation of transport density: the bigger number of shortest paths going through the given route, the higher should be the number of shippers on this route and the higher the transport density. I calculate two transport density measures: potential density, which is a minimized distance between countries; and actual density, which is derived through minimization of actual transportation cost. The difference between actual and potential measures gives us an insight to the size of geographical, transportation and infrastructure barriers for transporting traded goods.

The transportation costs function is then estimated as a function of distance and density variables. The estimated coefficients provided correct sign with high significance for actual density and relative density variables. Then, the new measures are tested in trade gravity regression. The new measures are compared to alternative ones (cif/fob ratio, distance and border effects). Finally, I detail how such contributions can be of interest for economists who want to predict and quantify frictions arising from trading goods.

The rest of the paper proceeds as follows. Section 2 provides discussion on theoretical and empirical formulation of iceberg transport costs function, as well as its introduction into general equilibrium model of international trade. Section 3 estimates transport density variables. Section 4 provides robustness analysis of new variables, and compares them to alternative ones. Section 5 gives some insights on the gains that researchers could find in applying new variables in gravity models of trade, while Section 6 concludes.

2. Melting Iceberg in International Trade

2.1 Theoretical background

Geography is introduced into international economic theory in the form of an iceberg transport cost function, in which part of the good to be delivered 'melts' along the way by the very act of transportation. This iceberg formulation of transport cost was first introduced by Samuelson (1952) as analytical device to avoid problems associated with defining costs explicitly in geographical terms. Krugman (1991a, 1991b) initiated application of iceberg transport cost in economic geography models. It appears to be a convenient technique to avoid additional modeling of transport industry, and consistent with Dixit-Stiglitz (Dixit and Stiglitz, 1977) model of monopolistic competition.

Aspatial Samuelsonian iceberg function is explicitly defined as a continuous function of geographical distance. Krugman (1991a, 1991b) formulation of transport costs is:

$$T(d) = e^{-\tau d}, \tag{1}$$

where $T(d)$ is a transportation cost, τ is an iceberg decay parameter, d is a haulage distance. Long distance means high cost for transporting goods, and vice versa, close neighbors can trade with each other with much lower expenses on transportation.

Despite its popularity among economists, this interpretation of iceberg transport cost model has been criticized on several grounds. McCann (2005) criticizes Krugman's iceberg exponential functional form as an unrealistic assumption. He claims that this function is rather concave than convex with distance, which is not supported by empirical facts. Moreover, Ottaviano and Thisse (2003) argue that the iceberg assumption also unrealistically implies that any increase in the price of the transported good is accompanied by a proportional increase in its transport cost. Proponents of spatial representation of transport cost usually respond to criticism by saying that iceberg model incorporate not only distance-related transactions, but all other forms of trade costs, including information costs, institutional barriers, tariff barriers, quality standards and cultural differences.

Another theoretical representation of transport cost has been proposed by Mori and Nishikimi (2002). They define transport cost of intermediate products as a linear function of distance and increasing returns in transportation as following:

$$T(d,Q) = \begin{cases} d & \text{if Q} < \sigma \\ d\,\sigma/Q & \text{if Q} \geq \sigma' \end{cases} \tag{2}$$

where d is a distance, Q and σ are measures of transportation density: Q is an actual traffic density, while σ is a positive constant indicating the degree of density economies. Transportation density means a number of traffic passing through a particular transportation link. Thus, up to some threshold level σ, the transport rate per distance equal to one, but beyond σ, the transport rate decreases as the transport density increases. Value of σ is a parameter, which is defined exogenously.

Actual density is a function of distance and trade costs here. According to the formulation, the geographically closest transport link can attract many firms to the country, which in turn enlarges the transport demand there, generating far greater transport density. The extent to which increase in actual density occurs depends on the size and spatial distribution of demand for manufactured goods, and the size of trade barriers. For example, if two countries are geographically close to each other, then the traffic movement should be high, which is represented by high geographic density.

Let's now assume that threshold level σ is not some constant, but rather a potential level of transport density, which indicates a degree of transport density under the assumption that only distance determines transport costs. Then define transport cost as a function of distance and relative density as following:

$$T(d,Q) = d\,\sigma/Q \tag{3}$$

In this setting, σ is defined by distance induced traffic agglomeration process, or in other words, the higher distance between two points, the lower the potential density. Actual density Q is defined by actual agglomeration process, or generated by actual transport costs. High actual transport cost is associated with small actual density.

The ratio between two density measures vaguely represents other than distance transport barriers, like efficiency of transportation facilities, quality of infrastructure and other barriers, as well as changes in tastes and preferences of consumers. If $\sigma/Q>1$ between two countries, then potential density is higher than actual density due to disrupt of market demand or trade barriers, and transportation costs is higher than distance between those countries. If $\sigma/Q<1$, then vice versa, actual transport density higher than potential due to high demand for this particular link. The existence of various barriers increases the cost of transportation between two counties, and consequently reduces the actual transport density between two countries. Barriers limit the size of transport demand, and hence, limit the scale of density economies attainable. Relative density here is not a pure proxy of trade barriers and can also include some changes in market demand and consumer preferences.

2.2 A model of trade with transport costs

Assume a new trade theory model with a single horizontally differentiated good, which is produced with two factors of production capital and labor, and traded between countries of different size and relative factor endowments. Consumer preferences are characterized by a "love for variety" so that the Dixit and Stiglitz (1977) constant elasticity of substitution (CES) demand assumptions apply.

A firm in a country i produces a single good for domestic consumers by x_{ii} and for consumers abroad in country j by x_{ij}. For each good shipped from i to j the exporter incurs shipping costs equal to $\left(t_{ij}-1\right)$ of country i good. Equilibrium exports in this model are known to be:

$$n_i p_i x_{ij} = n_i \left(\frac{p_i t_{ij}}{P_j}\right)^{1-\varepsilon} y_j, \tag{4}$$

where n_i denotes the number of firms (varieties) originating from country i; p_i is the producer price; y_j is the total income in country j, and

$$P_j = \left(\sum_{i=1}^{C} n_i \left(p_i t_{ij}\right)^{1-\varepsilon}\right)^{\frac{1}{1-\varepsilon}}, \tag{5}$$

is aggregate CES price index of country j. Equation (4) is an exports demand equation, which is positively related to domestic variety n_i and foreign cost p_j; and negatively related to foreign variety n_j and domestic cost p_i. And finally, bilateral exports decline in response to increase in transport costs.

I insert transport costs function, defined by equation (3) and concentrate on bilateral exports normalized by importer's income:

$$\frac{n_i p_i x_{ij}}{y_j} = n_i \frac{\left(p_i\left(d_{ij}\frac{\sigma_{ij}}{Q_{ij}}\right)\right)^{1-\varepsilon}}{\widetilde{P_j}}, \quad \text{where} \quad \widetilde{P_j} = P_j^{1-\varepsilon} \quad \text{and} \quad t_{ij} = d_{ij}\frac{\sigma_{ij}}{Q_{ij}} \tag{6}$$

Further, taking the log of equation I focus on comparative static analysis and look at separate effects of all determinants of transport costs. First, an unambiguously negative distance effect can be identified for distance as:

$$\frac{\partial \ln\left(n_i p_i x_{ij} / y_j\right)}{\partial \ln\left(d_{ij}\right)} = -\left(\varepsilon - 1\right)\left(1 - \frac{n_i\left(p_i\left(d_{ij}\frac{\sigma_{ij}}{Q_{ij}}\right)\right)^{1-\varepsilon}}{\widetilde{P}_j}\right) = -\left(\varepsilon - 1\right)\theta < 0 \tag{7}$$

Similarly, and most importantly for our purposes, bilateral exports decline in relative transport density:

$$\frac{\partial \ln\left(n_i p_i x_{ij} / y_j\right)}{\partial \ln\left(\frac{\sigma_{ij}}{Q_{ij}}\right)} = -\left(\varepsilon - 1\right)\theta < 0 \tag{8}$$

If I look at separate effect, then potential density should have a negative effect on bilateral trade:

$$\frac{\partial \ln\left(n_i p_i x_{ij} / y_j\right)}{\partial \ln\left(\sigma_{ij}\right)} = -\left(\varepsilon - 1\right)\theta < 0 \tag{9}$$

While increase in actual transport density increases bilateral exports:

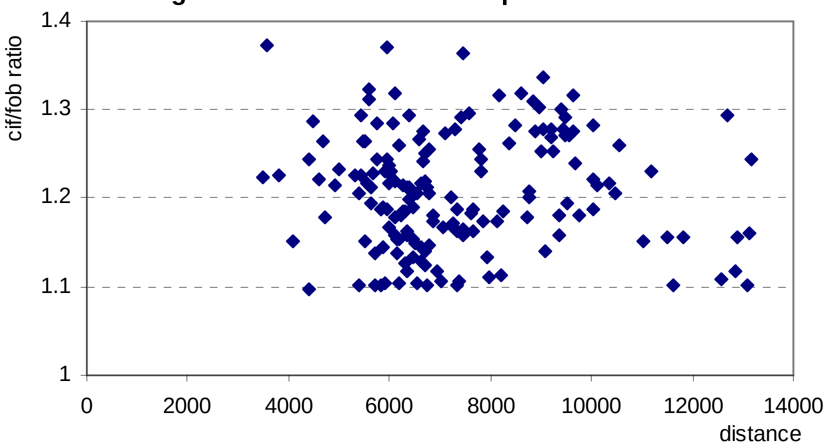
$$\frac{\partial \ln\left(n_i p_i x_{ij} / y_j\right)}{\partial \ln\left(Q_{ij}\right)} = \left(\varepsilon - 1\right)\theta > 0 \tag{10}$$

The basic intuition behind these effects is simply that in general transport costs have negative effect on volumes of trade, however continuous development of transportation network positively affect trade by improving quality of transport infrastructure and reducing transport costs.

2.2 Empirics of transport costs

I now turn to review of empirical implications of transport cost function. A number of authors have recently conducted an empirical investigation of the determinants of transport costs (Limao and Venables, 2001; Mico and Perez, 2002; Clark, Dollar and Mico, 2004; Egger, 2005; Combes and Lafourcade, 2005; Martinez-Zarzoso and Nowak-Lehmann, 2006). These studies showed significant positive linear correlation of distance and transport costs. However, almost all researchers agree that distance only cannot explain variability in transport cost. For instance, Radelet and Sachs (1998) find that a 10% increase in sea distance leads to a 1.3% increase in transport costs only. Limao and Venables (2001) add that distance explains only 10% of the transport costs variability. Using Philippine imports data, Kuwamori (2006) concludes that distance only does not capture all transport costs. Figure 1 below plots distance against cif/fob ratio. It is evident that countries equally remote from their trade partners do not have same transport costs.

Figure 1: Distance and transportation cost



There many other factors that determine transport costs. Transport costs include many various factors, and cost of overcoming distance is one of them. Besides distance, time has appeared to be very important definition of transport cost, when shippers are ready to pay a large premium for not waiting too long for delivery. Geographical differences, like mountainous terrain, are another effects, which can arise when some factors can create delays on one way of the trip. Transport mode refers to level of development of transport infrastructure (roads, rails, airports, sea ports) and characteristics of vehicle used (cars, trucks, airplane, ship). Absence of access of landlocked countries to sea routes makes them to pay a higher costs of inland transportation, and sometimes creates incentives for air carriers to impose discriminating prices for transportation services. The nature of commodity like perishability, size dangerousness also makes transport costs more or less expensive.

In addition to Hummels (1999) and Hummels (2001), Limao and Venables (2001), Micco and Perez (2002), Martinez-Zarzoso and Suarez-Burguet (2001) emphasize the role of quality of transport infrastructure, geographic conditions, the type of transport used, energy prices, trade imbalances, transport mode, competition and regulations as the most important factors explaining the variations in transport costs across countries.

Despite the increased recognition of the importance of transport costs in international trade, most empirical studies in international trade that commonly use gravity equations, replace transport costs with geographic distance. Even though estimated coefficients of distance variable are always statistically significant with the correct sign, criticism of distance related trade regressions suggests, that if embedded into the gravity model, it does not reveal whether the impact of distance on trade flows is primarily via the impact of distance on transport costs or on the impact of transport costs on trade volumes (Overman et al, 2001). In addition, distance does not vary across time and commodity, this is why this measure is useless to capture time-series and cross-commodity variations in transport costs. Kuwamori (2006) investigates a detailed trade data of Philippines and found that even overall import increases at about 29 percent as distance doubles, the cross-commodity estimation provides a conflicting results.

Similar to transport costs regression, Bougheas et al (1999) found a significant effect of cross-border infrastructure on bilateral trade [2], however they use infrastructure data on source and destination countries rather than infrastructure development on the way between those countries. Using Spanish trade with Turkey and Poland, Martinez-Zarzoso and Nowak-Lehmann (2006) found significant impact of the quality of services and transport condition, and transit time, as well as port production and efficiency.

3. Estimation of Transport Density

3.1 Data and method

The core of calculations is a shortest path algorithm that has been extensively applied in network economics, including transportation engineering (Bank, 1998), computer network routing (Kurose and Ross, 2000) and even scientific collaboration networks (Newman, 2001). A "shortest-path-counting-problem" (SPCP), which is the number of shortest paths passing each edge was applied by Oyama and Taguchi (1991), and later extended by Oyama and Morohosi (2004) to real road network in Japan to evaluate the level of congestion for each road segment in Japan.

Shortest path problem can be stated in many ways. In graph theory, the single-source shortest path problem is the problem of finding a path between two vertices such that the sum of the weights of its constituent edges is minimized. In transportation network vertices would represent the cities, the edges would represent the roads, and the weights would be the transport cost or distance of that road. Given a number of cities and the costs of traveling from any city to any other city, "shortest path problem" represents the lowest cost trip from one city to another.

Following the standard approach in international trade theory, I assume that

[2] The product of two countries' infrastructure scaled by distance between the two countries

all countries are dimensionless points. I look at the World Atlas and think of countries as a set of nodes in a transportation network, which is described by an undirected and connected graph (N, E): a set of N={1,2,…N} of nodes which are connected by a set of E edges. Two countries i and j for which there exists and edge $(i,j)\in E$ are called neighbor countries. I further denote by $c_{(i,j)}\geq 0$ the capacity of the edge, which may be loosely interpreted as the cost of 'crossing' it. A path between two nodes i and j is a sequence $H=\{(i,k_1),(k_1,k_2),...,(k_n,j)\}$ of edges linking them. A graph is said to be connected if there exists at least one path between any pair of nodes $(i,j)\in N$. In what follows, I focus exclusively on graphs with at most one edge between each pair of nodes. Since countries are dimensionless points, they are assumed to be same in size, shape, geographical and economic features.

Shipping between two countries i and j occurs along a path P of the network linking the origin and the destination country. Arbitrage by profit maximizing firms ensures that shipping always occurs along the lowest cost route. Capacity of each edge is determined by distance-related costs. More formally, let H_{ij} denote the set of all paths between i and j, and d stands for the 'iceberg' coefficient between two countries. Then, the traveling cost between i and j is the overall cost calculated along the minimum distance path:

$$\delta(i,j)=\delta_{ij}=\min_{P\in P_{ij}}\sum_{(l<m)\in P}d_{lm},\ \text{with}\ \sum_{(l<m)\in P}d_{lm}=d_{ik1}+d_{k1k2}+...+d_{knj} \tag{14}$$

Using transport cost data I assume another type of network, which calculates the lowest transport cost path from one country to another. Because transport cost is a share of a good that has melted along particular segment, in this case minimum transport cost path is product of transport costs for all segments of the path P:

$$\varphi(i,j)=\varphi_{ij}=\min_{P\in P_{ij}}\prod_{(l<m)\in P}T_{lm},\ \text{with}\ \prod_{(l<m)\in P}T_{lm}=T_{ik1}T_{k1k2}...T_{knj} \tag{15}$$

In accordance to definition derived above the number of shortest path per each segment of the network represents the potential level of transport density σ, and number of cheapest path represents actual transport density Q.

$$\sigma_{ij}=\sum\delta\ \text{ for segment between i and j} \tag{16}$$

$$Q_{ij}=\sum\varphi\ \text{for segment between i and j} \tag{17}$$

A network of 170 countries is created with data on distance and CIF-cost between each country pair. As it was mentioned before cost is represented by two proxies: distance and cif/fob ratio. Haulage distance is calculated with a great-circle distance formula between capital cities of each countries pair[3]. The CIF/FOB ratio is derived from IMF's Direction of Trade Statistics (DOTS) data. In this database exports are valued on FOB price, while imports on CIF price, and all data are represented in matrix form from reporting country to all partner countries. Transposed imports matrix can be treated as exports on CIF price, so CIF/FOB ratio is calculated by dividing transposed imports matrix on exports matrix. There are some complications with this data that arise because of discrepancies in trade statistics of different countries[4]. Many missing and zero values do not necessarily mean absence of trade but rather unreported values. Asymmetric CIF/FOB ratios appear when exports costs are different from imports costs. Very high or very small

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[3] Distance data is taken from USDA website: http://www.wcrl.ars.usda.gov/cec/java/capitals.htm.
The Great Circle Distance Formula
r * acos[sin(lat1) * sin(lat2) + cos(lat1) * cos(lat2) * cos(lon2 - lon1)]
Where r is the radius of the earth, lat1 and lat2 are latitude, lon1 and lon2 are longitude of two cities.

[4] Hummels and Lugovsky (2003) analyses cif/fob ratio data and provide evidence for biasedness of data. They conclude that although data cannot be used for cross-coomodity and cross-time analysis, it provides good estimate for transportation costs in a cross-country analysis.

CIF/FOB ratios also point to underreported data problem. In order to deal with data problem, I delete all cases when cif/fob ratio is smaller than 1 (cif price cannot be smaller than fob price) or bigger than 5 (cif price cannot be bigger than 5 times of fob price).

I calculate shortest paths for different type of network using Dijkstra's algorithm, which is based on assigning temporary labels to nodes, the label on a node being an upper bound on the path length from origin to that node. These labels are then continuously reduced by an iterative procedure and at each iteration exactly one of the temporary labels becomes permanent indicating that it is no longer an upper bound but the exact length of the shortest path from origin to the node in question. Computations of SPCP are performed on XPRESS–MP Dash-optimization package.

3.2 Results

Table 2 below reports result of SPCP computations. Each number is average count of shortest paths passing through all network segments that this group of countries is involved. Number of shortest paths for distance cost variable is σ and number of shortest paths for transport cost variable is Q, and last column shows average relative density. I take averages of shortest paths counts for each country, and report data for three country groups: landlocked countries ('LLC), transit coastal countries ('TRN), islands ('ISL') and non-transit coastal countries ('Others'). The lower part of the table provides average counts of shortest paths going through bilateral segments connecting various groups of countries with the world.

Table 2: SPCP results

Countries	#	σ	m Q	σ/Q
Landlocked (LLC)	**33**	241	501	0.95
Islands (ISL)	**34**	252	445	0.96
Transit (TRN)	**45**	261	959	0.72
Others	**58**	249	846	0.78
All countries	**170**	251	729	0.83
Landlocked with world		2.72	6.02	1.05
Islands with world		2.74	5.13	1.69
Others with world		2.49	7.73	1.05
All		2.58	7.48	1.30

Results are quite interesting. In all cases transit countries have a biggest number of paths going through their territory: this explain the beneficial position of those countries. Although average σ for landlocked countries is lowest, the average number of cheapest paths going through landlocked countries Q is higher than those of islands. This can be explained by beneficial position and low transport costs of European landlocked countries. Without those countries the average number of paths is 382, which is lower that average for islands.

If I assume that a country can trade through all routes passing its territory, then the maximum number of paths would give a maximum utility for this country. If cost of transporting goods is zero, then any representative merchant would choose the shortest path for her exports. But with the existence of other than distance costs her payments increase. Then the difference between total estimated value and geographic component would give me approximate estimate for other than distance components of transport costs, which I call 'relative transport density'. In Table 2, the σ/Q reports relative transport density for all groups of countries. Without European countries landlocked counties put in a very disadvantaged position with a relative density number of 1.06 which makes number of paths predicted by haulage distance on average bigger than number of paths predicted by cif/fob ratio.

4 Robustness: Functional Form and Alternative Dependent Variables

Here I estimate the transport cost function as it has been defined by equation (3). That is I regress transport cost on haulage distance and relative density variable. To control for idiosyncratic characteristics of reporting and partner countries I add fixed effect dummies for each country.

Table 3: Transport cost function

(Dependent variable: log of cif/fob ratio)

	(1)	(2)	(3)	(4)
Distance	0.10 [0.032]	0.11 [0.032]	0.08 [0.021]	0.13 [0.017]
Common border dummy	- 0.04 [0.104]	- 0.06 [0.104]		
Landlocked country dummy	0.11 [0.109]	0.03 [0.053]		
Island dummy	0.00 [0.000]	0.00 [0.000]		
Infrastructure		- 0.05 [0.009]		
Percapita GDP		- 0.04 [0.014]		
Neighbor's infrastructure	0.50 [0.119]	0.03 [0.019]		
Patner country neighbors' infrastructure	0.00 [0.028]	- 0.36 [0.344]		
Potential transport density			0.01 [0.028]	
Actual transport density			- 0.15 [0.007]	
Relative transport density				0.13 [0.008]
Country fixed effects	Reporter and partner fixed effects	Partner fixed effects	Reporter and partner fixed effects	Reporter and partner fixed effects
Observations	3979	3979	8277	8277
R-squared	0.42	0.33	0.43	0.43

Notes: All varaibles, except dummy variables are in natural logarithms. Robust standard errors are in brackets

Table 3 shows result of linear estimation of transport cost. There are four regressions in the table: first two columns present alternative determinants of transport cost, while the last two columns show regression results for density variables. Distance variable has strong effect as expected: the longer the distance, the higher is the transport cost. Surprisingly, geographical dummies for landlocked countries, islands, and common border dummy do not have any significant effect on cif/fob ratio. Infrastructure, which is proxied by road density, has a crucial negative impact on transport cost: the higher the number of roads per area of a country, the lower the transport cost. However, coefficients on neighbors' infrastructure variable either are statistically insignificant or have wrong sign. Higher per capita GDP is associated with lower transport cost. It is noteworthy that the point estimates of all density variables are in line with the theoretical predictions. One percent increase in actual density lead to development of transport facilities and 0.15 percent decrease in transport costs. Potential density is a potential quality of transport facilities and that is why it does not correlate with transport costs. A point estimate shows that one percent increase in relative density leads to a 0.13 percent increase in transport costs. Estimated R-squared is higher in last two regressions, indicating the importance of transport density for transport cost.

5 International Trade, Geography and Transport Costs

The trade model, based on Equation (9), is estimated and results are presented in Table 4. I examine impact of density variables on trade flows and compare it with alternative specifications with distance and geographical variables, as well as cif/fob ratio.

Model (1) regresses conventional geographical variables, and exporter's GDP and GDP per capita on bilateral imports to GDP ratio. All variables have theoretically correct signs and are statistically significant. In Model (2) I replace geographical variables with a cif/fob ratio. As expected, the cif/fob ratio has negative sign and statistically significant. In Model (3) the cif/fob ratio is replaced with potential and actual density measures along with distance. Our measure for potential density is not statistically significant, but actual density is significant and negative. In Model (4) potential and actual density variables are replaced with relative density variable. As expected, the relative density variable has a negative sign and is statistically significant.

Table 4: International trade and transport costs

(Dependent variable – Log of bilateral exports over importer GDP)

	(1)	(2)	(3)	(4)	(5)
Exporter GDP	1.67	1.61	1.13	1.12	1.06
	[0.058]	[0.070]	[0.028]	[0.024]	[0.031]
Exporter GDP percapita	0.65	0.30	0.25	0.26	0.24
	[0.136]	[0.298]	[0.084]	[0.087]	[0.109]
Cif / fob ratio		-0.36			
		[0.022]			
Distance	-1.65		-1.71	-1.72	-1.74
	[0.032]		[0.040]	[0.034]	[0.034]
Common border dummy	1.00				
	[0.150]				
Lanlocked country dummy	-0.29				
	[0.061]				
Island dummy	0.53				
	[0.061]				
Potential density			-0.03		
			[0.058]		
Actual density			0.06		
			[0.021]		
Relative density				-0.06	-0.04
				[0.021]	[0.027]
Interaction term 1:					-0.17
Relative density x Landlocked dummy					[0.038]
Interaction term 2:					0.09
Relative density x Island dummy					[0.040]
Constant	-55.77	-63.63	-38.92	-38.58	-36.71
	[0.916]	[3.984]	[1.316]	[1.236]	[1.541]
County fixed effects	Partner fixed effects	Partner fixed effects	Partner fixed effects	Partner fixed effects	Partner fixed effects
Observations	11122	10070	8210	8210	8210
R-squared	0.66	0.58	0.68	0.67	0.68

Notes: All varaibles, except dummy variables are in natural logarithms. Robust standard errors are in brackets

It is well-known that historically coastal countries experience faster economic development because they had direct access to world markets, while landlocked countries stayed apart from global developments because of isolation. Islands are usually distantly located from other countries, however development of marine transportation should have helped them to overcome distance and get a better access for their commodity trade. Thus, by looking at number of shortest paths for each country group I assess benefits of coastal countries and disadvantages of islands and landlocked countries. A one percent increase in relative density of landlocked countries lead to a 0.17 percent decrease in their trade volumes. And one percent increase in marine transport development lead to 0.09 percent increase in trade of islands.

6 Conclusion

Clearly, the methodology presented here could overcome the lack of reliable data in international trade and economic geography, while bringing usual proxies together into a single measure of transport costs. Separate national statistical data would be the more precise in estimating transport costs, however bringing all national statistics data into one single unit would encompass and large amount of extra costs. The challenge in measuring trade frictions stemming from transport costs is to get homogenous data sets that are comparable across countries and not unique and specific to one of them. Our methodology appears to be easily applicable to international data.

The use of cif/fob ratio as a proxy for transport costs has been criticized for its unreliability. Hummels and Lugovsky (2003) also point out that it can be error-ridden in levels, and contain few useful information for time series or cross-commodity variations. Nevertheless, unlike distance, it can change across time and type of commodity, making it good measure for testing our hypothesis.

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