Gravity and Globalization*

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Abstract

This paper presents a solution to the empirical puzzle of the persistent effect of distance on international trade. The main contribution of the paper is to show that globalization has an undetermined impact on the elasticity of distance. I argue that the process of globalization corresponds to a simultaneous reduction of trade costs (distance and non-distance related) and barriers to production decentralization. I show that a reduction in trade costs due to a reduction in transport costs unequivocally reduces the magnitude of the distance elasticity. In contrast, a reduction in the portion of trade costs unrelated to distance (e.g. tariffs or communication costs), can either increase or decrease the magnitude of the distance elasticity. I also show that a reduction of the barriers pertaining to decentralizing production increases the magnitude of the distance elasticity in countries that are technologically more developed, while the opposite effect occurs for less technologically developed countries. Finally, I provide empirical evidence in favor of these results and show that the changes in the composition of trade costs are the main explanation for the evolution of the distance elasticity over time.

JEL classification codes: C20, F10, F23.

Key Words: Trade, Gravity Model, Globalization.

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1. INTRODUCTION

A well-established empirical result in the trade literature is that, over time, the coefficient of distance in the context of a gravity model has remained persistently high. This result is puzzling because, intuitively, people expect that as the world becomes more globalized the effect of distance on international trade should decrease. Empirically, this is not verified. Not only does the magnitude of the distance elasticity not decrease, in some cases the opposite occurs. That is, the magnitude of the distance elasticity increases. This result of persistently high distance elasticity is illustrated in Figure 1.

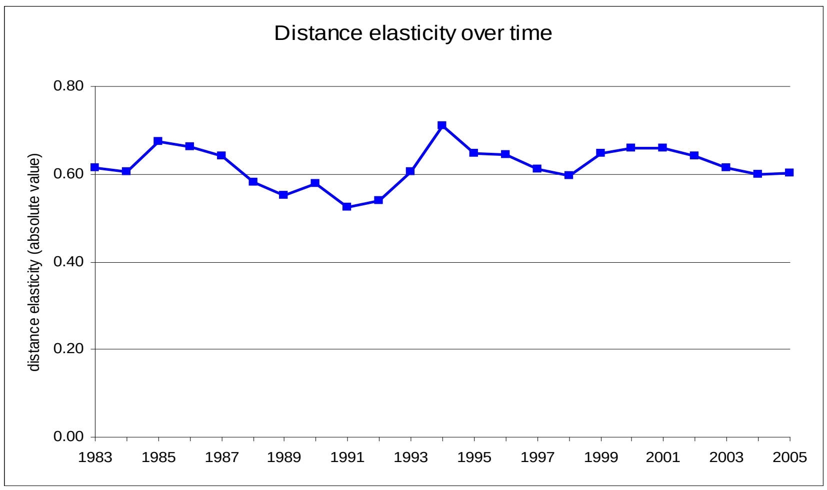


FIG.1 - Distance elasticity estimates over time, author's estimation.

One possible justification for the time evolution of the distance elasticity is that the assumption that the world has become more globalized is incorrect. Therefore, Figure 1 just reflects this fact. To contradict this idea, I show in Figure 2 the evolution of ad valorem air freight costs between 1974 and 2004. During this period, the average ad valorem transportation costs decreased roughly 4 percentage points (or around 25%) from 13% to 9%. If the distance elasticity is only capturing the effect of transportation costs on trade, then it is curious that while transportation costs decline, the distance elasticity does not.

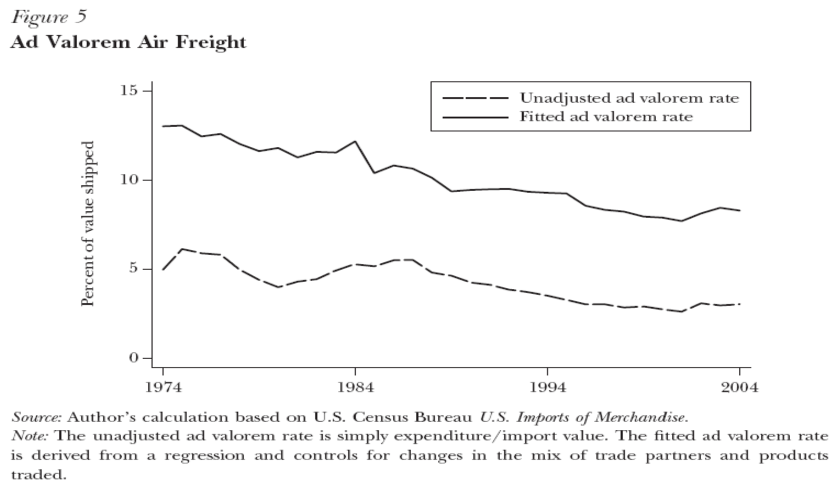


FIG.2 - Ad valorem air freight over time, source Hummels (2007)

What can explain the apparent inconsistency of Figures 1 and 2? I claim that two factors need to be considered. First, although the component of trade costs that is related to distance has decreased, consideration must be given to the components of trade costs that do not depend on distance. Second, despite the fact that the gravity model is a model used to understand the geography of trade, there is nothing in the model that controls for changes in the geography of production. Related to these two points, Figure 3 shows that tariffs, a component of trade costs that is less related to distance, have decreased significantly during the last two decades, and Figure 4 shows that at the same time there has been a dramatic change in the geography of production caused by a generalized increase of FDI stocks.

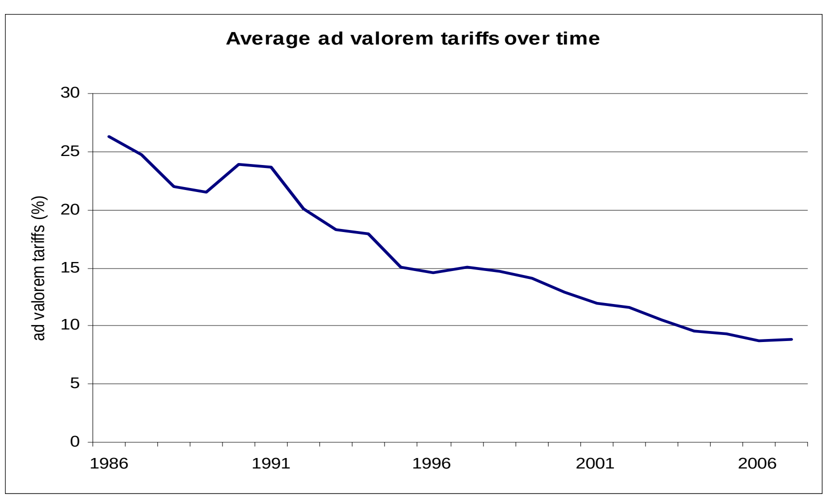


FIG.3 - Average ad valorem tariffs over time - source World Bank.

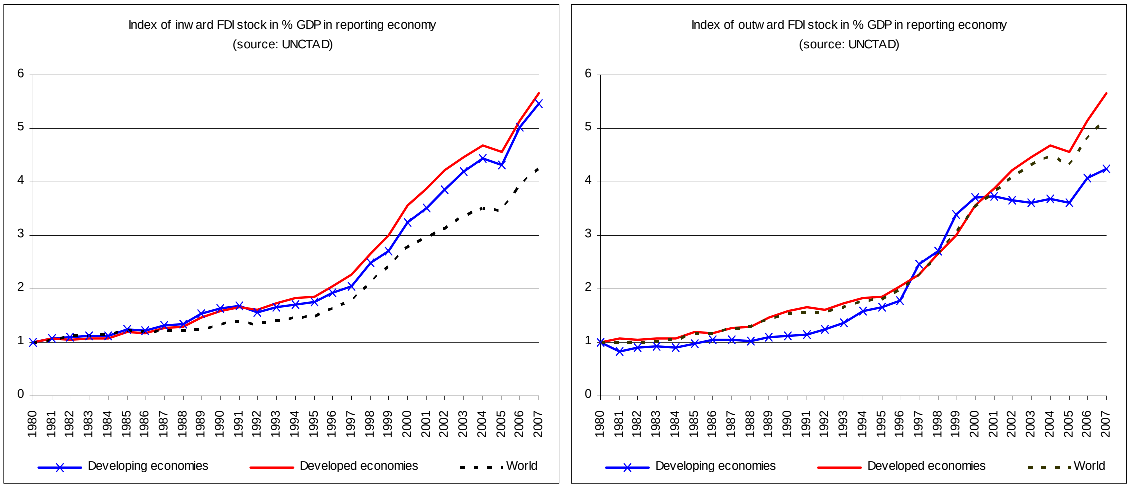


FIG.4 - Inward and outward FDI stock as % of GDP - source UNCTAD.

An obvious question is how do Figures 3 and 4 help explaining the apparent inconsistency between Figures 1 and 2? First, as tariff rates fall, the relative composition of trade costs changes. This is because tariffs are less related to distance than transportation costs and therefore the relative importance of distance for international trade increases. Second, when the barriers to FDI decrease there is an increase in the stocks of FDI in the global economy. The implication is that the distribution of production capacity also changes. Some countries substitute exports for FDI, and consequently they export to shorter distances. Other countries become more competitive due to FDI inflows, and therefore will have their exports less affected by distance. If we accept that Figures 2, 3 and 4 summarize economic globalization, then Figure 1 could exhibit any shape (flat, increasing, decreasing, U-shaped, hump-shaped, etc.) and still be consistent with a more globalized economy. The shape of Figure 1 only reflects the relative strength of the factors illustrated by Figures 2, 3 and 4.

The main contribution of this paper is to show that the distance elasticity, in the context of a gravity model of international trade, does not only reflect the direct importance of (physical) distance, but also reflects the relative importance of transportation costs in trade costs and the existence of alternatives to exporting products. I first show how these mechanisms work using a well-known model of trade and then provide empirical evidence.

The remainder of the paper is organized as follows: in section 2 I review the relevant literature; in section 3 I adapt the Eaton and Kortum (2002) model of trade to show how transportation costs, tariffs and barriers to FDI affect the distance elasticity; in section 4 I estimate a gravity model that controls for the average tariff rate facing exporters and inward and outward FDI stocks of exporting countries; finally, section 5 presents concluding remarks.

2. LITERATURE REVIEW

In this section I review the most relevant literature regarding the topic of the paper. The section is split into three parts, covering the history of the gravity equation, the persistent effect of distance on trade, and globalization.

The gravity model[1]

The origins of the gravity model applied to international trade go back to 1962, when for the first time Tinbergen (1962) suggested its utilization. The idea of the gravity model applied to international trade is very simple and very similar to Newton's law of universal gravitation. According to Newton's law of universal gravitation, the gravitational force between two point masses is given by the equation:

$$F = G\frac{m_1 m_2}{d^2}, \tag{1}$$

where F represents the gravitational force between point mass 1 and 2, m_1 and m_2 are the mass of point mass 1 and 2, respectively, G is the gravitational constant and d is the distance between the two point mass. Tinbergen's formulation of the gravity model of trade is highly inspired by equation (1) and it is equal to the following equation:

$$X_{1,2} = A\frac{GDP_1 GDP_2}{d^\gamma}, \tag{2}$$

where $X_{1,2}$ are the exports from country 1 to country 2, GDP_i is the GDP of country $i = 1, 2$, A is some constant and d is the distance between the two countries. The similarities between the two equations are obvious, with the most significant difference coming from the impact of distance. While in Newton's formulation, the term of distance has an exponent of 2, Tinbergen did not impose any value and allowed the data to speak for itself. Due to its outstanding empirical properties, equation (2) became very popular in the international trade literature. Nevertheless, this model was criticized for its lack of a theoretical foundation. The first author to successfully propose a theoretical structure that is compatible with (2) was Anderson (1979). He proposed a model in which it was assumed that countries produced

[1] This part of the text is mostly based on Feenstra (2008).

different goods, and from there he derived a trade equation that was similar to equation (2). The central assumption of Anderson's (1979) model was that countries produced different goods, and from there he derived an equation for trade flows that depended on transportation costs and on the size of the countries. Besides Anderson (1979), there are other authors who used the same assumption of country-specific goods to derive, and in some cases estimate, a gravity model that is micro-founded; examples are Bergstrand (1985; 1989), Helpman (1987) and Anderson and van Wincoop (2003). An alternative to assuming country-specific goods is to assume homogenous goods, that is, every good can be produced in any country, and this was the assumption made by Eaton and Kortum (2002) to show an alternative theoretical foundation for the gravity equation.

Even though the gravity equation in economics has been used primarily in the context of international trade, there are examples of applications where the dependent variable is not exports. For instance, Eaton and Tamura (1994) and Head and Ries (2005) use a gravity equation to model FDI, while Engel and Rogers (1996) study the variance in prices across cities by means of a gravity equation.

The persistent effect of distance on trade

Frances Cairncross, in her 1997 book, "The Death of Distance", suggested that changes in telecommunications would make distance obsolete in the sense that economic activities would be equally distant from each other. Despite being a reasonable idea, the truth is that such a result is not visible in trade data. One of the first papers to mention this fact was Leamer and Levinsohn (1995) - "... Leamer's (1993) estimated elasticities in 1985 are not dramatically smaller than the 1970 elasticity." Several more recent papers have shown exactly the same: Brun et al. (2005), Carrere and Schiff (2005), Disdier and Head (2008), and Berthelon and Freund (2008) are some examples. Brun et al. (2005) estimate a panel gravity model and conclude that the magnitude of the coefficient of distance decreases over time. Carrere and Schiff (2005) approach the problem differently and instead of estimating the impact of distance on trade using a gravity model, they calculate the weighted average distance of trade for various countries. They show that for the majority of countries this distance has decreased over time which is akin to an increase in the impact of distance on trade. In both papers, the authors justify the increase of the impact of distance on trade by changes in the composition of trade costs, that is, the non-distance related trade costs decreased more than the distance related trade costs. This explanation is similar to part of my explanation, but there are important differences. These differences will become clear in sections 3 and 4 of this paper. Disdier and Head (2008) analyze 103 different papers that have estimated the effect of distance on trade and show that in the vast majority of these papers the effect of distance did not disappear and in many cases actually increased over time. Berthelon and Freund (2008) use disaggregated data to test the idea that changes in the product mix caused the distance elasticity to not decrease over time. The conclusion of these authors is that there is no evidence of such effect. What these authors find is that products with higher elasticities of substitution experienced the highest increase in the effect of distance.

One of the few papers that obtains a decreasing effect of distance is Coe et al. (2007). In this paper, the authors claim that by using a non-linear estimator to estimate the gravity equation they obtained an effect of distance that is decreasing over time. In my own estimates I also use a non-linear estimator, but I am not able to replicate such a finding. A final paper that is worth mentioning is Buch et al. (2004). The authors of this paper claim that if distance were reduced for all countries in the same proportion, then, there should not be any change in the coefficient of distance. Their claim is equivalent to assuming that trade costs are linear in distance and there are no other trade costs. It is well documented that this hypothesis is incorrect - see Anderson and van Wincoop (2004) or Hummels (2007).

Globalization

The topic of globalization is broad and rich enough to generate an entire library, and therefore no literature review on the topic could address all the aspects of globalization (even if only the economic ones). In that sense I am not even going to attempt to make a broad literature review regarding this subject, but instead I will focus on three components of globalization that are particularly important for this paper: transportation costs, tariffs and barriers to foreign investment.

Since countries, vis-a-vis economic activity, are separated by physical distance, the costs of transporting goods plays an important role in the process of globalization. That is, it is hard to think of a globalized economy where the costs of shipping goods from one continent to the other or simply just within a continent were so high that would be almost impossible to trade. In that sense, the level and changes in the level of transportation costs are a very important ingredient for a true economic globalization. Hummels (2007) showed that between 1974 and 2004 ad valorem air and ocean freight decreased substantially. It is important to mention that, although the ad valorem transportation costs decreased over this period of time, the cost per unit of weight either increased or remained constant.

Another important barrier to economic globalization is the existence of tariffs, one type of trade cost not directly related to distance. The imposition of tariffs creates a barrier to economic globalization as they create an artificial protection of local production at the cost of foreign production, which in many cases is obtained at higher productivity levels. The increase in preferential trade agreements and the effects of multilateral trade arrangements have led to significant reductions in trade tariffs and/or trade quotas. Clemens and Williamson (2004) estimate that between 1960 and 1995 average import tariffs dropped from 8.6% to 3.2%, while based on World Bank estimates between 1986 and 2007 average applied tariff rates dropped from 26.3% to 8.8%. Despite the large difference in the levels, both sources suggest that during the periods covered tariffs decreased by more than 60%. The reason to mention transportation costs and tariffs separately is that I am implicitly assuming that the former are directly related to distance while the latter are not. This is a rather strong assumption, but, as long as over time there was a force driving tariffs down that was common to all countries, this assumption is sensible. The driving forces that are common to most countries and have led to an overall reduction in tariffs are the GATT (General Agreement on Trade and Tariffs) and the WTO (World Trade Organization). Tomz, Goldstein and Rivers (2007) show that membership in GATT increases trade, which is due to a reduction in tariffs common to all members.

The last strand of literature that I find relevant for this paper is the literature regarding the impact that changes in barriers to foreign investment have on multinational firms' operations. The first paper that is worth mentioning is Lee and Mansfield (1996). In this paper the authors show that countries that increase protection of intellectual property are also countries that have an increase in FDI flows from the US. The idea here is that as firms face fewer threats to their assets when they expand their operations to other countries, the costs they face from doing investment abroad are smaller. Another paper along the same lines, but focusing on changes in capital controls, is Desai, Foley and Hines (2006). The conclusion of these authors is that capital controls liberalizations are associated with significant increases in multinational activity. In this case, the main idea is that firms will be more likely to invest in a given country if they are able to transfer back their profits.

3. THE MODEL

In this section, I present my model and derive various results to be tested in the next section. The starting point is the Eaton and Kortum (2002) model, which I modify to incorporate FDI, and some trade costs that vary with distance and others that do not. These modifications allow me to analyze how the distance elasticity is affected by changes in trade costs (distance related and unrelated) and by changes in barriers to FDI. The specifics of these modifications will become clear below when I describe the various components of the model. For simplicity I focus on the case of two countries - Home (H) and Foreign (F).

Consumers

In both countries, consumers' preferences over a continuum of goods indexed by $j \in [0,1]$ are represented by the function

$$U = \left[\int_0^1 x\left(j\right)^{\frac{\sigma-1}{\sigma}} dj \right]^{\frac{\sigma}{\sigma-1}} \tag{3}$$

Consumers choose their consumption by maximizing (3) subject to the budget constraint

$$\int_0^1 x\left(j\right) p\left(j\right) dj \leq X \tag{4}$$

where X denotes income, which consumers take as given.

Technology

Firms produce output of the j^{th} good using a linear production function in which labor is the only input

$$F\left(j\right) = z\left(j\right) l, \tag{5}$$

where $z\left(j\right)$ denotes the productivity of labor, which is assumed to be random. The distribution function of $z\left(j\right)$ is the Frechet with parameters T and θ:

$$G\left(z\left(j\right)\right) = \Pr\left[Z\left(j\right) \leq z\left(j\right)\right] = e^{-Tz(j)^{-\theta}}. \tag{6}$$

In this function, the parameter T is a location parameter, which, as emphasized in Eaton and Kortum (2002), can be seen as an indicator of the level of technological development of a country. So that, if $T_F > T_H$, then Foreign is technologically more developed than Home. The other parameter of (6), θ, is a scale parameter, which, as pointed out by Eaton and Kortum (2002), controls the gains from trade. In particular, the lower θ is the higher the variance of $z(j)$ is, the productivity in producing product j, thus the larger the difference between the productivity draws can be. As in Eaton and Kortum (2002), I assume that θ is the same for both countries, but T can vary across countries.

A second element of technology in this model is foreign investment technology. The way I introduce foreign investment is based on Dias and Richmond (2009). This corresponds to assuming that each of the countries, when producing the j^{th} good, gets a productivity draw for producing locally and another productivity draw to produce abroad, where $z(j)_{F,F}$ denotes the productivity of Foreign in producing product j at home, and $z(j)_{F,H}$ denotes the productivity of Foreign in producing product j abroad (in Home). In the case of two countries, for each product j there are four different productivity draws, $z(j)_{F,F}$, $z(j)_{F,H}$, $z(j)_{H,F}$ and $z(j)_{H,H}$, which come from four different distribution functions like (6). I assume that these functions have the same parameter θ, but T varies - $T_{F,F}$, $T_{F,H}$, $T_{H,F}$ and $T_{H,H}$. For simplicity I assume that all productivity draws are independent of each other. In order to introduce costs and benefits of foreign investment I model $T_{F,H}$ and $T_{H,F}$ as follows:

$$\begin{aligned} T_{F,H} &= \lambda T_{H,H} + (1-\lambda)\,\tau T_{F,F}, \\ T_{H,F} &= \lambda T_{F,F} + (1-\lambda)\,\tau T_{H,H}. \end{aligned} \tag{7}$$

The idea is that when Foreign decides to produce in Home its productivity level is affected in two ways: First, I assume that when Foreign produces in Home it needs to use resources from Home. This assumption corresponds to assuming that the technology used when producing abroad is a combination of the technology of both countries. The parameter λ determines how large this effect is. Second, I assume that there are barriers to transferring technology. To capture this effect I assume that the technology of Foreign when producing in Home is a fraction of what it is in Foreign - the parameter τ represents this fraction.

Prices

In order to determine prices it is necessary to define the market structure in the economy. I assume that markets are competitive and therefore the price of good j in country l is the minimum price possible among all different possible prices. This means that the price of good j in country l is the following:

$$p_l(j) = \min\{p_{H,H}(j), p_{F,H}(j), p_{H,F}(j), p_{F,F}(j)\}. \tag{8}$$

Here $p_{m,n}(j)$ denotes the price of good j if produced in country n using country $m's$ technology, $m = H, F$, $n = H, F$. Like Eaton and Kortum (2002) I assume that there are iceberg type transportation costs, which I denote by d. Given my interest in separating the effects on the distance elasticity of changes in transportation costs from the effects of other trade costs, I define d to be as follows:

$$d = 1 + \alpha + \beta\delta \tag{9}$$

In equation (9) δ is the distance between Home and Foreign, β is the unit cost of distance, and α represents all other trade costs that are unrelated to distance.[2] The distinction between trade costs that vary with distance and those that do not is fundamental to several results in this paper, and this assumption is not always explicitly made by other researchers. For instance, an example of an alternative assumption is Anderson and van Wincoop (2003) who assume that all transportation costs vary with distance, despite considering tariffs and transportation costs in their specification. In Appendix A I discuss in detail the importance of (9) for my results.

If w denotes the wage, for a given level of productivity z, the price of good j if produced and consumed in the same country is:

$$p = \frac{w}{z}. \tag{10}$$

The price of a product produced and consumed in different countries is:

$$p = \left(\frac{w}{z}\right) d. \tag{11}$$

By combining results from Eaton and Kortum (2002) and Dias and Richmond (2009), the resulting price levels in each country are given by the following expression:

$$p_F = \gamma\left[\widetilde{T}_F (w_F)^{-\theta} + \widetilde{T}_H (dw_H)^{-\theta}\right]^{-\frac{1}{\theta}}. \tag{12}$$

$$p_H = \gamma\left[\widetilde{T}_F (dw_F)^{-\theta} + \widetilde{T}_H (w_H)^{-\theta}\right]^{-\frac{1}{\theta}}. \tag{13}$$

[2] Two examples of trade costs that, in general, are unrelated to distance are tariffs and communication costs.

where γ denotes the Euler constant, and $\widetilde{T}_F$ and $\widetilde{T}_H$ are, respectively, $((1+\lambda)\,T_{F,F} + (1-\lambda)\,\tau T_{H,H})$ and $((1-\lambda)\,\tau T_{F,F} + (1+\lambda)\,T_{H,H})$.

Trade flows and gravity

By combining all the previous results it is possible to obtain an expression for the fraction of goods that Foreign buys from Home (or Home exports to Foreign)

$$\pi_{FH} = \frac{X_{FH}}{X_F} = \frac{\widetilde{T}_H\,(dw_H)^{-\theta}}{\widetilde{T}_F\,(w_F)^{-\theta} + \widetilde{T}_H\,(dw_H)^{-\theta}}. \tag{14}$$

Since I assume that the level of expenditure of each country is exogenous, from equation (14) it is possible to get an expression for the trade flows between the two countries:

$$X_{FH} = \pi_{FH} \cdot X_F = \left(\frac{\widetilde{T}_H\,(dw_H)^{-\theta}}{\widetilde{T}_F\,(w_F)^{-\theta} + \widetilde{T}_H\,(dw_H)^{-\theta}}\right) X_F. \tag{15}$$

As it is shown in Eaton and Kortum (2002), equation (15) can be manipulated algebraically to obtain an expression that is very close to the traditional gravity equation:

$$X_{FH} = \frac{\left(\frac{d}{p_F}\right)^{-\theta} X_F}{\left(\frac{1}{p_H}\right)^{-\theta} X_H + \left(\frac{d}{p_F}\right)^{-\theta} X_F} Q_H. \tag{16}$$

Where $Q_H = \widetilde{T}_H\,(w_H)^{-\theta}\left\{\frac{X_H}{\widetilde{T}_H(w_H)^{-\theta}+\widetilde{T}_F(dw_F)^{-\theta}} + \frac{(d)^{-\theta}X_F}{\widetilde{T}_H(dw_H)^{-\theta}+\widetilde{T}_F(w_F)^{-\theta}}\right\}$ represents the total sales of Home (internal and external). An alternative expression to equation (16), and from my perspective a preferred one, is the following:

$$X_{FH} = \left(\frac{\widetilde{T}_H}{(w_H)^{\theta}} \frac{\left\{1 + \left(\frac{P_F}{dP_H}\right)^{\theta} \frac{X_F}{X_H}\right\}}{\left\{\left(\frac{P_H}{P_F}\right)^{\theta} X_H + d^{-\theta} X_F\right\}}\right)\left(\frac{X_F X_H}{d^{\theta}}\right) \tag{17}$$

Equations (17) and (2) are very similar; the only, and important, difference is the first term. While in equation (2) the first term is just a constant common to all countries, in equation (17) this term is country specific.

The distance elasticity

Like any other elasticity, the elasticity of distance is simply a ratio of relative variations. In this case, it is the percentage variation on the exports from Home to Foreign if these two countries were 1% farther from each other. By applying this definition to equation (16) (or equivalently (15)) I get the following expression for the distance elasticity:

$$\varepsilon_{X,\delta} = \frac{\partial X}{\partial \delta}\frac{\delta}{X} = -\theta \frac{\beta}{1+\alpha+\beta\delta}\left(1-\pi_{FH}\right). \tag{18}$$

The impact of globalization on (18) is the net effect of changes in β, the unit cost of transportation, in α, the component of trade costs that does not vary with distance, and in τ, the barriers to foreign investment. In what follows I derive the impact that changes in each of these factors have on the distance elasticity.

Proposition 1: The distance elasticity is inversely related to the unit cost of transportation, that is, $\frac{\partial \varepsilon_{X,\delta}}{\partial \beta} < 0$.

Proof: Immediately from

$$\frac{\partial \varepsilon_{X,\delta}}{\partial \beta} = -\frac{\theta^2\left(1-\pi_{FH}\right)}{\left(1+\alpha+\beta\delta\right)^2}\left\{(1+\alpha)+\beta\delta\pi_{FH}\right\} < 0. \tag{19}$$

An increase in the marginal cost of transportation decreases the magnitude of the distance elasticity, and vice versa. This result corresponds to what is usually assumed to be the relationship between transportation costs and distance elasticity. Intuitively, as the unit transportation cost decreases the relative effect on prices is larger for countries that are farther apart. If two countries are δ_1 units away from each other and two other countries are $\delta_2 > \delta_1$ units away from each other, the ratio of trade costs for these two groups of countries is equal to $\Upsilon = \left(1+\alpha+\beta\delta_2\right)/\left(1+\alpha+\beta\delta_1\right)$. As β decreases, this ratio becomes smaller, which means that the trade costs for the group of countries that is farther apart decreased proportionally more than for the other group.[3] The implication is that after a decrease in the unit transportation cost, trade increases proportionally more for countries that are farther away.

Proposition 2: The effect that the fixed component of trade costs has on the distance elasticity depends on the amount of trade and the potential gains from trade. If $\theta\pi_{FH} < 1 \Rightarrow \frac{\partial \varepsilon_{X,\delta}}{\partial \alpha} > 0$ and if $\theta\pi_{FH} < 1 \Rightarrow \frac{\partial \varepsilon_{X,\delta}}{\partial \alpha} > 0$.

Proof: Immediately from

$$\frac{\partial \varepsilon_{X,\delta}}{\partial \alpha} = \frac{\theta\beta}{\left(1+\alpha+\beta\delta\right)^2}\left(1-\pi_{FH}\right)\left(1-\theta\pi_{FH}\right). \tag{20}$$

[3] To see this, $\partial\Upsilon/\partial\beta = \left(\delta_2-\delta_1\right)\left(1+\alpha\right)/\left(1+\alpha+\beta\delta_1\right)^2 > 0$.

Since the terms $\theta\beta/(1+\alpha+\beta\delta)^2$ and $(1-\pi_{FH})$ are positive, the sign of equation (20) is determined by the term $(1-\theta\pi_{FH})$. In particular, if $\theta\pi_{FH}<1 \Rightarrow \frac{\partial\varepsilon_{X,\delta}}{\partial\alpha}>0$ and if $\theta\pi_{FH}<1 \Rightarrow \frac{\partial\varepsilon_{X,\delta}}{\partial\alpha}>0$. The reason for this result is that a change in α simultaneously changes the relative composition of trade costs, and the total trade costs and these two effects have opposing impacts on $\varepsilon_{X,\delta}$. When α decreases, the relative importance of distance in total trade costs increases, which makes the impact of distance on trade higher. On the other hand, as total trade costs decrease due to a reduction in α, trade increases - $\frac{\partial\pi_{FH}}{\partial\alpha}=-\theta\frac{\pi_{FH}(1-\pi_{FH})}{d}<0$. Since trade increases, it is as if the distance barrier had become less important. It is interesting to see that the response of trade to α increases with the value of θ. This is because θ controls the variance of the distribution of productivities - the smaller θ, the larger the variance of productivities. As the variance of productivities increases, the potential gains from trade also increase because the relative comparative advantages are larger. The implication for this is that trade costs in general become less relevant for trade. Likewise, as the parameter θ increases, the distribution of productivities becomes more concentrated around the absolute comparative advantage parameter - T - which means that the relative comparative advantages become smaller. When this happens, the impact of trade costs on trade increases.

Proposition 3: A reduction in the barriers to foreign investment increases the magnitude of the distance elasticity for more developed countries, while for less developed countries the effect is opposite - $\frac{\partial\varepsilon_{X,\delta}}{\partial\tau}>0$ if $T_H<T_F$ and $\frac{\partial\varepsilon_{X,\delta}}{\partial\tau}<0$ if $T_H>T_F$. If the two countries are technologically identical, then the distance elasticity does not change - $\frac{\partial\varepsilon_{X,\delta}}{\partial\tau}=0$ if $T_H=T_F$.

Proof: Immediately from

$$\frac{\partial\varepsilon_{X,\delta}}{\partial\tau}=-\frac{\theta\beta}{(1+\alpha+\beta\delta)}\frac{(dw_Hw_F)^{-\theta}(T_F+T_H)}{\left(\widetilde{T}_F(w_F)^{-\theta}+\widetilde{T}_H(dw_H)^{-\theta}\right)^2}(1-\lambda)(T_H-T_F). \tag{21}$$

From equation (21), it is immediately seen that the sign of $\frac{\partial\varepsilon_{X,\delta}}{\partial\tau}$ is solely determined by the relative technologies of the two countries. If Home, the exporter, is more technologically developed than Foreign, the importer, then $\frac{\partial\varepsilon_{X,\delta}}{\partial\tau}<0$. This means that the magnitude of the distance elasticity faced by Home when exporting to Foreign increases as the barriers to decentralize production decrease. The mechanism that generates this outcome is the following, when $T_H>T_F$: Home is able to establish production facilities in Foreign that are more productive than the existing ones. This type of movement also happens in the opposite direction; that is, Foreign also starts producing certain products in Home. In net terms, the increase of products being produced in Foreign is larger than the outflow of products from Foreign that start being produced in Home. The impact is an increase in the magnitude of Home's distance elasticity, and a decrease in the magnitude of Foreign's distance elasticity decreases. A third possible situation is when the two countries are equally technologically developed, that is, $T_H = T_F$. In this case $\frac{\partial \varepsilon_{X,\delta}}{\partial \tau} = 0$. This is so because the number of products that Foreign starts producing in Home is equal to the number of products that Home starts producing in Foreign.

Based on the results of propositions 1, 2 and 3 it is now clear that the impact of globalization on the distance elasticity is an empirical matter, and ex-ante it is hard to tell which effect is going to be the most important.

4. EMPIRICAL RESULTS

In this section I estimate a modified gravity equation, which allows me to test the results of the previous section. Before presenting the empirical results, I first describe the data, explain the link between theory and data and discuss the econometric methodology.

4.1. Data

The estimation of gravity model requires data on bilateral exports, GDP, population and physical and cultural distance between countries. The data on bilateral exports comes from the IMF DOTS database and it corresponds to free on board (FOB) values. The period covered is 1948-2005 and it has 31,786 different pairs of countries. The data on GDP and population comes from the World Development Indicators (WDI) dataset of the World Bank. This information is available during the period 1960-2005 for 148 different countries. The third data component is the information on distance, both physical and non-physical. The source for this data is the CEPII research center, and it has information on physical distance between the capitals of the countries in the pair, on colonial linkages, on language proximity, on the number of islands in the pair, on the number of land-locked countries in the pair and on the area of the two countries. Other data used in the estimation of gravity models is an indicator of a country's "remoteness" and information on the regional trade agreements (RTA) and on currency unions (CU). The variable "remoteness" is the log-GDP weighted average distance from country X to all other countries, which corresponds to the definition of Wei (1996). Regarding the information on RTA's and CU's, I use the data from Frankel (1997), which only runs until 1997, and update it until 2005 using the WTO dataset on regional trade agreements and currency unions. Besides the data I just listed I also use data on tariffs and FDI stocks. The tariff data comes from the World Bank and is available in two formats: 1) the average tariff rate charged by country X to all other countries, which is available from 1981 to 2007; and 2) bilateral tariff rates data at the HS6 product level. In both cases I compute the (unweighted) average tariff facing an exporting country.[4] The FDI stocks information come from the United Nations Conference on Trade and Development (UNCTAD) and is available for 186 countries from 1980 to 2007. In particular, I use outward and inward FDI stock as a share of GDP. Due to different period coverage and different sets of countries for which there is available data, the final dataset that was used in estimation runs from 1983 to 2005, and it covers 19,494 different exporter-importer pairs of countries.

4.2. Linking the Theory to the Data

Before discussing the econometric methodology used in this paper, I first show how the various components of the model presented in section 3 are linked to the data. In order to show theory links with the data I use equation (17):

$$X_{FH} = \left(\frac{\widetilde{T}_H}{(w_H)^\theta} \frac{\left\{ 1 + \left(\frac{P_F}{dP_H} \right)^\theta \frac{X_F}{X_H} \right\}}{\left\{ \left(\frac{P_H}{P_F} \right)^\theta X_H + d^{-\theta} X_F \right\}} \right) \left(\frac{X_F X_H}{d^\theta} \right) \tag{22}$$

As mentioned previously in section 3, the second component in equation (22) - $\left(\frac{X_F X_H}{d^\theta} \right)$ - corresponds to the most basic version of the gravity equation, while the first component - $\left(\frac{\widetilde{T}_H}{(w_H)^\theta} \frac{\left\{ 1 + \left(\frac{P_F}{dP_H} \right)^\theta \frac{X_F}{X_H} \right\}}{\left\{ \left(\frac{P_H}{P_F} \right)^\theta X_H + d^{-\theta} X_F \right\}} \right)$ -.corresponds to assuming a constant term that is country-specific. Regarding the estimation of the second term, both X_F and X_H are observed and therefore can be used directly in the estimation. In this specification both X_F and X_H enter the equation with unitary elasticity. In the empirical application I do not impose any values on the parameters associated to X_F and X_H. Besides that, I substitute X_F and X_H for $X_F = x_F Pop_F$ and $X_H = x_H Pop_H$. I do this transformation as a way to allow size and income to have different effects. With respect to the trade costs component, unfortunately these costs are not easily observable for all countries. What is available for a large number

[4] The reason for using these two alternative tariffs data sources will become clear when I discuss the results.

of countries are variables that are known to impact trade costs, in particular the distance between countries and tariff rates. Based on the information that is available, one possibility is to approximate $d(\delta,\alpha)$ by a polynomial function (similar to a Taylor series approximation). In the empirical application I use the following approximation:

$$\ln\left[d(\delta,\alpha)\right] \simeq k + \gamma_\delta \ln(\delta) + \gamma_\alpha \ln(1+\alpha) + \gamma_{\delta,\alpha} \ln(\delta)\ln(1+\alpha). \tag{23}$$

One advantage of using equation (23) is that it encompasses the trade cost function that is commonly used in the literature - $d(\delta,\alpha) = (1+\alpha)\delta^\beta$ - and therefore, equation (23) can be used to test whether this assumption is correct or not.[5]

After having dealt with the most straightforward term in equation (22), I now describe how I deal with the first term from the same equation. The first term in equation (22) is not observed and therefore it is not possible to use it in the estimation. There are two possibilities to overcoming this problem. One possibility is to approximate the unobserved component by using some variables that are correlated with the various parts of $\left(\frac{\widetilde{T}_H}{(w_H)^\theta}\frac{\left\{1+\left(\frac{P_F}{dP_H}\right)^\theta \frac{X_F}{X_H}\right\}}{\left\{\left(\frac{P_H}{P_F}\right)^\theta X_H + d^{-\theta}X_F\right\}}\right)$. To approximate $\frac{\left\{1+\left(\frac{P_F}{dP_H}\right)^\theta \frac{X_F}{X_H}\right\}}{\left\{\left(\frac{P_H}{P_F}\right)^\theta X_H + d^{-\theta}X_F\right\}}$ I use remoteness indices (which I defined in the previous section) for both importer and exporter. Regarding $\widetilde{T}_H$ and $(w_H)^\theta$ I use inward and outward stock of FDI as a share of GDP as proxies for these terms. The link between $\widetilde{T}_H$ and $(w_H)^\theta$ and FDI stocks is not obvious, but it is to be expected that larger values of $\widetilde{T}_H$ would be associated with more outward stock of FDI and smaller values of $(w_H)^\theta$ would be associated with more inward stock of FDI. Finally, I also include two interaction terms between between outward and inward stocks of FDI and $\ln(\delta)$ to approximate the effect that lower barriers to FDI have on the distance elasticity.

The second possibility to deal with the unobserved component of equation (22) is to use importer and exporter fixed effects. That is,

$$X_{FH} = (\mu_F \mu_H)\left(\frac{1}{d^\theta}\right) \tag{24}$$

The advantage of this approach is that it is not necessary to rely on so many approximations to unobserved variables, and therefore the parameters are likelier to be more accurately estimated. The disadvantage is that it is impossible to test for the effect that changes in FDI

[5] If $d(\delta,\alpha) = (1+\alpha)\delta^\beta \Leftrightarrow \ln(d(\delta,\alpha)) = \ln(1+\alpha) + \beta\ln\delta$, which correspons to having $\gamma_{\delta,\alpha} = 0$.

barriers may have on the distance elasticity, and equation (24) cannot be used for forecasting purposes. I opted for first estimating equation (22) using proxy variables for the unobserved variables, and then I used the fixed effects approach as a robustness check of the first results.

4.3. Econometric Methodology

One important characteristic of the gravity model is that it is non-linear. What this means is that without any transformation, it is not possible to use OLS to estimate the parameters of interest. To solve this problem, it is common practice in the literature to log-linearize the model by using the $\ln(\cdot)$ operator. The benefit of this transformation is that the resulting equation is linear and therefore can be estimated by OLS. Until recently, this procedure was not seen as problematic, and it was the norm in terms of empirical applications of the gravity model. Two recent papers, Santos Silva and Tenreyro (2006) and Helpman, Melitz, and Rubinstein (2008), point out that such data transformation can generate important econometric problems, in particular, the natural log operator - $\ln(\cdot)$ - cannot be applied to situations in which the bilateral trade-flow equals zero, and inference problems may arise due to Jensen's inequality. This situation causes two problems: first, it generates a sample selection problem as all combinations of countries for which trade-flow is zero have to be disregarded; second, it will in general create a situation of endogeneity in the log-linearized model. Although both methods address the zero trade flows problem, only the Santos Silva and Tenreyro (2006) method addresses both. I now contrast both methods.

In the case of HMR (2008), the authors develop a trade model with heterogeneous firms and fixed costs of exporting goods. Based on this model they derive an equation that determines which trade flows are zero and which are not. This is the selection equation. Once the selection equation is obtained, they estimate their reduced form gravity equation (only for positive trade flows), correcting for the sample selection bias in the same way the sample selection model of Heckman (1979) does. This approach suffers from the typical problem that sample selection models suffer, that is, how to properly model the sample selection process. Moreover, as pointed out by Santos Silva and Tenreyro (2008), it relies on important distributional assumptions, like error homoscedasticity, and neglects the consequences of Jensen's inequality.

The second approach is the one by Santos Silva and Tenreyro (2006). These authors propose addressing the sample selection and Jensen's inequality problems simultaneously by estimating the gravity equation in its non-linear form. The advantages of using a non-linear estimation method is that all observations can be used, and therefore the sample selection problem is avoided. At the same time it is not necessary to make any assumptions for the error term, as is the case with the HMR(2008) approach.[6] Santos Silva and Tenreyro (2006) use Monte Carlo simulation to test alternative non-linear estimation methods, and their conclusion is that in the vast majority of cases the estimator that behaves best is the Poisson pseudo maximum likelihood (PPML) estimator. This estimator amounts to running a Poisson regression on the levels of the bilateral trade variable against the natural log of the dependent variables. This is the method I chose.

One alternative approach that I have not yet discussed is to estimate an extended version of the model presented in section 3. Even though this would be a preferred approach, it is not possible to implement for an extended time period as it requires data that is not easily available.

After having discussed some of the econometric issues that surround the estimation of the gravity model, I now describe the econometric model that I use. The starting point for my empirical exercise is the standard gravity model:

$$X_{i,j,t} = A_t \frac{y_{i,t}^{\alpha_1} y_{j,t}^{\alpha_2} Pop_{i,t}^{\lambda_1} Pop_{i,t}^{\lambda_2}}{D_{i,j}^{\theta}} \exp\left(Z'_{i,j,t}\beta\right) \varepsilon_{i,j,t} \tag{25}$$

In equation (25), $X_{i,j,t}$ are the exports from country i to country j in year t, $y_{i,t}$ and $y_{j,t}$ are the GDP/capita of countries i and j in year t, $Pop_{i,t}$ and $Pop_{j,t}$ are countries' i and j populations in year t, $D_{i,j}$ is the distance in Kms between the capitals of countries' i and j and $Z_{i,j,t}$ is a vector of variables that includes all distance measures other than physical distance and the remoteness indicators. Based on my results of section 3, I propose changing equation (25) in a way that allows the effect of distance to depend on the average tariff rates facing an exporter and also on the amounts of inward and outward FDI stock as a percentage of GDP. [7]

To account for the effects that barriers to multinational production have on the distance elasticity I added outward and inward FDI stock as a share of GDP interacted with distance.

[6] Santos Silva and Tenreyro (2006) show that the log-linear transformation creates endogeneity problems if the error term in the non-linear model is not independent of the regressors. This a strong assumption as it rules out any form of heteroscedasticity.

[7] The rationale for these modifications was discussed previously in section 4.2.

Besides adding these interaction terms I also added the same variables in levels. To be more specific with respect to the changes I made to (25):

$$X_{i,j,t} = A_t \frac{y_{i,t}^{\alpha_1} y_{j,t}^{\alpha_2} Pop_{i,t}^{\lambda_1} Pop_{i,t}^{\lambda_2}}{D_{i,j}^{\left(\theta+\gamma_1 \overline{Tariff}_{i,t}+\gamma_2 FDI\_in_{i,t}+\gamma_3 FDI\_out_{i,t}\right)}} \exp\left(\widetilde{Z}'_{i,j,t}\beta\right) \varepsilon_{i,j,t} \tag{26}$$

with $\widetilde{Z}_{i,j,t} = \left[Z_{i,j,t} \quad \overline{Tariff}_{i,t} \quad FDI\_in_{i,t} \quad FDI\_out_{i,t}\right]$.

Because my main interest is to estimate the effect of distance over time, I need to obtain estimates of θ for every year. This can be done in at least two ways. One possible way is to estimate equation (26) every year. The other alternative would be to estimate the same equation only once but allow θ to vary over time. Econometrically, the first option is less restrictive and therefore more robust. The main problem with this approach has to do with the ability to identify the effect of tariffs on distance. The data on tariffs that is available either has very little cross section variation but varies substantially over time, or it is very rich from a cross section variation point of view but very poor from a time variation point of view (only one year). The implication is that if I estimate equation (26) for every year, it will be very difficult to identify the effect of tariffs on the elasticity of distance given the reduced cross sectional variability. The only year for which there is data on tariffs with sufficient cross sectional variation to separately identify the effects of distance and of tariffs on distance is 2004. The problem with this alternative is that I only obtain one estimate of θ, and therefore cannot conclude anything about the variation of the distance elasticity over time.

The second estimation alternative, estimating one equation like (26) for all years, can solve this identification problem because it uses not only the (reduced) cross section variation of the average tariffs but also its time variation. One criticism of this option is that I allow certain parameters to vary over time, while I require other parameters to remain constant. However, given the large number of parameters, not fixing certain ones would make the equation very difficult to estimate and interpret.

As a robustness check of my results I also estimate equation (26) for only 2004 (the year for which I have an alternative source for tariffs data). As a further robustness check of my results I estimate a model similar to the one described by equation (24), that is:

$$X_{i,j,t} = A_t \frac{1}{D_{i,j}^{\left(\theta+\gamma_1 \overline{Tariff}_{i,t}+\gamma_2 FDI\_in_{i,t}+\gamma_3 FDI\_out_{i,t}\right)}} \mu_{i,t}\mu_{j,t}\varepsilon_{i,j,t} \tag{27}$$

4.4. Estimation Results

In table 1 I show the estimation results for four different model specifications. Specification (1) excludes both tariffs and FDI data (this specification corresponds to the most traditional gravity model specification); specification (2) excludes tariffs but includes FDI stocks data; specification (3) includes tariffs but excludes FDI stocks data; and finally, specification (4) includes both tariffs and FDI stocks data. In Figure 5 I show the estimates of θ_t for the four different model specifications.

Exports from country i to country j

Variables	(1)	(2)	(3)	(4)
ln (Exporter GDP/capita) - α_1	0.819 0.007	0.735 0.011	0.820 0.007	0.732 0.011
ln (Importer GDP/capita) - α_2	0.864 0.009	0.857 0.009	0.772 0.011	0.763 0.011
ln (Exporter population) - λ_1	0.841 0.008	0.846 0.008	0.836 0.008	0.841 0.008
ln (Importer population) - λ_2	0.900 0.009	0.878 0.008	0.906 0.009	0.884 0.008
Contiguity - $\beta_{contiguity}$	0.741 0.029	0.744 0.029	0.734 0.029	0.738 0.029
Average tariff *ln (distance) - γ_1	–	–	0.010 0.003	0.016 0.003
Exporter inward FDI stock % GDP*ln(distance) - γ_2	–	0.038 0.003	–	0.039 0.003
Exporter outward FDI stock % GDP*ln(distance) - γ_3	–	−0.034 0.006	–	−0.036 0.006
ln(Average tariff) - $\beta_{average\ tariff}$	–	–	−2.478 0.194	−2.540 0.188
ln (Exporter outward FDI stock % GDP) - β_{out_FDI}	–	0.117 0.013	–	0.124 0.013
ln (Exporter inward FDI stock % GDP) - β_{in_FDI}	–	−0.041 0.015	–	−0.039 0.014
# Observations	205469	205469	205469	205469
Pseudo - R^2	0.906	0.908	0.907	0.909
Robust standard errors				

Table 1 - Gravity regression results for different model specifications.[8]

The results of Table 1 show that, as suggested by proposition 2 in section 3, countries that face higher tariff rates are less affected by distance. The estimates of the interaction term between distance and tariffs,γ_1, is positive and statistically significant, which means that as tariffs decrease, the magnitude of the distance elasticity decreases. At the same time,

[8] The remainder of the results can be found in Appendix C, Table C1.

countries that face higher tariffs export less. The estimates of $\beta_{average\ tariffs}$ are negative and statistically significant, which means that the higher the tariff rates facing the exporting country the less that country exports. Another result from Table 1 is that, as suggested by proposition 3 in section 3, countries with higher levels of outward FDI stocks face a higher distance elasticity while countries with higher levels of inward FDI stocks face a lower distance elasticity. This conclusion comes from the fact that the estimates of the interaction term between distance and outward FDI, γ_3, are negative and statistically significant, and from the fact that the estimates of the interaction term between distance and inward FDI, γ_2, are positive and statistically significant. An interesting result is that countries with higher stocks of outward FDI tend to export more, but the level of inward FDI has no impact on the amount of exports. If we accept that outward FDI comes mostly from technologically more developed countries, then it is not surprising that countries with higher levels of outward FDI stocks export more. On the other hand, since the recipients of FDI are both the more and the less technologically developed countries, it is not surprising that the effect of this variable is not statistically significant. This is because less developed countries tend to export less than more developed countries, and therefore the net effect must be close to zero. Despite some numerical differences, these results are robust to the different specifications since the majority of the parameters do not change much with the model specification.

In Table 1, among other parameters, I presented all the terms affecting the distance elasticity except for the baseline distance elasticity parameters, θ_t. The reason these parameters were not included in Table 1 is that there are 23 of them, which would make Table 1 too large. As an alternative, I plot all the estimates of θ_t in Figure 5 for the four different model specifications and show the actual estimates and corresponding standard deviations in Appendix C.

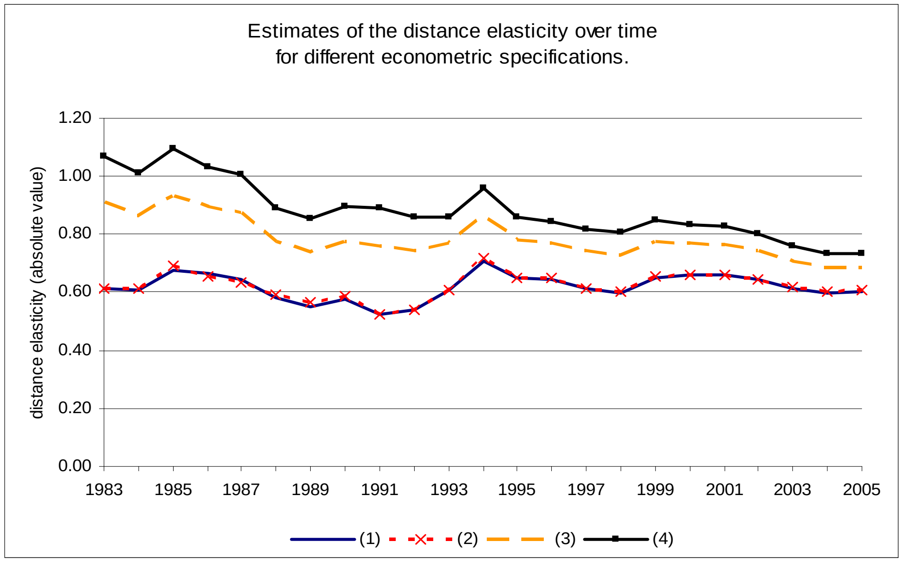


FIG.5 - Distance elasticity estimates over time for different model specifications.

The result that immediately arises from Figure 5 is that for specifications (3) and (4), the ones that control for tariff rates, the distance elasticity is decreasing over time. This result, in my view, can be seen as evidence in favor of proposition 1, that is, *ceteris paribus*, as transportation costs fall, the magnitude of the distance elasticity also falls. This result does not come directly from the regression. My assumption underlying this conclusion is that in specifications (3) and (4), I was controlling for two out of three factors that I defined as being aspects of economic globalization. This means that only the third factor is not being taken into account. Therefore, given what we know about transportation costs over time from Hummels (2007), it was expected that the portion of the distance elasticity that is caused solely by transportation costs would be decreasing over time. A final remark concerning the results of specifications (3) and (4) shown in Figure 5 is that the differences between the estimates at the beginning of the sample and at the end are statistically significant.[9]

4.5. Robustness Check

In the previous section I provided empirical evidence that favors the propositions of section 3. Despite these favorable results, there are still a few concerns that must be addressed in order to make these findings more robust. First, I show that these results are not being driven by either rich or poor countries (vis-a-vis, more and less technologically developed countries,

[9] These results are shown in Table C1 of Appendix C.

respectively). Second, I estimate specifications (1) and (4) for different sample periods - from 1983 to 1994 and from 1995 to 2005 - to show that the results hold for different time periods. Third, I show that the results are robust to time-series and cross section identification. At the same time, by estimating the model for only one year, I can also address a possible concern regarding the stability of some parameters that I assumed to be constant throughout the sample period. Fourth and last, I estimate equation (27), which replaces country-specific variables with country fixed effects, for the whole sample period and just for 2004. The results of this robustness check exercise are presented next.

Rich vs. Poor countries

In order to compare the results for rich and poor countries I divided the sample into two different groups. In the first group, the rich countries group, I included all exporters whose GDP/capita ranking is above the 87^{th} percentile. The second group has all remaining countries. The choice of the cut-off may seem random, but it is not. The cut-off was chosen in such a way that the two groups of countries have approximately 50% of total exports in the sample.[10] One problem that arises from creating these two groups is that in the first years of the sample, the group of rich countries does not have many observations per year, and that creates estimation difficulties. As a solution to this problem I decided to exclude the first three years of the sample - 1983, 84 and 85. The results obtained are presented in table 2.

[10] To be more precise, the group of rich countries generates 51.5% of total exports, while the group of poor countries generates 48.5% of total exports.

Exports from country i to country j

Variables	Rich countries (1)	Rich countries (4)	Poor countries (1)	Poor countries (4)
ln (Exporter GDP/capita) - α_1	0.732 0.078	0.693 0.078	0.847 0.009	0.777 0.014
ln (Importer GDP/capita) - α_2	0.829 0.013	0.778 0.016	0.814 0.011	0.696 0.014
ln (Exporter population) - λ_1	0.794 0.011	0.790 0.011	0.910 0.011	0.923 0.013
ln (Importer population) - λ_2	0.904 0.014	0.874 0.012	0.896 0.013	0.879 0.010
Contiguity - $\beta_{contiguity}$	0.688 0.046	0.628 0.044	0.893 0.047	0.862 0.043
Average tariff *ln (distance) - γ_1	–	0.030 0.006	–	0.038 0.004
Exporter inward FDI stock % GDP*ln(distance) - γ_2	–	0.095 0.010	–	0.039 0.003
Exporter outward FDI stock % GDP*ln(distance) - γ_3	–	−0.046 0.015	–	−0.039 0.008
ln(Average tariff) - $\beta_{average\ tariff}$	–	−1.506 0.307	–	−3.324 0.237
ln (Exporter outward FDI stock % GDP) - β_{out_FDI}	–	0.051 0.043	–	0.100 0.014
ln (Exporter inward FDI stock % GDP) - β_{in_FDI}	–	−0.102 0.028	–	0.089 0.017
# Observations	25048	25048	175418	175418
Pseudo - R^2	0.921	0.927	0.853	0.864

Robust standard errors

Table 2 - Gravity regression results for different groups of countries - Rich vs. Poor.[11]

As is visible from the comparison of Table 1's column 4 with table 2's columns 2 and 4, in both cases the results are not only qualitatively very similar but also quantitatively. Regarding the estimates of θ_t for these two groups of countries, the estimation results are shown in Figure 6.

[11] The remainder of the results were excluded on purpose as they are not of central interest in this paper. They are available upon request.

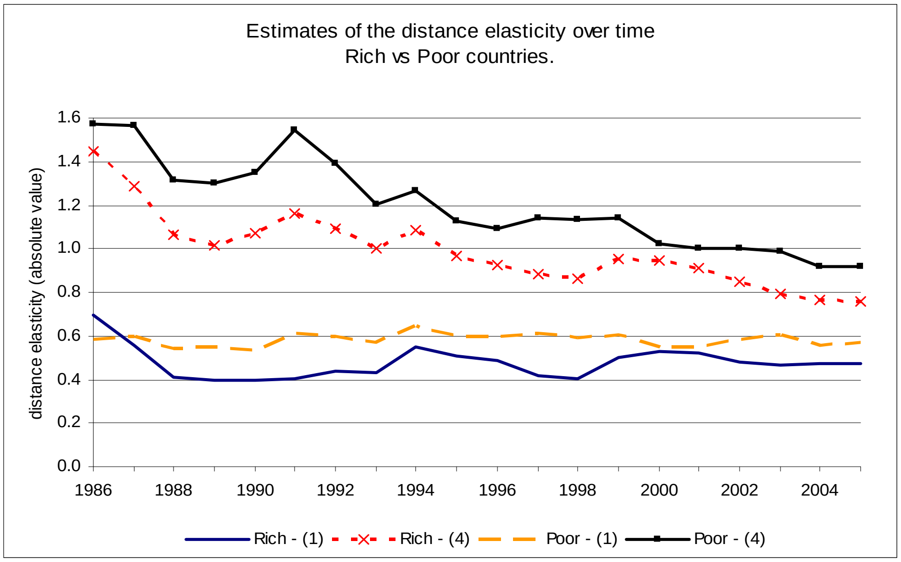


FIG.6 - Estimates of the distance elasticity over time - Rich vs Poor countries.

Similar to the results shown in Figure 4, for both groups of countries the distance elasticity is decreasing over time when it is controlled for changes in tariffs and in the distribution of FDI. What is interesting to see is that rich countries tended to be less affected by distance than poor countries, but both benefited equally from lower transportation costs.

Different sample periods

One question that may arise is whether these results are driven by some sub-sample. In order to show that this is not the case, as I did above, I re-estimated equation (26) for two sub-samples: 1) 1983 to 1994 and 2) 1995 to 2005. The results are presented in Table 3 and Figure 7.

Exports from country i to country j

Variables	1983-1994 (1)	1983-1994 (4)	1995-2005 (1)	1995-2005 (4)
ln (Exporter GDP/capita) - α_1	0.892 0.015	0.805 0.022	0.771 0.009	0.706 0.013
ln (Importer GDP/capita) - α_2	0.829 0.013	0.700 0.015	0.825 0.011	0.717 0.014
ln (Exporter population) - λ_1	0.841 0.013	0.871 0.012	0.864 0.010	0.875 0.011
ln (Importer population) - λ_2	0.865 0.017	0.877 0.017	0.919 0.012	0.899 0.010
Contiguity - $\beta_{contiguity}$	0.650 0.048	0.599 0.045	0.823 0.039	0.815 0.037
Average tariff *ln (distance) - γ_1	–	0.048 0.005	–	0.039 0.004
Exporter inward FDI stock % GDP*ln(distance) - γ_2	–	0.032 0.004	–	0.047 0.004
Exporter outward FDI stock % GDP*ln(distance) - γ_3	–	−0.056 0.014	–	−0.040 0.009
ln(Average tariff) - $\beta_{average\ tariff}$	–	−2.230 0.215	–	−3.324 0.278
ln (Exporter outward FDI stock % GDP) - β_{out_FDI}	–	0.088 0.025	–	0.100 0.015
ln (Exporter inward FDI stock % GDP) - β_{in_FDI}	–	0.013 0.024	–	0.089 0.019
# Observations	48943	48943	156526	156526
Pseudo - R^2	0.894	0.901	0.896	0.902

Robust standard errors

Table 3 - Gravity regression results for different sample periods - 1983-1994 and 1995-2005.[12]

[12] The remainder of the results were excluded on purpose as they are not of central interest in this paper. They are available upon request.

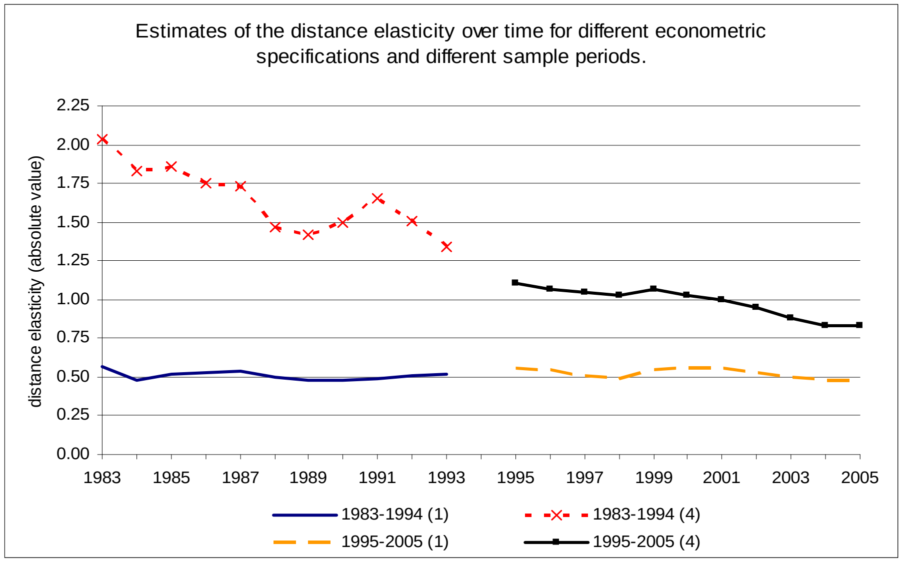


FIG.7 - Estimates of the distance elasticity over time for different sample periods - 1983-1994 and 1995-2005.

Similar to the comparison between rich and poor countries, the main qualitative results shown in Table 2 and Figure 5 hold when the estimation is done for different sample periods. Moreover the parameters estimates do not change much from one period to the other, which means that results are similar even from a quantitative point of view.

Time-series vs. Cross section identification

As I mentioned before, the results of Table 1 may be affected by the estimation technique that was used. In particular, due to data availability constraints, I ran a pooled regression instead of individual regressions for each year. In order to show that this concern is not important, I re-estimate equation (26) but only for the year 2004. The key difference is that for the year 2004 I am able to use a different source for the tariff data, which is more detailed than the one used in the first set of regressions. The results of this exercise are presented in Table 4.

Exports from country i to country j - 2004

Variables	(1)	(2)	(3)	(4)
ln (Exporter GDP/capita) - α_1	0.746 0.021	0.686 0.037	0.770 0.022	0.694 0.036
ln (Importer GDP/capita) - α_2	0.849 0.030	0.845 0.030	0.852 0.030	0.847 0.029
ln (Exporter population) - λ_1	0.840 0.025	0.857 0.030	0.869 0.024	0.894 0.029
ln (Importer population) - λ_2	0.909 0.029	0.887 0.026	0.927 0.029	0.907 0.026
Contiguity - $\beta_{contiguity}$	0.711 0.099	0.695 0.101	0.688 0.095	0.672 0.097
ln (distance) - θ	−0.681 0.040	−0.704 0.038	−1.046 0.196	−1.151 0.200
Average tariff *ln (distance) - γ_1	−	−	0.037 0.021	0.046 0.021
Exporter inward FDI stock % GDP*ln(distance) - γ_2	−	0.072 0.013	−	0.070 0.014
Exporter outward FDI stock % GDP*ln(distance) - γ_3	−	−0.052 0.022	−	−0.054 0.022
ln(Average tariff) - $\beta_{average\ tariff}$	−	−	−0.461 0.184	−0.559 0.188
ln (Exporter outward FDI stock % GDP) - β_{out_FDI}	−	0.103 0.043	−	0.134 0.043
ln (Exporter inward FDI stock % GDP) - β_{in_FDI}	−	−0.084 0.053	−	−0.073 0.051
# Observations	19588	19588	19588	19588
Pseudo - R^2	0.901	0.904	0.903	0.907
Robust standard errors				

Table 4 - Gravity regression results for different model specifications - only 2004.[13]

The comparison of Tables 1 and 4 reveals that the results are very similar, from a qualitative and quantitative perspective. This result is particularly reassuring for two reasons. First, it shows that the identification method used to obtain the results of Table 1 and of Figure 5 is not driving the main findings, since similar results are obtained using a different identification scheme. Second, the results of Table 4 suggest that, with the exception of the distance parameter, assuming all parameters to be constant over time is not a restrictive assumption since the estimation results are very similar in both cases.

Exporter and Importer fixed effects

Since the contribution of Anderson and van Wincoop (2003), it has been common practice to include exporter and importer fixed effects in the estimation of the gravity equation. These exporter and importer fixed effects are known in the literature as "multilateral resistance

[13]The remainder of the results can be found in Appendix C, Table C2.

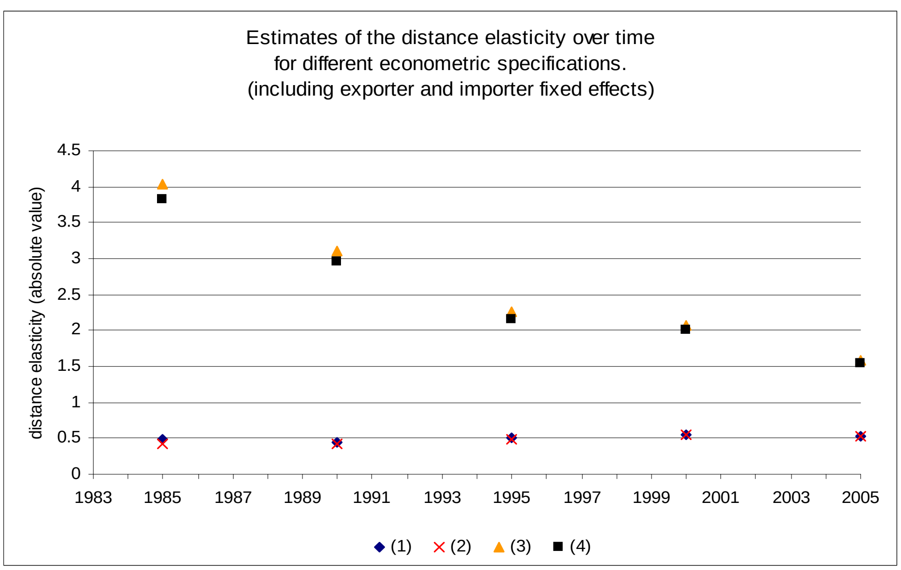
terms." In section 4.2 I discussed the advantages and disadvantages of this approach for the question I am trying to answer, and based on those I opted for a different approach. To demonstrate that most of the results I have shown thus far are robust to the econometric methodology, I now present results equivalent to the ones shown in Tables 1 and 4 when exporter and importer fixed effects are included. The econometric model I estimate corresponds to equation (27). The results are summarized in the following tables and figure.

Exports from country i to country j

Variables	(1)	(2)	(3)	(4)
Contiguity - $\beta_{contiguity}$	1.349 0.143	1.375 0.138	1.288 0.135	1.315 0.131
Average tariff *ln (distance) - γ_1	–	–	0.127 0.018	0.121 0.018
Exporter inward FDI stock % GDP*ln(distance) - γ_2	–	-0.158 0.048	–	-0.118 0.041
Exporter outward FDI stock % GDP*ln(distance) - γ_3	–	0.220 0.042	–	0.200 0.037
# Observations	47576	47576	47576	47576
Pseudo - R^2	0.799	0.806	0.806	0.811

Robust standard errors

Table 5 - Gravity regression results for different model specifications - including exporter and importer fixed effects.[14]



[14]The remainder of the results were excluded on purpose as they are not of central interest in this paper. They are available upon request.

FIG.8 - Distance elasticity estimates over time for different model specifications - including exporter and importer fixed effects.

Exports from country i to country j - 2004

Variables	(1)	(2)	(3)	(4)
Contiguity - $\beta_{contiguity}$	0.656 0.075	0.656 0.075	0.648 0.075	0.648 0.075
ln (distance) - θ	-0.758 0.026	-0.758 0.026	-1.171 0.194	-1.171 0.194
Average tariff *ln (distance) - γ_1	–	–	0.043 0.020	0.043 0.020
Exporter inward FDI stock % GDP*ln(distance) - γ_2	–	-0.778 0.153	–	-0.770 0.159
Exporter outward FDI stock % GDP*ln(distance) - γ_3	–	0.151 0.088	–	0.184 0.089
# Observations	19588	19588	19588	19588
Pseudo - R^2	0.940	0.940	0.941	0.941
Robust standard errors				

Table 6 - Gravity regression results for different model specifications including exporter and importer fixed effects - only 2004.[15]

As is visible from the comparison of Tables 1 and 5 and 4 and 6, there are some important differences. In particular, when exporter and importer fixed effects are used in the estimation, the signs of the interaction terms between distance and FDI stocks invert in comparison to the results presented previously. This difference can be caused by various factors. For instance, the inclusion of exporter and importer fixed effects has the benefit of controlling for all variables that are country-specific; the disadvantage is that these dummy variables eliminate much of the variability in the data. Regarding all other results, despite some quantitative differences, qualitatively the results obtained from the two approaches are very similar. The effect of FDI on the gravity of trade will have to be clarified in future research.

5. CONCLUDING REMARKS

In this paper I re-evaluated an existing puzzle in international economics, the persistent effect of distance on trade. Ex-ante this was an important question as the empirical findings were at odds with the theory. Ex-post, the importance of the question depends entirely on the answer.

[15] The remainder of the results were excluded on purpose as those are not of central interest in this paper. These are available upon request.

To answer this question I modified a well-known model of trade, Eaton and Kortum (2002), to show that globalization does not necessarily lead to a decrease in the effect of distance on trade. When globalization is a combination of changes in transportation costs, changes in the component of trade costs that is independent of distance, and changes in barriers to production decentralization, it is not possible to determine the impact that globalization has on the distance elasticity, as different sources of globalization impact the distance elasticity differently.

By changing the traditional gravity model in a way that allows the effect of distance to depend on the average tariffs (which is one of the many trade costs that do not depend directly on distance) facing the exporting country and on the amounts of inward and outward stocks of FDI as a share of GDP, I was able to show that, after controlling for these two effects, the elasticity of distance actually decreased over time. At the same time, I provided empirical evidence on the relevance of the economic mechanisms discussed in the context of the model presented in section 3.

The results of section 4 suggest that of all three globalization effects - changes in transportation costs, distance-unrelated trade costs, and the barriers to production decentralization - the one that has the most significant impact on the distance elasticity is the reduction of distance-unrelated trade costs. This conclusion, though, is not completely fair. By using tariffs as a proxy for distance-unrelated trade costs I am using a very important component of trade costs that do not depend on distance. The same is not true in terms of FDI stocks as a proxy for production decentralization, as I am only considering one of many forms of production decentralization. For instance, production contracts or licensing are alternative ways that firms have to decentralize production that are not covered by FDI stocks. The implication is that the estimates of the effect of production decentralization are just a lower bound for the real effects, while the estimated effects of changes in distance-unrelated trade costs should be much closer to the true effect. At the same time, by estimating the effect of transportation costs on trade as the residual of the other two effects, my results will also be biased if any of the other effects are being under or over-estimated. On top of this, there were some conflicting results with respect to the effects of FDI stocks that need to be better understood.

As a follow-up to this paper I plan to test further the main idea addressed in this paper, that is, that the elasticity of distance does not depend only on transportation costs but also on other forms of globalization. These alternative forms of globalization play an important role in understanding the time evolution of the distance elasticity. For this purpose I plan to use US export and import data at the product level combined with data on tariffs, communication costs, inward and outward FDI, intellectual property rights protection, capital account liberalization and other forms of production decentralization, and with this data carry out a similar analysis to the one presented in this paper.

While this paper focused mainly on providing an explanation for the persistent effect of distance on trade, as a by-product of its central objective it also provided a micro-founded gravity model that takes into account changes in the distribution of production capacity across the world economy. As an additional by-product I showed that the idea of the death of distance caused by the communications revolution, which was put forward by Cairncross (1997), is actually incorrect. Contrary to what is suggested by Cairncross (1997), a reduction in communications costs has the effect of increasing the impact of distance on trade and not reducing it.

Finally, there are important implications to be drawn from these results. First, I showed that although a reduction in trade costs benefits all countries, the distribution of the benefits depends on which trade costs are reduced. When the reduction of trade costs is caused by a reduction in distance-related costs, more remote countries are the main beneficiaries of this reduction. This is because the prices of exports of these countries are proportionally more affected by distance costs than the prices of goods from other countries. When the reduction of trade costs comes from reductions in the component of trade costs that is not related to distance, countries that have more central geographic position benefit the most. This effect is due to the fact that more central countries are less affected by distance, which implies that the relevant trade costs for these countries are the costs of trade that do not depend on distance. The second implication is methodological. A common assumption in trade models is modelling trade costs as the product of two components, transportation costs and tariffs - $d(\delta, \alpha) = g(\delta) h(\alpha)$. My empirical results reject such an assumption. A direct implication of this result is that, contrary to what is expected, certain parameters are not identified (an example of a paper that relies on this assumption to identify the effect of distance on trade is Anderson and van Wincoop (2003).) Third and last, though there are some exceptions, most theoretical gravity models do not consider the possibility of production decentralization, and this is at odds with reality. Any successful empirical or theoretical model of trade should contemplate this possibility, as it is a very important feature of today's world economy.

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APPENDIX A

As I mentioned in section 3, the choice of the trade costs function - d - impacts the theoretical results of this paper. To show this, I derive the expression for the distance elasticity that is implied by the Eaton and Kortum (2002) model for a generic trade costs function. That expression is the following:

$$\varepsilon_{X,\delta} = \frac{\partial X}{\partial \delta}\frac{\delta}{X} = -\left(\frac{\theta\left(1-\pi_{FH}\right)\delta}{d}\right)\left(\frac{\partial d}{\partial \delta}\right). \tag{28}$$

In general, function d depends both on distance - δ - and on other trade costs - α -, that is, $d = d(\delta, \alpha)$. In order to see the importance of the choice of the function d, I derive the three propositions of section 3 assuming the same trade cost function that was used by Anderson and van Wincoop (2003) - $d(\delta,\alpha) = (1+\alpha)\,\delta^{\beta}$. Given this assumption, equation (28) becomes:

$$\varepsilon_{X,\delta} = -\theta\beta\left(1-\pi_{FH}\right). \tag{29}$$

Based on (29) the propositions of section 3 become:

Proposition $\widetilde{1}$: $\frac{\partial \varepsilon_{X,\delta}}{\partial \beta} = -\theta\left(1-\pi_{FH}\right)\left\{1+\frac{\theta\beta^2}{\delta}\pi_{FH}\right\} < 0.$

Proposition $\widetilde{2}$: $\frac{\partial \varepsilon_{X,\delta}}{\partial \alpha} = -\theta^2\frac{\beta}{(1+\alpha)}\left(1-\pi_{FH}\right)\pi_{FH} < 0.$

Proposition $\widetilde{3}$: $\frac{\partial \varepsilon_{X,\delta}}{\partial \tau} = -\frac{\theta\beta}{(1+\alpha)\delta^{\beta}}\frac{(dw_H w_F)^{-\theta}(T_F+T_H)}{\left(\widetilde{T}_F(w_F)^{-\theta}+\widetilde{T}_H(dw_H)^{-\theta}\right)^2}\left(1-\lambda\right)\left(T_H-T_F\right)\begin{cases} <0 \text{ if } T_H > T_F \\ =0 \text{ if } T_H = T_F \\ >0 \text{ if } T_H < T_F \end{cases}.$

The qualitative results of propositions 1 and 3 and $\widetilde{1}$ and $\widetilde{3}$ are the same. The only propositions that are different are propositions 2 and $\widetilde{2}$. The reason for this difference comes from the fact that the when the trade costs function is assumed to be $d(\delta,\alpha) = (1+\alpha)\,\delta^{\beta}$ all trade costs depend on distance, while for $d(\delta,\alpha) = (1+\alpha+\beta\delta)$ that is not the case. Therefore, the composition of trade costs effect (distance related vs. non-distance related trade costs) is only important for $d(\delta,\alpha) = (1+\alpha+\beta\delta)$.

APPENDIX B

List of countries included in the sample		
Albania	Cape Verde	Ghana
Algeria	Central African Republic	Greece
Angola	Chad	Grenada
Antigua and Barbuda	Chile	Guatemala
Argentina	China	Guinea
Armenia	Colombia	Guinea Bissau
Australia	Comoros	Guyana
Austria	Costa Rica	Haiti
Azerbaijan	Cote d'Ivoire	Honduras
Bahamas	Croatia	Hong Kong
Bahrain	Cyprus	Hungary
Bangladesh	Czech Republic	Iceland
Barbados	Denmark	India
Belarus	Djibouti	Indonesia
Belgium	Dominica	Iran
Belize	Dominican Republic	Ireland
Benin	Ecuador	Israel
Bermuda	Egypt	Italy
Bhutan	El Salvador	Jamaica
Bolivia	Equatorial Guinea	Japan
Botswana	Eritrea	Jordan
Brazil	Estonia	Kazakhstan
Brunei	Ethiopia	Kenya
Bulgaria	Fiji	Korea
Burkina Faso	Finland	Kuwait
Burundi	France	Kyrgyzstan
Cameroon	Gabon	Laos
Canada	Georgia	Latvia

List of countries included in the sample (cont.)		
Lebanon	Pakistan	Swaziland
Lesotho	Panama	Sweden
Liberia	Papua New Guinea	Switzerland
Libya	Paraguay	Syria
Lithuania	Peru	Tajikistan
Luxembourg	Philippines	Tanzania
Macao	Poland	Thailand
Macedonia	Portugal	The Gambia
Madagascar	Qatar	Togo
Malawi	Romania	Trinidad and Tobago
Malaysia	Russian Federation	Tunisia
Mali	Rwanda	Turkey
Malta	Sao Tome and Principe	Turkmenistan
Mauritania	Saudi Arabia	U.S.A
Mauritius	Senegal	Uganda
Mexico	Seychelles	Ukraine
Moldova	Sierra Leone	United Arab Emirates
Mongolia	Singapore	United Kingdom
Morocco	Slovakia	Uruguay
Mozambique	Slovenia	Uzbekistan
Namibia	Solomon Islands	Vanuatu
Nepal	Somalia	Venezuela
Netherlands	South Africa	Vietnam
Netherlands Antilles	Spain	Western Samoa
New Zealand	Sri Lanka	Zambia
Nicaragua	St Christopher and Nevis	Zimbabwe
Niger	St Lucia	
Nigeria	St. Vincent	
Norway	Sudan	
Oman	Suriname	

APPENDIX C

Exports from country i to country j

Variables	(1)	(2)	(3)	(4)
ln(distance)$_{83}$ - θ_{83}	-0.615 0.113	-0.611 0.116	-0.913 0.130	-1.069 0.139
ln(distance)$_{84}$ - $(\theta_{84} - \theta_{83})$	0.009 0.134	0.000 0.136	0.051 0.106	0.056 0.115
ln(distance)$_{85}$ - $(\theta_{85} - \theta_{83})$	-0.060 0.130	-0.083 0.131	-0.020 0.101	-0.029 0.110
ln(distance)$_{86}$ - $(\theta_{86} - \theta_{83})$	-0.048 0.129	-0.045 0.131	0.018 0.099	0.038 0.109
ln(distance)$_{87}$ - $(\theta_{87} - \theta_{83})$	-0.027 0.127	-0.024 0.129	0.040 0.098	0.063 0.107
ln(distance)$_{88}$ - $(\theta_{88} - \theta_{83})$	0.034 0.122	0.018 0.125	0.140 0.104	0.178 0.112
ln(distance)$_{89}$ - $(\theta_{89} - \theta_{83})$	0.063 0.120	0.046 0.122	0.176 0.102	0.216 0.110
ln(distance)$_{90}$ - $(\theta_{90} - \theta_{83})$	0.038 0.121	0.022 0.123	0.140 0.101	0.173 0.109
ln(distance)$_{91}$ - $(\theta_{91} - \theta_{83})$	0.091 0.124	0.086 0.125	0.153 0.102	0.176 0.108
ln(distance)$_{92}$ - $(\theta_{92} - \theta_{83})$	0.076 0.123	0.070 0.125	0.171 0.104	0.211 0.111
ln(distance)$_{93}$ - $(\theta_{93} - \theta_{83})$	0.010 0.118	0.002 0.120	0.144 0.103	0.207 0.111
ln(distance)$_{94}$ - $(\theta_{94} - \theta_{83})$	-0.094 0.117	-0.105 0.120	0.049 0.103	0.112 0.111
ln(distance)$_{95}$ - $(\theta_{95} - \theta_{83})$	-0.032 0.117	-0.040 0.120	0.130 0.107	0.209 0.115
ln(distance)$_{96}$ - $(\theta_{96} - \theta_{83})$	-0.029 0.116	-0.038 0.119	0.144 0.107	0.225 0.115
ln(distance)$_{97}$ - $(\theta_{97} - \theta_{83})$	0.003 0.118	-0.004 0.120	0.170 0.107	0.249 0.134
ln(distance)$_{98}$ - $(\theta_{98} - \theta_{83})$	0.020 0.118	0.010 0.120	0.186 0.108	0.264 0.116
ln(distance)$_{99}$ - $(\theta_{99} - \theta_{83})$	-0.033 0.116	-0.042 0.118	0.137 0.106	0.218 0.114
ln(distance)$_{00}$ - $(\theta_{00} - \theta_{83})$	-0.043 0.116	-0.048 0.118	0.142 0.109	0.234 0.116
ln(distance)$_{01}$ - $(\theta_{01} - \theta_{83})$	-0.043 0.116	-0.050 0.118	0.147 0.110	0.240 0.118
ln(distance)$_{02}$ - $(\theta_{02} - \theta_{83})$	-0.027 0.116	-0.033 0.118	0.169 0.112	0.266 0.120
ln(distance)$_{03}$ - $(\theta_{03} - \theta_{83})$	0.000 0.116	-0.007 0.118	0.204 0.113	0.306 0.121
ln(distance)$_{04}$ - $(\theta_{04} - \theta_{83})$	0.016 0.116	0.008 0.118	0.227 0.115	0.333 0.123
ln(distance)$_{05}$ - $(\theta_{05} - \theta_{83})$	0.014 0.116	0.005 0.119	0.226 0.114	0.333 0.122

Robust standard errors

Table C1 - Gravity regression results for different model specifications - Table 1 continued.

Exports from country i to country j

Variables	(1)	(2)	(3)	(4)
ln (Exporter remoteness)	1.389 0.045	1.255 0.045	1.320 0.045	1.161 0.045
ln (Importer remoteness)	1.009 0.044	0.962 0.044	1.026 0.044	0.984 0.044
Regional trade agreement dummy	0.094 0.029	0.077 0.029	0.114 0.029	0.102 0.029
Currency union dummy	0.083 0.106	0.140 0.099	0.130 0.090	0.194 0.083
ln(area exporter * area importer)	−0.150 0.005	−0.131 0.005	−0.144 0.005	−0.126 0.004
Dummy indicating one country in the pair is landlocked	−0.473 0.024	−0.432 0.023	−0.490 0.023	−0.452 0.023
Dummy indicating both countries in the pair are landlocked	−0.261 0.065	−0.170 0.064	−0.291 0.064	−0.204 0.063
Dummy indicating one country in the pair is an island	−0.336 0.032	−0.275 0.029	−0.343 0.031	−0.284 0.029
Dummy indicating both countries in the pair are islands	−0.103 0.047	−0.021 0.050	−0.113 0.044	−0.032 0.047
Common waters dummy	0.000 0.024	0.013 0.024	−0.005 0.024	0.007 0.023
Common official language dummy	0.112 0.041	0.010 0.042	0.101 0.041	−0.004 0.042
Common secondary language dummy	0.251 0.035	0.303 0.036	0.268 0.035	0.320 0.036
Colonial relationship dummy	−0.190 0.033	−0.185 0.033	−0.200 0.034	−0.193 0.033
Common colonizer dummy	0.360 0.059	0.363 0.057	0.431 0.056	0.436 0.054
Current colony dummy	−0.019 0.251	0.068 0.247	−0.082 0.257	−0.007 0.257
Colonial relationship post 1945 dummy	0.153 0.073	0.221 0.071	0.199 0.072	0.267 0.069
Same country dummy	0.541 0.080	0.536 0.078	0.556 0.076	0.548 0.075

Robust standard errors

Table C1 (cont.) - Gravity regression results for different model specifications - Table 1 continued.

Exports from country i to country j - 2004

Variables	(1)	(2)	(3)	(4)
ln (Exporter remoteness)	1.439 0.145	1.272 0.137	1.327 0.146	1.144 0.136
ln (Importer remoteness)	1.211 0.138	1.211 0.143	1.204 0.136	1.187 0.139
Regional trade agreement dummy	0.154 0.076	0.125 0.075	0.182 0.073	0.157 0.072
Currency union dummy	−0.177 0.267	−0.152 0.248	−0.281 0.298	−0.236 0.266
ln(area exporter * area importer)	−0.142 0.016	−0.124 0.016	−0.161 0.016	−0.145 0.017
Dummy indicating one country in the pair is landlocked	−0.363 0.068	−0.319 0.064	−0.460 0.072	−0.421 0.068
Dummy indicating both countries in the pair are landlocked	−0.305 0.210	−0.232 0.209	−0.530 0.218	−0.466 0.215
Dummy indicating one country in the pair is an island	−0.344 0.104	−0.317 0.098	−0.381 0.102	−0.345 0.097
Dummy indicating both countries in the pair are islands	−0.194 0.150	−0.162 0.166	−0.235 0.149	−0.199 0.175
Common waters dummy	−0.096 0.079	−0.081 0.077	−0.082 0.078	−0.061 0.077
Common official language dummy	0.024 0.136	−0.064 0.138	0.060 0.126	−0.036 0.128
Common secondary language dummy	0.195 0.118	0.231 0.121	0.154 0.111	0.189 0.114
Colonial relationship dummy	−0.168 0.108	−0.151 0.112	−0.151 0.111	−0.140 0.113
Common colonizer dummy	0.306 0.195	0.298 0.188	0.235 0.185	0.217 0.178
Current colony dummy	−0.116 0.764	−0.040 0.765	−0.015 0.785	0.071 0.791
Colonial relationship post 1945 dummy	0.226 0.264	0.264 0.259	0.142 0.268	0.193 0.260
Same country dummy	0.563 0.222	0.547 0.213	0.566 0.210	0.543 0.202

Robust standard errors

Table C2 - Gravity regression results for different model specifications - only 2004 - Table 2 continued.