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A Note on Trade Costs and Distance

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Abstract

One of the most famous and robust findings in international economics is that distance has a strong negative effect on trade. Bernard, Jensen, Redding, and Schott (2007) discuss how this can be decomposed into an effect due to the number of products and an effect due to average exports per product. Using US firm-level data, they show that distance has a strong negative effect on the number of products exported. However, they find that the intensive margin—average sales of individual products—is *increasing* with distance. We show that this apparently puzzling finding is consistent with models featuring firm heterogeneity in productivity and fixed costs associated with exporting to each market. We also show how evidence of this type can be used to derive new estimates of how distance affects fixed and variable trade costs and how these two costs combine to generate the distance effect on trade.

1 Introduction

One of the most famous and robust findings in international economics is that distance has a strong negative effect on trade.[1] This pattern suggests that distance must have a substantial impact on the costs associated with trade. There is little evidence, however, on exactly how the distance effect operates and which types of trade costs are impacted.[2] One important distinction discussed in recent theoretical research is that between variable trade costs that increase with the volume of trade (usually modelled with the "iceberg" formulation) and fixed trade costs that must be incurred independent of how much revenue is generated. The traditional literature on the gravity equation, such as the widely-cited work of Anderson and van Wincoop (2003), focuses almost exclusively on variable costs.[3] More recently, papers such as Chaney (2007) and Helpman, Melitz and Rubinstein (2007) have emphasized the separate roles that fixed and variable costs may play: While an increase in variable trade costs will likely reduce volumes of all firms selling in a particular market, heterogeneity in productivity will imply that an increase in fixed costs may cause some firms to decide not to export to the market at all.

In this note, we provide new estimates of how distance affects fixed and variable trade costs and how these two costs combine to generate the distance effect on trade. The starting point for our analysis is some recent evidence presented by Bernard, Jensen, Redding, and Schott (2007, henceforth BJRS). Using US firm-level data on exports by destination, BJRS decompose the effect of distance on exports into two elements: An extensive margin due to variations in the number of products exported to each market, and an intensive margin due to variations in average sales per product in these markets. A priori, one might expect distance to have a negative effect on both of these margins, and indeed BJRS find that distance has a strong negative effect on the number of firms that sell to an export market as well as the number of products per firm exported. However, somewhat surprisingly, they find that the intensive margin—average sales of individual products—is *increasing* with distance. BJRS observe that this finding "is at first sight puzzling" and suggest one potential explanation is that variable trade costs may operate in a different manner than the "iceberg" formulation standard in the trade literature.

[1] Disdier and Head (2006) reported that that the average elasticity of trade with respect to distance from 103 empirical papers was -0.9.

[2] One notable exception is the work of David Hummels (2001, 2007).

[3] For instance, the extensive survey of trade costs in Anderson and van Wincoop (2004) contains only one page of discussion of fixed costs.

Our paper's first contribution is to show that the apparently puzzling finding of distance having a positive effect on average sales per product does not require a new formulation of variable trade costs. In fact, this result turns out to be consistent with the traditional iceberg approach, once it is combined with the assumptions of firm heterogeneity in productivity and fixed costs associated with exporting to each market.

We illustrate this point by applying the model in Chaney (2007) to the product level, implying heterogeneity in productivity and fixed and variable trade costs associated with each product. We discuss the effects of both types of trade costs on the number of products exported to each market as well as the average sales per product in these markets. As would be expected, this model predicts that the number of products exported to a market depends negatively on both fixed and variable trade costs. More surprisingly, however, it also predicts that average sales per product does not depend on variable trade costs at all, and depends positively on fixed trade costs. This is because profitably selling a product in a foreign market requires covering fixed trade costs and this requires a minimum level of productivity and sales. Thus, to the extent that fixed trade costs increase with distance, one should expect to find individual product sales relating positively to distance.

The paper's second contribution is to demonstrate how data on numbers of products exported to each market and average sales per product can be used to estimate the effects of distance on fixed and variable trade costs. We show that the BJRS evidence implies that distance has a stronger effect on fixed trade costs than on variable costs. In addition, we show how these estimates can be used to decompose the elasticity of trade with respect to distance into a component due to fixed trade costs and a component due to variable trade costs. We find that despite fixed costs being more sensitive to distance than variable costs, the effect of distance on trade is largely due to its effect on variable trade costs. This is because reductions in fixed trade costs increase aggregate trade only by introducing new firms to exporting, but these are more marginal low-productivity firms and so have a weaker effect on total exports.

The rest of the paper is organized as follows. Section 2 reviews the evidence on numbers of firms, numbers of products and exports per product presented by BJRS. Section 3 presents a version of Chaney's model and uses it to illustrate the effects of trade costs on the number of products exported as well as export sales per product. Section 4 then uses the model to estimate the effect of distance on fixed and variable trade costs and to decompose the contributions of these costs to the distance effect on trade. Section 5 concludes.

2 Evidence on Distance and Trade

Almost all of the previous research on the so-called gravity relationship in international trade has focused on aggregated data, which sum up bilateral exports over sectors or whole economies. One reason for this limited focus is that, until recently, researchers have not had access to firm-level data reporting both the quantity and the destination of each firm's exports. However, papers such as Eaton, Kortum, and Kramarz (2004) and Bernard, Jensen, Redding and Schott (2007) have shown how such data can generate substantial insights into the processes underlying international trade.[4]

Eaton, Kortum, and Kramarz (2004) do not explicitly discuss the effect of distance on the pattern of trade, but they report results that indicate the traditional approach to the gravity relationship, based on homogenous firms within each country, is incorrect. Using a cross-sectional sample of French firms from 1986, they show that the so-called extensive margin of trade (variations in the number of firms that serve export markets) appears to be more important than the intensive margin (variations in average export sales per firm).

More recently, BJRS use transactions-based data from the US Census (the Linked-Longitudinal Firm Trade Transaction Database or LFTTD) to provide a detailed picture of US exporting firms. A unique aspect of the LFTTD data is that, in addition to specifying which markets firms sell to, it also specifies how many products they sell (as described by ten-digit product classifications), as well as the total sales of each product. BJRS use this dataset to estimate a standard log-linear gravity equation for US exports in 2000 and then decompose the elasticities with respect to distance and GDP into three components: Extensive components due to the number of firms and number of products that are exported and an intensive component due to the value of export sales per product. We report their estimated elasticities for the extensive and intensive margins in Table 1. Focusing in particular on the coefficients on distance, it is striking that the negative distance elasticity of -1.36 obtained from this regressions is completely determined by extensive margin, which has a negative elasticity on -2.2.[5] In contrast, the effect of distance on the intensive margin is a *positive* elasticity of 0.84.

[4] Lawless (2007) also analyzes a data set of this type for Irish firms.

[5] BJRS report that the negative elasticity of -2.2 on number of products is about evenly divided between an effect due to the number of firms and an effect due to the number of products per firm.

Table 1: Gravity Equation Coefficients for Aggregate US Exports in 2000

	Total Export Value	Number of Products	Export Value Per Product
GDP	0.98	1.23	-0.25
Distance	-1.36	-2.20	0.84

Source: Figures are based on Table 6 in Bernard, Jensen, Redding and Schott (2007). All coefficients are significant at the 1% level. The coefficients for "Number of Products" are a combination of the coefficients on number of firms and average products per firm reported by BJRS.

BJRS note that this last finding is "at first sight puzzling." They suggest an explanation based upon variable trade costs that differ from the usual "iceberg" formulation. The iceberg approach assumes that a certain fraction of the goods produced for export "melt away" during the exporting process. Thus, the increased cost of producing a certain number of units for export is proportional to the initial production costs. BJRS argue that if these costs depended on quantity or weight then only high unit value products would be worth exporting: For instance, if variable trade costs depend on weight then diamonds and computer chips are more likely to be exported to a distant country than tins of baked beans.

One weakness of this argument as an explanation for the 0.84 elasticity is that this figure relates to the effects of distance on the average value of export sales per product, and this is not necessarily related to high unit values. For instance, if both diamonds and computer chips are exported to a particular country, then there is little reason to expect that the total value of export sales of diamonds will necessarily be higher than the value of sales of computer chips. In the next section, we show that one can in fact explain this finding with a model based upon the standard iceberg formulation of export costs.

3 Modelling Numbers of Products and Sales Per Product

In this section, we show how a model containing the features first introduced by Melitz (2003)—heterogeneity in productivity and both fixed and variable trade costs—can explain the finding of average sales per product increasing with distance. Specifically, we adapt a model with these features presented by Chaney (2007) to derive its predictions for the number of products exported and average sales per product.

3.1 Assumptions

We assume that each country produces a continuum of separate differentiated products, and that consumers in country j have utility function across the goods produced in all countries that takes the form

$$U_j = \left[\int x_j(k)^{\frac{\epsilon-1}{\epsilon}} dk \right]^{\frac{\epsilon}{\epsilon-1}} \tag{1}$$

Thus, the demand for good i in country j is

$$x_j(i) = \frac{p_j(i)^{-\epsilon} Y_j}{P_j^{1-\epsilon}} \tag{2}$$

where $p_j(i)$ is the price charged in country j for good i, Y_j is real income in country j and P_j is the Dixit-Stiglitz price level defined by

$$P_j = \left[\int p_j(k)^{1-\epsilon} dk \right]^{\frac{1}{1-\epsilon}} \tag{3}$$

We will focus on the model's predictions for the exports from a specific country, which for convenience we will assume produces a continuum of goods of unit mass. In light of the evidence above on product-level exports we assume that all costs, including fixed and variable trade costs, are incurred at the product level. In other words, we assume that price and quantity are set separately for each product as though it they are each sold by a separate firm.[6] For convenience, we assume that our exporting country produces a continuum of separate differentiated products of unit mass. Each product is produced according to a Ricardian technology with cost-minimizing unit cost $\frac{c}{a}$. Following Helpman, Melitz and

[6]This means that we are leaving aside a number of interesting questions related to multi-product firms. See Bernard, Redding, and Schott (2006) and Eckel and Neary (2006) for theoretical models that address these questions.

Yeaple (2004), the productivity parameter a is assumed to be randomly drawn from a Pareto distribution with probability density function $G(a) = \gamma a^{-\gamma-1}$ on the support $[1, \infty]$ (meaning c has the interpretation of the cost of the minimum-productivity technology).

Finally, there are two types of trade costs associated with exporting to country j. First, there are fixed costs F_j. These can be viewed as related to the bureaucratic paperwork costs associated with exporting, to marketing costs, and to the costs of running a wholesale and retail distribution chain. It is likely that each of these costs increase with the scale of exports; however, it is also likely that many of these costs need to be incurred independent of the scale of subsequent export sales. Second, there are variable costs, which are modelled with the iceberg specification so that τ_j units have to be shipped from our country of interest to country j for one unit to arrive. These can be viewed as transport costs, tariffs, and the variable costs associated with marketing and distribution.

3.2 Effects of Trade Costs

The assumptions about market structure and trade costs imply that the optimal selling price to country j for a good produced with technology level a is

$$p_j(a) = \frac{\epsilon}{\epsilon - 1} \frac{\tau_j c}{a} \tag{4}$$

This implies profits generated by this product in country j are given by

$$\pi_j(a) = \mu \left(\frac{P_j a}{\tau_j c} \right)^{\epsilon - 1} Y_j - F_j \tag{5}$$

where $\mu = (\epsilon - 1)^{\epsilon - 1} \epsilon^{-\epsilon}$. These profits are positive as long as

$$a > \left(\frac{F_j}{\mu Y_j} \right)^{\frac{1}{\epsilon - 1}} \frac{\tau_j c}{P_j} \tag{6}$$

This defines a cut-off level of productivity necessary for exporting to country j as

$$\bar{a}_j = \left(\frac{F_j}{\mu Y_j} \right)^{\frac{1}{\epsilon - 1}} \frac{\tau_j c}{P_j} \tag{7}$$

so that only firms with productivity above this level will sell in country j. As would be expected, this cut-off level of productivity is increasing in both types of trade costs and in domestic cost levels, while it is negatively affected by export country GDP and the price level in country j.

To interpret the evidence presented by BJRS, it is useful to derive the model's predictions for the extensive and intensive margins, that is, the number of products exported and the average exports per product.[7] The extensive margin can be derived as follows using the formula for the cut-off level of productivity

$$N_j = \int_{\bar{a}_j}^{\infty} G(a)da = \bar{a}_j^{-\gamma} = \left(\frac{P_j}{\tau_j c}\right)^{\gamma} \left(\frac{\mu Y_j}{F_j}\right)^{\frac{\gamma}{\epsilon-1}} \tag{8}$$

To calculate the intensive margin, we start by calculating the total value of export sales to country j. Export sales for a good produced with technology level a are

$$s_j(a) = p_j(a)x_j(a) = \left(\frac{P_j}{p_j(a)}\right)^{\epsilon-1} Y_j \tag{9}$$

Inserting the formula for the optimal price, we get

$$s_j(a) = \left(\frac{\epsilon-1}{\epsilon}\frac{P_j a}{\tau_j c}\right)^{\epsilon-1} Y_j \tag{10}$$

Thus, sales of an individual good depend positively on productivity, on the export country's GDP and price level, and negatively on variable trade costs. Once it has been decided that a product will be exported, its subsequent sales are independent of the fixed cost. Total export sales to country j are obtained by integrating across all productivity levels above the threshold:

$$S_j = \left(\frac{\epsilon-1}{\epsilon}\frac{P_j}{\tau_j c}\right)^{\epsilon-1} Y_j \int_{\bar{a}_j}^{\infty} a^{\epsilon-1} G(a)da \tag{11}$$

$$= \frac{\gamma}{\gamma-\epsilon+1}\left(\frac{\epsilon-1}{\epsilon}\frac{P_j}{\tau_j c}\right)^{\epsilon-1} Y_j \bar{a}_j^{\epsilon-\gamma-1} \tag{12}$$

Note from this last calculation that it is necessary to assume $\gamma > \epsilon - 1$. Higher values for γ implies that the distribution of productivity levels falls off faster. If this parameter is assumed to be too small, then firms with high productivity (and thus high sales) would become so important that the integral for total sales would not converge to a finite value.

The average value of exports per product can now be calculated directly as

$$\frac{S_j}{N_j} = \frac{\gamma}{\gamma-\epsilon+1}\left(\frac{\epsilon-1}{\epsilon}\frac{P_j}{\tau_j c}\right)^{\epsilon-1} Y_j \bar{a}_j^{\epsilon-1} \tag{13}$$

[7] As we discuss below, Chaney (2007) does not discuss the model's implications for these series because he focuses on a different definition of the intensive and extensive margins.

This can be simplified considerably by inserting the formula for the cutoff value of productivity. In this case, all of the terms involving Y_j, P_j, τ_j and c cancel out, leaving the strikingly simple formula

$$\frac{S_j}{N_j} = \frac{\gamma\epsilon}{\gamma - \epsilon + 1} F_j \tag{14}$$

Sales per firm are directly proportional to fixed trade costs. This result relies on the assumption that the productivity distribution is Pareto. This assumption, however, has more than analytical simplicity in its favor. There is empirical evidence that important firm-level distributions, such as for firm size, follow a Pareto distribution.[8] In addition, Gabaix (1999) has shown that Pareto distributions can be generated from an aggregation of random micro-level exponential growth shocks to each of the individual units, while Kortum (1997) has shown that the upper tail of productivity distributions needs to be Pareto if steady-state growth paths are to be sustained.

Finally, combining equation (8) for number of firms and equation (14) for sales per firm produces a simplified formula for total exports from our model economy to market j

$$S_j = \left(\frac{\gamma\epsilon}{\gamma - \epsilon + 1}\right)\left(\frac{P_j}{\tau_j c}\right)^{\gamma} (\mu Y_j)^{\frac{\gamma}{\epsilon-1}} F_j^{\frac{\epsilon-1-\gamma}{\epsilon-1}} \tag{15}$$

which is our version of equation (6) in Chaney's paper.

3.3 Discussion

These results show how the combination of fixed costs and firm heterogeneity can lead to somewhat counter-intuitive results for the effects of trade costs on the extensive and intensive margins seen in the data, i.e the number of products exported and average sales of these products. Equation (8)'s prediction that the number of products sold to a market is negatively related to both fixed and variable trade costs would be expected. However, equation (14)'s predictions that average export sales per product are independent of τ_j and depend *positively* on the fixed cost F_j are more surprising.

Intuitively, this result can be explained as follows. First consider the effects of variable trade costs. Equation (9) tells us that, for each individual product, an increase in τ_j reduces the exports of all firms that choose to continue sell to market j. However, this increase also eliminates some marginal low-sales products from the market. When productivity is drawn from a Pareto distribution, these two counteracting forces exactly offset each other.

[8] See Axtell (2001) for evidence on size distributions of US firms.

As a result, variable trade costs (as well as foreign country GDP and price level) have no effect on average exports per product. In contrast, fixed trade costs have no effect on sales of individual products (once a firm has decided to supply the product) but an increase in these costs removes some marginal products with low sales from the market. For this reason, average exports per firm depend positively on fixed costs. Thus, to the extent that fixed trade costs increase with distance, one should expect to obtain BJRS's finding of sales per product depending positively on distance.

Before discussing the relationship between trade costs and distance in more detail, it is worth noting that our discussion of intensive and extensive margins differs from that in Chaney (2007) because he focuses on different definitions of these margins. Equations such as (8) and (14) for number of firms and sales per firm are not discussed in his paper. Instead, he uses the Leibniz Integral Rule to divide changes in total exports due to shifts in an exogenous parameter x as follows

$$\frac{\partial S_j}{\partial x} = \int_{\bar{a}_j}^{\infty} \frac{\partial s_j(a)}{\partial x} G(a)da - s_j(\bar{a}_j)G(\bar{a}_j)\frac{\partial \bar{a}_j}{\partial x} \tag{16}$$

For instance, consider a change that leads to firms exiting market j. The first term in this decomposition (the intensive margin) describes the change in exports keeping the group of exporting firms unchanged: The exports of firms that have exited are measured based on the optimal (loss-making) level of sales that they would have obtained had they stayed in the market. The second term (the extensive margin) measures the loss in sales due to these firms having exited the market. This provides a useful theoretical decomposition of the effects of changes in exogenous parameters. It has the disadvantage, however, of being based on a thought experiment: How much would firms that have exited sell if they were still exporting, or how much would firms that have just arrived have sold if they were exporting last period? This means that, in practice, these two components cannot be observed over time in datasets such as the LFTTD.[9] In addition, unlike the decomposition of exports into number of products and exports per product, this decomposition has no analogue in cross-sectional data such as those that generated the BJRS results.

[9] An additional complication is that one is likely to see simultaneous entry and exit to each individual export market. Lawless (2007) documents this is a significant pattern using a sample of Irish exporting firms.

4 Distance, Trade Costs, and Gravity

Equations (8) and (14) describe how fixed and variable trade costs can affect exports when there is heterogeneity in productivity. These relationships can also be linked directly to the gravity regressions presented by BJRS by making assumptions about the form of the relationships between these trade costs and both distance and destination country GDP. Here, we provide a simple log-linear model of these relationships and derive estimates of its parameters. We then show how these estimates can be used to decompose the elasticity with respect to distance in an estimated gravity relationship into a component due to fixed trade costs and a component due to variable trade costs.

4.1 How Does Distance Affect Trade Costs?

Because the gravity regression takes a log-linear form, it is natural to also assume this specification for the relationship between trade costs and distance and GDP. Omitting other factors, this leads to the following simple formulation:

$$F_j = d_j^{\theta_1} Y_j^{\theta_2} \tag{17}$$

$$\tau_j = d_j^{\theta_3} Y_j^{\theta_4} \tag{18}$$

Substituting these into equations (8) and (14), we now obtain expressions for the intensive and extensive margins directly in terms of the effects of distance and destination-country GDP, as in the BJRS regressions (reported here in Table 1):

$$N_j = \left(\frac{P_j}{c}\right)^{\gamma} d_j^{-\gamma\left(\theta_3+\frac{\theta_1}{\epsilon-1}\right)} Y_j^{\left(\frac{\gamma}{\epsilon-1}\right)(1-\theta_2-\theta_4(\epsilon-1))} \tag{19}$$

$$\frac{S_j}{N_j} = \frac{\gamma\epsilon}{\gamma-\epsilon+1} d_j^{\theta_1} Y_j^{\theta_2} \tag{20}$$

The elasticities with respect to distance and GDP in these equations can now be related directly to the estimated values obtained by BJRS, so that

$$\begin{array}{rclrcl} -\gamma\left(\theta_3+\frac{\theta_1}{\epsilon-1}\right) & = & -2.2 & \left(\frac{\gamma}{\epsilon-1}\right)(1-\theta_2-\theta_4(\epsilon-1)) & = & 1.23 \\ \theta_1 & = & 0.84 & \theta_2 & = & -0.25 \end{array} \tag{21}$$

The estimated elasticities for sales per product translate directly into the elasticities for fixed trade costs. Thus, the elasticity of fixed trade costs with respect to distance is $\theta_1 = 0.84$, while the elasticity with respect to GDP is $\theta_2 = -0.25$. This latter estimate is somewhat

surprising because one might have expected larger markets to have higher set-up costs. One possible explanation is that richer countries tend to have better infrastructure and lower regulatory burdens and these advantages may be more important for fixed trade costs.

The parameters of the variable trade equation cannot be directly identified because the remaining two equations have four unknown parameters: θ_3, θ_4, ϵ and γ. Our approach is to use values for ϵ and γ that have been derived elsewhere on the basis of firm-level data. Specifically, we follow Bernard, Redding, and Schott (2007) and use $\epsilon = 3.8$ and $\gamma = 3.4$. This results in estimates of $\theta_3 = 0.35$ and $\theta_4 = 0.08$.[10] This latter estimate implies that destination country GDP has very little effect on variable trade costs.[11]

The pattern of the estimated effects of distance are perhaps a bit surprising. The most obvious trade costs that are directly related to distance are transport costs. And indeed, our estimate of an elasticity of 0.35 for variable trade costs with respect to distance is very similar to the estimates of the effect of distance on various types of transport costs (rail, shipping, air) presented by Hummels (2001). However, the far larger effect of distance on fixed costs trade costs suggests a more complicated set of barriers that appear to increase with distance.

4.2 Decomposing the Distance Effect on Trade

Equations (19) and (20) can be combined to provide a full expression for total export sales from our model economy to country j as a function of distance and GDP, illustrating the separate roles these factors play through their effects on fixed and variable costs:

$$S_j = \left(\frac{\gamma\epsilon}{\gamma - \epsilon + 1}\right)\left(\frac{P_j}{c}\right)^{\gamma}(\mu Y_j)^{\frac{\gamma}{\epsilon-1}}\left(d_j^{\theta_3}Y_j^{\theta_4}\right)^{-\gamma}\left(d_j^{\theta_1}Y_j^{\theta_2}\right)^{\frac{\epsilon-1-\gamma}{\epsilon-1}} \tag{22}$$

Combining this equation with our estimates of the trade costs functions and Bernard, Redding, and Schott's values for ϵ and γ, we can decompose the effect of distance on exports (reported in Table 1 to be -1.36) into the effect due to its impact on fixed trade costs and the effect due to its impact on variable trade costs. The total distance elasticity

[10] Experimentation with other values of ϵ and γ with the ranges reported in the literature, while maintaining the necessary assumption of $\gamma > \epsilon - 1$, gave relatively similar values.

[11] We should note that this calculation could have been done somewhat differently. Chaney (2007) applies this model to determine the price level in all countries so that P_j depends on Y_j. Once this adjustment is made, the overall elasticity of N_j with respect to Y_j becomes one, as in the traditional gravity equation. Applying our calculation to this version of the equation, the elasticity of variable trade costs with respect to destination country GDP becomes $\theta_4 = 0.02$, further confirming our conclusion of a weak relationship.

of -1.36 turns out to be composed of an effect of $-0.17\left(=-\frac{\epsilon-1-\gamma}{\epsilon-1}\theta_1\right)$ due to fixed costs, while the remaining $-1.19\,(=-\gamma\theta_3)$ is due to variable costs. Thus, the impact of distance on total exports works primarily through the channel of variable costs, even though these are less sensitive to distance than are fixed costs. This result is obtained because fixed costs only influence exports by adding or removing marginal products with lower sales, while variable trade costs influence both the entry decision and subsequent sales for all firms.

This last calculation sheds some interesting light on the effect of distance on exports. In this model, it is the presence of fixed costs that generates the extensive margin: Without these costs, the model would predict that all firms would export to all markets. And the BJRS evidence shows that the extensive margin is what determines the negative effect of distance on exports (see the elasticity of -2.2 in Table 1). Thus, one might expect that the effect of distance on exports largely reflects its effect on fixed trade costs. However, it turns out that the distance elasticity is mainly due to the effect of distance on variable trade costs.

One way to understand this result is through the formula for the cut-off value of productivity for exporting, equation (7). While it is the existence of fixed costs that implies the existence of a productivity cutoff, the subsequent importance of this margin depends more on variable trade costs than on fixed costs. Equation (7) shows that the elasticity of the cutoff with respect to variable costs is one, while the elasticity with respect to fixed costs is $\frac{1}{\epsilon-1}$, which our estimates suggest is about one-third.

5 Conclusions

That distance inhibits trade is one of the most robust findings in empirical international economics. The recent finding from detailed data on US firms of Bernard, Jensen, Redding and Schott (2007) that export sales per product tend to increase with distance is therefore very surprising. We have shown that this apparently counterintuitive finding is in fact consistent with models of international trade that assume firm heterogeneity in productivity and fixed costs such as the models of Melitz (2003) and Chaney (2007).

Heterogeneity in productivity helps to explain the finding because those firms engaged in exporting to distant locations are predicted to be more productive than those that only export close to home. However, the presence of fixed trade costs is also crucial. For instance,

other models featuring heterogeneous productivity, such as Eaton and Kortum (2002) can generate intensive and extensive margins in trade without fixed costs by invoking different assumptions about preferences—that all economies can produce the same set of goods and trade only takes place when one country can be the cheapest supplier of a product to another country. However, the Eaton-Kortum model does not predict that sales per product should increase with distance. Thus, the BJRS results appear to favor models that incorporate fixed trade costs that increase with distance, so that firms that export to distant markets need to sell enough to cover these costs.

We have also shown how evidence on numbers of products exported and average sales per product can be combined with the Melitz-Chaney model to estimate the effects of distance on fixed and variable trade costs. We find that fixed trade costs appear to rise more with distance than variable costs. However, while fixed costs are necessary for this model to generate the extensive margin of trade and it is through this margin that the distance affects trade negatively, we estimate that the elasticity of trade with respect to distance is largely due to its effect on variable costs.

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