Exports versus FDI*

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COMMENTS AND SUGGESTIONS ARE WELCOMED

1 Introduction

Multinational sales have grown tremendously in the last two decades. Growth of these sales has even outpaced the remarkable expansion of trade in manufactures. Consequently, the trade literature has sought to incorporate the mode of foreign market access into the "new" trade theory. This literature recognizes that firms can service foreign buyers through a variety of channels: they can export their products to foreign customers; serve them through foreign subsidiaries by engaging in foreign direct investment (FDI); and license or contract with foreign firms to produce and sell their products.

Our work focuses on the firm's choice between exports and "horizontal" FDI sales.[1] Horizontal FDI refers to investments in production facilities abroad that are designed to serve foreign customers. We therefore exclude "vertical" motives for FDI, that involve

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[1] See Ethier (1986), Horstmann and Markusen (1987), and Ethier and Markusen (1996) for models that incorporate the licensing alternative.

the fragmentation of the production process across countries (see Helpman (1984) and Markusen (1996) for treatments of this form of FDI in general equilibrium). We follow the previous literature on horizontal FDI by assuming that foreign affiliate production is intended for the local market.[2] However, we show in an appendix how our model can be extended to incorporate exports by foreign affiliates. This adds a new motive for FDI: the use of affiliates as "export platforms." In all these cases, however, firms invest abroad when the gains from avoiding transport costs outweigh the costs of maintaining capacity in multiple markets. This is known as the proximity-concentration trade-off.

We extend the "proximity-concentration trade-off" literature by introducing intra-industry firm heterogeneity. We build a simple multi-country, multi-sector general equilibrium model that explains the decisions of heterogeneous firms to serve foreign markets through exports or local subsidiary sales. These modes of market access have different relative costs, some of which are sunk (such as entry costs) while others vary with sales (such as transport costs and tariffs). Relative to FDI, exporting involves lower sunk costs but higher per-unit costs.[3]

We show that firm heterogeneity plays an important role in understanding the structure of international commerce. First, only the most productive firms engage in foreign activities. This result mirrors other findings on firm heterogeneity and trade; in particular, the results reported in Melitz (2002).[4] Second, of those firms that do serve foreign markets, only the most productive engage in FDI. Third, the extent of intra-industry firm heterogeneity plays a key role in determining the volume of FDI relative to the volume of exports. Hence, we identify a new industry characteristic — the dispersion of productivity levels across firms — as a determinant of the composition

[2] See, for example, Horstmann and Markusen (1992), Brainard (1993), and Markusen and Venables (2000).

[3] Sunk costs associated with exporting allow the model to explain two important empirical patterns: the existence of substantial subsets of firms within every manufacturing sector that do not engage in any form of international commerce; and the existence of large numbers of foreign wholesale affiliates whose main activity is to redistribute the output manufactured by the parent firm. Although such firms are technically multinationals, the foreign affiliates do not duplicate the production process. In the context of our model, we characterize such firms as exporters who incur fixed distribution costs in the destination country. In our empirical work, we exclude the sales of these wholesale affiliates from our measure of FDI sales.

[4] See also Bernard, Eaton, Jenson and Kortum (2000) for an alternative theoretical model and Tybout (2002) for a survey of the empirical literature.

of trade.

This allows us to derive new insights into the proximity-concentration trade-off. First, standard proximity-concentration variables determine only the productivity levels that a firm must achieve to make its international activities attractive, and FDI attractive in particular. So while higher transport costs have the effect of reducing the productivity levels that must be enjoyed by a firm to induce it to undertake FDI rather than export, a complete prediction over the composition of international commerce also requires information about the degree of dispersion of productivity levels across firms within an industry.[5] Second, our model avoids the knife-edge conditions associated with existing general equilibrium models of FDI that are based on representative firms. In a typical model from this family, exogenous industry characteristics mandate that either all firms invest abroad or that none does.[6] In contrast, our model implies that standard proximity-concentration variables determine only the cutoff productivity levels for various modes of organization. Firm heterogeneity then ensures that there is a determinant number of firms that export and firms that invest abroad. This provides a more appealing and realistic explanation for the concomitant use of export and FDI sales. Finally, our model identifies a new "home market bias," whereby the number of firms that locate their headquarters in a particular country rises disproportionately with the country's size. In addition, small markets are disproportionately served by affiliates of multinational companies and by exporters from other countries.

We test the predictions of the model on U.S. outward export and FDI data that cover 52 manufacturing industries and 38 countries. We show that the productivity dispersion measures help to predict the composition of trade and investment in the manner predicted by the model. Industries in which productivity levels vary highly across firms are characterized by an increased volume of FDI relative to exports. We show that these results are robust across several measures of productivity dispersion.

[5] Our model formalizes the old idea that multinational firms must have some form of ownership advantage conferred by access to firm-specific intangible assets (for a discussion of this literature, see Markusen (1995)). In our model this intangible asset takes the form of a superior production technology. Our analysis takes this idea much further by allowing industry characteristics, such as transport costs, to govern the extent of an ownership advantage needed to become a multinational and by positing a distribution of these assets within an industry.

[6] Only on the "knife-edge" can firms that export and firms that do FDI coexist.

In addition, we confirm the predictions of the proximity-concentration trade-off. We find that firms tend to substitute FDI for exports when transport costs are relatively high and when plant-level returns to scale are relatively weak. We conclude that intra-industry firm heterogeneity plays an important role in determining the composition of international trade.

The remainder of this paper is composed of three sections. In section 2 we elaborate the model and characterize its equilibrium. We then map the theoretical results into an empirical strategy for testing our main hypotheses concerning the role played by firm heterogeneity in the proximity-concentration trade-off between exports and FDI. In section 3 we describe the data. Finally, we report and interpret the empirical results in section 4.

2 Theoretical Framework

There are N countries that use labor to produce goods in $H+1$ sectors. One sector produces a homogeneous product while H sectors produce differentiated products. A fraction β_h of income is spent on differentiated products of sector h and a fraction $1-\sum_h \beta_h$ on the homogeneous good, which is our numeraire.

Country i is endowed with L^i units of labor. We take $\sum_h \beta_h$ to be small enough and differences in L^i to be small enough so that the homogeneous product is produced in every country and wages are equalized across countries.[7] The homogeneous product is produced with one unit of labor per unit output. As a result, the common wage rate equals one.

Now consider a particular sector h that produces differentiated products. For the time being we drop the index h, and it has to be understood that all sectoral variables refer to sector h.

To enter the industry in country i, a firm bears the fixed costs of entry f_E, measured in labor units. An entrant then draws a labor per unit output coefficient a from

[7] We will show later the precise restrictions on the cross country variation in L^i that are needed for this outcome.

a distribution $G(a)$. Upon observing this draw, a firm may decide to exit and not produce. If it chooses to produce, however, it bears additional fixed overhead labor costs f_D. There are no other fixed costs when the firm sells only in the home country. If the firm chooses to export, it bears additional fixed costs f_X per foreign market. On the other hand, if it chooses to serve a foreign market via foreign direct investment (FDI), it bears additional fixed costs f_I in every foreign market. We think about f_X as the costs of forming a distribution and servicing network in a foreign country (similar costs for the home market are included in f_D). The fixed costs f_I include these distribution and servicing network costs, as well as the costs of forming a subsidiary in a foreign country and the duplicate overhead production costs embodied in f_D. The difference between f_I and f_X thus indexes plant level returns to scale for the sector.[8] Goods that are exported from country i to country j are subjected to melting iceberg transport costs $\tau^{ij} > 1$. Namely, τ^{ij} units have to be shipped from country i to country j for one unit to arrive. After entry, producers engage in monopolistic competition.

Preferences over varieties of product h have the standard CES form, with an elasticity of substitution $\varepsilon = 1/(1-\alpha) > 1$.[9] These preferences generate a demand function $A^i p^{-\varepsilon}$ in country i for every brand of the product, where the demand level A^i is exogenous from the point of view of the individual supplier.[10] In this case, the brand of a monopolistic producer with labor coefficient a is offered for sale at the price $p = a/\alpha$, where $1/\alpha$ represents the markup factor. As a result, the effective consumer price is

[8] Part of the cost difference $f_I - f_X$ may also reflect some of the entry costs represented by f_E, such as the initial cost of building another production facility.

[9] The utility function is

$$u = \left(1 - \sum_{h=1}^{H} \beta_h\right) \log z + \sum_{h=1}^{H} \frac{\beta_h}{\alpha_h} \log \left(\int_{v \in V} x_h(v)^{\alpha_h} \, dv \right),$$

where z is consumption of the homogenous good, $x_h(v)$ is consumption of variety v from sector h, and V is the set of all potential varieties in sector h.

[10] As is well known, our utility function implies that

$$A^i = \frac{\beta E^i}{\int_0^n p^i(v)^{1-\varepsilon} \, dv},$$

where E^i is the aggregate level of spending in country i, n is the number (measure) of varieties available in country i and $p^i(v)$ is the consumer price of variety v.

a/α for domestically produced goods — be they supplied by a domestic producers or a foreign multinational (with the labor coefficient a) — and is $\tau^{ji}a/\alpha$ for imported products from country j (from exporters with the labor coefficient a). Imported products are thus more expensive than domestically produced goods due to transport costs.

A firm from country i that remains in the industry will always serve its domestic market through domestic production. It may also serve any foreign market j. If so, it also chooses a channel to access this foreign market: exports via domestic production or local sales via affiliate production (FDI). This choice is driven by the proximity-concentration trade-off: relative to exports, FDI eliminates the variable transport cost τ^{ij} but involves duplicating production facilities and hence higher fixed costs.[11] In equilibrium, no firm engages in both activities for the same foreign market.[12] We assume

$$f_I > \left(\tau^{ij}\right)^{\varepsilon-1} f_X > f_D. \tag{1}$$

We shall clarify the role of these conditions in the following analysis.

Operating profits from serving the domestic market are

$$\pi_D^i = a^{1-\varepsilon} B^i - f_D$$

for a firm with a labor-output coefficient a, where $B^i = (1-\alpha) A^i/\alpha^{1-\varepsilon}$.[13] On the other hand, the *additional* operating profits from exporting to country j are

$$\pi_X^{ij} = \left(\tau^{ij} a\right)^{1-\varepsilon} B^j - f_X,$$

[11] We exclude the possibility of exports by foreign affiliates. See, however, the appendix for a discussion of this possibility.

[12] In a dynamic model with uncertainty, an individual firm may choose to serve a foreign market through both exports and FDI. Rob and Vettas (2001) provide a rigorous treatment of this case.

[13] Note that the demand function $A^i p^{-\varepsilon}$ implies output $A^i \left(a/\alpha\right)^{-\varepsilon}$ when the price is a/α. Under these circumstances costs are $\alpha A^i \left(a/\alpha\right)^{1-\varepsilon}$ while revenue is $A^i \left(a/\alpha\right)^{1-\varepsilon}$. Therefore operating profits are

$$\pi_D^i = (1-\alpha) A^i \left(a/\alpha\right)^{1-\varepsilon} - f_D.$$

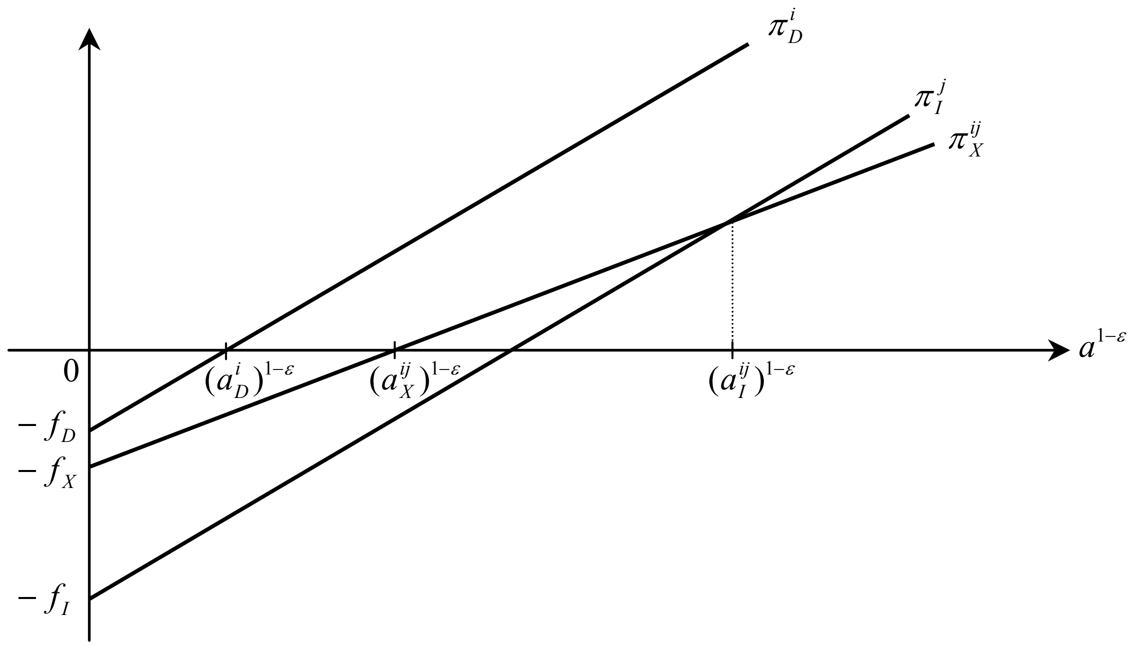

Figure 1: Profits from domestic sales, from exports and from FDI

and the additional operating profits from FDI in country j are

$$\pi_I^j = a^{1-\varepsilon} B^j - f_I \ .$$

These profit functions are represented in figure 1 for the case where the demand levels are the same in both country i and j.[14] In this figure, $a^{1-\varepsilon}$ is represented on the horizontal axis. Since $\varepsilon > 1$, this variable increases monotonically with labor productivity $1/a$, and can be used as a productivity index. All three profit functions are increasing linear functions of this index. More productive firms are therefore more profitable in all three activities.

The slope of π_D^i equals B^i while the slope of π_I^i equals B^j. These profit functions are parallel to each other when the demand levels are the same in countries i and j. Profits from FDI are lower, however, because the fixed costs of FDI, f_I, are higher

[14] We thank Dani Tsiddon for proposing this figure. In the figure $f_X > f_D$, which is a sufficient condition for the second inequality in (1). Evidently, this inequality can also be satisfied when $f_X < f_D$, and we need only the inequality in (1) in order to ensure that some firms serve only the domestic market.

than the fixed costs of domestic production, f_D. The slope of π_X^{ij} equals $(\tau^{ij})^{1-\varepsilon} B^j$, which is smaller than the slope of π_I^{ij}. Together with the first inequality in (1), these relationships imply that exports are more profitable than FDI for low productivity firms and less profitable for high productivity firms. Moreover, there exist productivity levels at which exporters have positive operating profits that exceed the operating profits from FDI. Namely, $\left(a_I^{ij}\right)^{1-\varepsilon} > \left(a_X^{ij}\right)^{1-\varepsilon}$, which ensures that some firms export to country j. In addition, the second inequality in (1) implies that $\left(a_X^{ij}\right)^{1-\varepsilon} > \left(a_D^{i}\right)^{1-\varepsilon}$, which ensures that some firms serve only the domestic market.

The least productive firms expect negative operating profits and therefore exit the industry. This fate befalls all firms with productivity levels below $\left(a_D^{i}\right)^{1-\varepsilon}$, which is the cutoff at which operating profits from domestic sales equal zero. Firms with productivity levels between $\left(a_D^{i}\right)^{1-\varepsilon}$ and $\left(a_X^{ij}\right)^{1-\varepsilon}$ have positive operating profits from sales in the domestic market, but expect to lose money from exports and FDI. They choose to serve the domestic market but not to serve the market in country j. The cutoff $\left(a_X^{ij}\right)^{1-\varepsilon}$ is the productivity level at which exporters just break even. Higher productivity firms can export profitably. But those with productivity above $\left(a_I^{ij}\right)^{1-\varepsilon}$ gain more from FDI. For this reason, firms with productivity levels between $\left(a_X^{ij}\right)^{1-\varepsilon}$ and $\left(a_I^{ij}\right)^{1-\varepsilon}$ export while those with higher productivity levels build subsidiaries in country j, which they use as platforms for servicing country j's market. It is evident from the figure that the cutoff coefficients $\left(a_D^{i}\right)^{1-\varepsilon}$, $\left(a_X^{ij}\right)^{1-\varepsilon}$ and $\left(a_I^{ij}\right)^{1-\varepsilon}$ are determined by

$$\left(a_D^{i}\right)^{1-\varepsilon} B^i = f_D \quad \text{for all } i, \tag{2}$$

$$\left(\tau^{ij} a_X^{ij}\right)^{1-\varepsilon} B^j = f_X \;\; \text{for all } j \neq i, \tag{3}$$

$$\left(1-\tau^{1-\varepsilon}\right)\left(a_I^{ij}\right)^{1-\varepsilon} B^j = f_I - f_X \;\; \text{for all } j \neq i. \tag{4}$$

We now calculate the expected operating profits of a potential entrant. Free entry ensures that these expected profits equal the entry costs f_E in equilibrium. This free entry condition can be expressed as[15]

$$V\left(a_D^i\right)B^i+\sum_{j\neq i}\left[1-\left(\tau^{ij}\right)^{1-\varepsilon}\right]V\left(a_I^{ij}\right)B^j+\sum_{j\neq i}\left(\tau^{ij}\right)^{1-\varepsilon}V\left(a_X^{ij}\right)B^j$$
$$-\left[G\left(a_D^i\right)f_D+\sum_{j\neq i}G\left(a_I^{ij}\right)\left(f_I-f_X\right)+\sum_{j\neq i}G\left(a_X^{ij}\right)f_X\right]=f_E\quad\forall i,\quad (5)$$

where

$$V\left(a\right)=\int_0^a y^{1-\varepsilon}dG\left(y\right)\ . \quad (6)$$

Equations (2)-(5) provide implicit solutions for the cutoff coefficients a_D^i, a_X^{ij}, a_I^{ij} and the demand levels B^i in every country. Evidently, these solutions do not depend on the country size variables L^i, as long as the variation in country size is not large enough to induce some countries to specialize in differentiated products. Moreover, it is easy to see that we can also allow cross country variations in the fixed cost coefficients, as long as these variations do not lead some countries to stop producing the outside good. These generalizations are useful for our empirical application.

2.1 Solving the Full General Equilibrium Model: A Special Case

In order to build intuition for our model and its empirical predictions, we first examine a special case that exploits some symmetry across countries. Assume, for this purpose, that all fixed cost coefficients are the same in every country, that the distribution function $G\left(\cdot\right)$ is the same in every country, and that transport costs per product are the same for every pair of countries. The latter assumption means that $\tau^{ij}=\tau>1$ for every $j\neq i$. These restrictions are within every sector, so that there can be variations

[15] The expected operating profits of a potential entrant are

$$\int_0^{a_D^i}\left(a^{1-\varepsilon}B^i-f_D\right)dG\left(a\right)+\sum_{j\neq i}\left\{\int_{a_I^{ij}}^{a_X^{ij}}\left[\left(\tau^{ij}a\right)^{1-\varepsilon}B^j-f_X\right]dG\left(a\right)+\int_0^{a_I^{ij}}\left(a^{1-\varepsilon}B^j-f_I\right)dG\left(a\right)\right\}.$$

Using this expression and the definition of the function $V\left(a\right)$ in (6), we obtain the free entry condition (5). Note that the expected operating profits can be smaller than the entry costs in some sectors, in which case no domestic firm would enter that industry. This is possible in a trading/investment equilibrium where consumers satisfy their consumption demand with foreign goods that are produced by either foreign exporters or by local subsidiaries of multinational corporations.

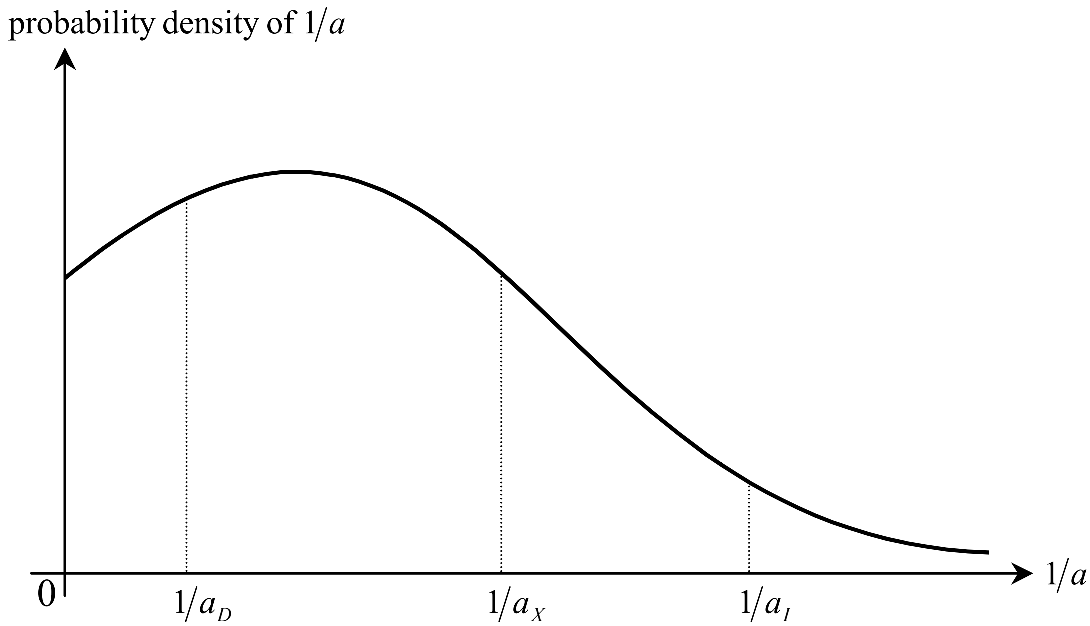

Figure 2: Probability density of labor productivity

in these characteristics across sectors. Moreover, countries can differ in size.

Under these circumstances, the equilibrium system (2)-(5) implies the same cutoffs $a_D^i = a_D$, $a_X^{ij} = a_X$, $a_I^{ij} = a_I$ and the same $B^i = B$ for every i, j. They are the solution to

$$a_D^{1-\varepsilon} B = f_D \ , \tag{7}$$

$$(\tau a_X)^{1-\varepsilon} B = f_X \ , \tag{8}$$

$$\left(1 - \tau^{1-\varepsilon}\right) a_I^{1-\varepsilon} B = f_I - f_X \ , \tag{9}$$

$$V(a_D) B + (N-1)\left(1 - \tau^{1-\varepsilon}\right) V(a_I) B + \tau^{1-\varepsilon} (N-1) V(a_X) B$$
$$- \left[G(a_D) f_D + (N-1) G(a_I)(f_I - f_X) + (N-1) G(a_X) f_X\right] = f_E. \tag{10}$$

Figure 2 describes the distribution of labor productivity that is induced by $G(a)$. It also describes the equilibrium cutoffs. The figure is the same for every country. The fraction of surviving firms is given by the area below the curve to the right of $1/a_D$.

The area between $1/a_D$ and $1/a_X$ represents the fraction of entrants who serve only the domestic market. The fractions of entrants who export or invest in foreign countries are represented, respectively, by the area between $1/a_X$ and $1/a_I$, and by the area above $1/a_I$.

Having solved the cutoffs and the demand level B, we can then determine the number of entrants in every country as a function of country size. To characterize the number of entrants in country i (in sector h), note that

$$B = \frac{1-\alpha}{\alpha^{1-\varepsilon}} A = \frac{(1-\alpha)\,\beta E^i}{\alpha^{1-\varepsilon} \int_0^n p^i(v)^{1-\varepsilon}\, dv}\ , \tag{11}$$

where E^i is the aggregate level of spending in country i, $p^i(v)$ is the consumer price of variety v in country i, and n is the number of brands available to consumers in country i. The latter is the same in every country. Since there are no pure profits in equilibrium, spending equals labor income: $E^i = L^i$. All brands that are produced in country i, by domestic firms or by foreign subsidiaries, have a consumer price of a/α when the producer's labor cost is a per unit output, and all imported brands have a consumer price of $\tau a/\alpha$ when the exporter's labor cost is a per unit output. It then follows from (11) that the numbers of entrants in country i, n_E^i, $i = 1, 2, ..., N$, are the solution of the linear system

$$\begin{bmatrix} v_D & v_{IX} & \cdots & v_{IX} \\ v_{IX} & v_D & \ddots & \vdots \\ \vdots & \ddots & \ddots & v_{IX} \\ v_{IX} & \cdots & v_{IX} & v_D \end{bmatrix} \begin{bmatrix} n_E^1 \\ n_E^2 \\ \vdots \\ n_E^N \end{bmatrix} = \frac{(1-\alpha)\,\beta}{B} \begin{bmatrix} L^1 \\ L^2 \\ \vdots \\ L^N \end{bmatrix},$$

where $v_D = V(a_D) > v_{IX} = V(a_I) + \tau^{1-\varepsilon}[V(a_X) - V(a_I)]$.[16] So long as the differences

[16] Since

$$\begin{aligned} \int_0^n p^i(v)^{1-\varepsilon}\, dv &= n_E^i \int_0^{a_D} \left(\frac{a}{\alpha}\right)^{1-\varepsilon} dG(a) + \sum_{j\neq i} n_E^j \left[\int_0^{a_I} \left(\frac{a}{\alpha}\right)^{1-\varepsilon} dG(a) + \int_{a_I}^{a_X} \left(\frac{\tau a}{\alpha}\right)^{1-\varepsilon} dG(a)\right] \\ &= \frac{v_D n_E^i + v_{IX} \sum_{j\neq i} n_E^j}{\alpha^{1-\varepsilon}} \end{aligned}$$

in the L^is are not too large, the number of entrants that solve this system is positive in every country; it is given by

$$n_E^i = \frac{(1-\alpha)\beta}{B\det(v)}\left\{\left[(N-1)v_{IX}+v_D\right]L^i - v_{IX}\sum_j L^j\right\}, \tag{12}$$

where $\det(v)$ is the determinant of the matrix v that has v_D as the diagonal elements and v_{IX} as the off diagonal elements. Since $v_D > v_{IX} > 0$, this determinant must be positive. Evidently, n_E^i is positive when all countries are of equal size. We assume that the difference in size are small enough so that $n_E^i > 0$ for every country.[17]

2.1.1 Home Market Effects

Equation (12) implies that more firms enter in larger countries and that $n^i/L^i > n^j/L^j$ for $L^i > L^j$. Namely, in a cross country comparison, the number of entrants rises more than proportionately with country size. Since the cutoff coefficients a_l, $l = D, X, I$, and the distribution function $G(\cdot)$ are the same in all countries, the number of firms that exit, the number of firms that serve only the domestic market, the number of firms that export, and the number of firms that invest in foreign countries, are all proportional to the number of entrants. In addition, the demand level coefficient B is also the same in all countries. Therefore aggregate sales of country-i based firms are proportional to n_E^i. Moreover, their sales in the domestic market are proportional to n_E^i, their exports are proportional to n_E^i, and foreign sales of subsidiaries of their multinationals are also proportional to n_E^i. It follows that larger countries have proportionately larger sales in each one of these categories.

Now define $n_O^i = G(a_D)n_E^i$ as the number of country-i based active firms and $n_B^i = G(a_X)\sum_{j\neq i} n_E^j + G(a_D)n_E^i = G(a_X)\sum_{j=1}^N n_E^j + \left[G(a_D) - G(a_X)\right]n_E^i$ as the number of

[17] Namely, we assume that

$$\frac{L^i}{\sum_j L^j} > \frac{v_{IX}}{(N-1)v_{IX}+v_D} \quad \forall i.$$

Since $v_D > v_{IX}$, the right hand side of this inequality is smaller than $1/N$, and therefore the inequality is satisfied when L^i is the same in all countries.

This assumption is not essential, however. Without it, the number of entrants is positive for the largest countries and zero for the smaller countries. The arguments that follow then apply only to the set of countries with positive entry.

firms doing business in country i. The ratio n_O^i/n_B^i is then higher in larger countries. Namely, the larger a country the larger the number of its active firms relative to the number of firms that operate in the country. Further note that n_B^i is larger in larger countries: consumers in larger countries enjoy higher levels of product variety and thereby higher welfare levels.[18]

Next consider relative market shares. Let σ_D^i be the market share of domestic firms in country i, let σ_X^i be the market share of foreign exporters in country i, and let σ_I^i be the market share of foreign multinationals in country i (these shares must sum to 1). Then

$$\sigma_D^i = \frac{BV(a_D)}{(1-\alpha)\beta}\frac{n_E^i}{L^i},$$
$$\sigma_X^i = \frac{B\tau^{1-\varepsilon}\left[V(a_X) - V(a_I)\right]}{(1-\alpha)\beta}\frac{\sum_{j\neq i} n_E^j}{L^i},$$
$$\sigma_I^i = \frac{BV(a_I)}{(1-\alpha)\beta}\frac{\sum_{j\neq i} n_E^j}{L^i}.$$

It follows that the larger is country i, the larger the market share of its firms in the domestic market, and the smaller the market share of foreign exporters and foreign multinationals. Moreover, the market shares of foreign exporters and foreign multinationals are proportionately smaller, because σ_X^i/σ_I^i is independent of country size.

2.1.2 Exports Versus FDI

We now consider the relative magnitude of exports and local FDI sales for any country pair. Let s_X^{ij} be the market share in country j of country i's exporters and let s_I^{ij} be the market share in country j of affiliates of country i's multinationals. The relative size of these market shares is then

$$\frac{s_X^{ij}}{s_I^{ij}} = \tau^{1-\varepsilon}\left[\frac{V(a_X)}{V(a_I)} - 1\right]. \quad (13)$$

[18] The country level price index $\int_o^n p^i(v)^{1-\varepsilon}dv$ is lower in bigger countries. This is driven by the effect of product variety as the average prices of varieties are identical across countries.

Given our symmetry assumptions on technologies and international transaction costs, this ratio is independent of i and j: every country has the same relative sales of exporters and affiliates in every other country. These relative sales increase with the exporting cutoff coefficient a_X and decrease with the FDI cutoff coefficient a_I. The cutoffs, in turn, are determined by the system of equilibrium conditions (7)-(10). This system can therefore be used to assess the consequences of changes in the costs of international transactions f_I, f_X, and τ.

A rise in the export costs f_X or τ, or a decrease in the FDI costs f_I, all have similar impacts on the a_X and a_I cutoffs: they induce an increase in a_I and a decrease in a_X.[19] The relative sales of exporters thus decline in all these cases. Recall that f_I encompasses both the country level fixed costs embodied in f_X as well as the duplicate plant overhead costs represented by f_D. It is therefore natural to consider the effects of equivalent increases in f_I and f_X (representing higher country level costs) and the effects of equivalent decreases in f_I and f_D (representing lower overhead plant costs, and hence smaller returns to scale). Again, manipulation of the system (7)-(10) indicate that the a_I and a_X cutoffs move in the same directions as before, entailing a decrease in relative export sales.

These are sensible comparative statics predicting the cross-sectoral variation in relative exports sales. We expect these relative sales of exporters to be lower in sectors with higher transport costs or fixed country level costs (even when the latter are also borne by multinational affiliates). We also expect them to be lower in sectors where plant-level returns to scale are relatively weak. This comparative statics analysis shows how the firm level proximity-concentration trade-off results can be extended to sectorial levels. In a departure from the previous literature, these sectorial level predictions are now based on the aggregation across heterogeneous firms that select different "modes" of foreign market access (FDI, exports, or neither).

[19] Given (7)-(9), it can be shown that shifts in the cutoffs a_l, $l = D, X, I$, have no first order effect on equation (10). Therefore (10) can be used to directly calculate the shifts in B in response to changes in any of the exogenous parameters. An increase in τ therefore induces an increase in B and a decrease in $\tau^{\varepsilon-1}B$. The direction of the change in the cutoffs a_X and a_I is then immediate from (8) and (9). Similarly, an increase in f_X will induce an increase in B and a decrease in B/f_X; a decrease in f_I will induce a decrease in B and an increase in $B/(f_I - f_X)$. The effects of these changes on the cutoffs are then once more directly obtained from (8) and (9).

We now shift the focus to the role of firm-level heterogeneity in explaining the cross-sectoral variation in relative export sales. Note from (13) that the function $V(.)$ directly impacts the relative sales (holding the cutoff levels fixed). Recall also that firm sales and variable profits are proportional to $a^{1-\varepsilon}$ in every market. $V(a)$ therefore captures (up to a multiplicative constant) the distribution of sales and variable profits among firms that make the same export or FDI decision. It also captures the distribution of domestic sales and variable profits among all surviving firms. We think of $V(a)$ as summarizing firm level heterogeneity in a sector. It is exogenously determined by the distribution of unit costs $G(a)$ and the elasticity of substitution ε, which magnifies differences in firm level outcomes that are induced by $G(a)$.

In order to index differences in firm-level heterogeneity across sectors, we parametrize $V(a)$ through a parametrization of the distribution $G(a)$. We use the Pareto distribution as a benchmark. When labor productivity $1/a$ is drawn from a Pareto distribution with shape parameter k, the distribution of firm domestic sales, indexed by $V(a)$, is also Pareto, with shape parameter $k-(\varepsilon-1)$.[20] The shape parameter of the Pareto distribution offers a natural and convenient index of dispersion, which we will use to characterize heterogeneity. Given our assumptions, the domestic sales of all firms with sales above any given cutoff are distributed Pareto with the same shape parameter $k-(\varepsilon-1)$. A higher dispersion of firm productivity draws (lower k) or a higher elasticity of substitution ε, generate an increase in the dispersion of firm domestic sales and variable profits. We now investigate the impact of such changes in firm level heterogeneity on the relative sales of exporters.

The Pareto benchmark implies that $V(a_1)/V(a_2)$ equals $(a_1/a_2)^{k-(\varepsilon-1)}$ for every a_1 and a_2 in the support of the distribution of productivity draws. The relative export

[20] The cumulative distribution function of a Pareto random variable X with shape parameter k is given by

$$F(x) = 1 - \left(\frac{b}{x}\right)^k, \text{ for } x \geq b > 0,$$

where b is a scale parameter that bounds the support $[b, +\infty)$ from below. $\log x$ is then distributed exponential with a standard deviation equal to $1/k$. Any truncation from below of X is also distributed Pareto with the same shape parameter k. X has a finite variance if and only if $k > 2$. We therefore assume that $k > \varepsilon + 1$, which ensures that both the distribution of productivity draws and the distribution of firm sales have finite variances.

sales in (13) can then be written as[21]

$$\frac{s_X^{ij}}{s_I^{ij}} = \tau^{1-\varepsilon}\left[\left(\frac{a_X}{a_I}\right)^{k-(\varepsilon-1)} - 1\right]$$

$$= \tau^{1-\varepsilon}\left[\left(\frac{f_I - f_X}{f_X}\frac{1}{\tau^{\varepsilon-1}-1}\right)^{\frac{k-(\varepsilon-1)}{\varepsilon-1}} - 1\right]. \quad (14)$$

Comparative statics on (14) predict that relative export sales decrease with decreases in k and increases in ε.[22] Thus, we expect sectors with higher levels of dispersion in firm domestic sales — generated either by higher dispersion levels of firm productivity or by a higher elasticity of substitution — to have lower levels of relative export sales. This is a significant implication of our model, highlighting the importance of firm level heterogeneity, that we will test.

2.2 Testable Implications

We focus our empirical work on the model's predictions concerning the determinants of the cross-sector and cross-country variation in relative export sales. This empirical analysis requires us to relax the symmetry assumptions imposed in the previous section and to allow for cross-country variation in wages, transport costs, and technology.

Consider the decisions of U.S. firms in sector h to serve country j via export sales versus affiliate sales. The equilibrium cutoff levels must satisfy:

$$\left(\tau_h^{Uj} w^U a_{hX}^{Uj}\right)^{1-\varepsilon_h} B_h^j = w^j f_X^j , \quad (15)$$

$$\left[\left(w^j\right)^{1-\varepsilon_h} - \left(w^U \tau_h^{Uj}\right)^{1-\varepsilon_h}\right]\left(a_{hI}^{Uj}\right)^{1-\varepsilon_h} B_h^j = w^j\left(f_{hI}^j - f_X^j\right) , \quad (16)$$

where w^U and w^j are the wage levels in the U.S. and country j, τ_h^{Uj} is the trade cost (transport and tariff) from the U.S. to country j in sector h, ε_h is the elasticity of substitution across varieties in sector h (common to all countries), B_h^j indexes the demand level for sector h in country j, and f_{hI}^j and f_X^j represent the fixed costs of doing

[21] Equations (8) and (9) are used in this derivation.

[22] Recall that $(f_I - f_X)/f_X\left(\tau^{\varepsilon-1}-1\right)$is greater than 1 by assumption.

FDI in and exporting to country j. These conditions replace (8) and (9). Note that f_{hI}^j is also indexed by sector h, since it includes plant set-up and overhead production costs. On the other hand, the fixed exporting costs are common across sectors; they index particular characteristics of doing business in country j for U.S. firms. These costs would also be incurred by U.S. firms setting-up affiliates in country j, so the difference $f_{hI}^j - f_X^j$ represents the overhead and set-up production costs. Let $f_{hP} \equiv f_{hI}^j - f_X^j$ reference these costs. (15) and (16) then imply:

$$\left(\frac{a_{hX}^{Uj}}{a_{hI}^{Uj}}\right)^{\varepsilon_h - 1} = \frac{f_{hP}}{f_X^j}\left[\left(\omega^j \tau_h^{Uj}\right)^{\varepsilon_h - 1} - 1\right]^{-1}, \tag{17}$$

where $\omega^j \equiv w^U/w^j$ indexes the U.S. wage relative to country j.

We further assume the following conditions on relative wages and trade costs:

- $w^U \tau_h^{Uj}/w^j < \left(1 + f_{hP}/f_X^j\right)^{1/(\varepsilon_h - 1)} = \left(f_{hI}^j/f_X^j\right)^{1/(\varepsilon_h - 1)}$, which ensures that there exist U.S. firms that prefer export to FDI in country j;

- $w^U \tau_h^{Uj}/w^j > 1$, which ensures that there exist firms that choose to locate in country j; and

- $w^j \tau_h^{jU}/w^U > 1$, which ensures that there exist firms that choose to locate in the U.S..[23]

We index the level of U.S. firm heterogeneity across sectors using the Pareto benchmark. We assume that the productivity draws for U.S. firms in sector h are distributed Pareto with shape k_h^U, and therefore that the distribution of U.S. domestic sales indexed by $V_h^U(a)$ is also Pareto with shape $k_h^U - (\varepsilon_h - 1)$. The sales of U.S. exporters

[23] The relative wage w^U/w^j must be measured in effective units of labor (adjusted for productivity and human capital differences). In our sample of countries the differences in productivity adjusted relative wages are small. In any case, our second and third conditions ensure that the relative wages are bounded by transport costs.

to country j relative to the U.S. affiliate sales in country j can then be written as

$$\begin{aligned}\frac{s_X^{Uj}}{s_I^{Uj}} &= \left(\omega^j \tau_h^{Uj}\right)^{1-\varepsilon_h} \left[\frac{V_h^U(a_{hX}^{Uj})}{V_h^U(a_{hI}^{Uj})} - 1\right] \\ &= \left(\omega^j \tau_h^{Uj}\right)^{1-\varepsilon_h} \left\{ \left[\frac{f_{hP}}{f_X^j} \frac{1}{\left(\omega^j \tau_h^{Uj}\right)^{\varepsilon_h - 1} - 1}\right]^{k_h^U - (\varepsilon_h - 1)} - 1 \right\}. \end{aligned} \qquad (18)$$

Comparing (14) and (18) confirms that all our previously derived comparative statics remain valid in a cross-section of both sectors and non-symmetric countries: the proximity-concentration forces predict lower U.S. relative export sales for country-sector pairs with high transport costs τ_h^{Uj}, countries with high fixed costs f_X^j, and sectors with low plant level returns to scale f_{hP}. As was previously the case, the extent of firm level heterogeneity remains an important determinant of relative export sales. Sectors with higher productivity dispersion levels (lower k) or higher elasticities of substitution, have lower relative export sales. We cannot separately measure k_h^U and ε_h. However, we can measure their difference $k_h^U - (\varepsilon_h - 1)$ under the Pareto assumption, because $1/\left[k_h^U - (\varepsilon_h - 1)\right]$ then indexes the measurable dispersion of firm size in sector h.

3 Data

To test our multi-sector, multi-country model, we require data that varies in both of these dimensions. The data required fall into roughly three categories: data on the composition of international commerce across countries and sectors, measures for key variables affecting the proximity-concentration trade-off, and indices capturing differences in the extent of firm level heterogeneity across sectors. In this section, we describe our choice of data in this order. Unless otherwise noted, all of the data described below are for the single year 1994.

3.1 The Composition of International Commerce

The biggest constraint on any analysis that considers the trade-off between exports and FDI is the dearth of internationally comparable measures of the extent of FDI across both industries and countries. Because the U.S. is one of only a handful of countries that collects multinational affiliate sales data disaggregated by both destination and by industry, our study covers only the composition of U.S. international commerce.

In the United States, the organization that collects census type data on FDI is the Bureau of Economic Analysis (BEA).[24] In its Benchmark surveys conducted every five years, the BEA collects affiliate level data on a wide range of establishment level variables including total affiliate sales. Affiliates are classified by their main line of business and assigned to one of 52 manufacturing classifications, which are shown in Table 1. The classification of affiliates and their sales by main line of business raises the concern that affiliates may sell a wide range of products from different industries. Our discussions with BEA employees suggests that while the sales of U.S. affiliates in foreign countries closely line up with the industrial classification of the affiliates, the same cannot be said of the sales of foreign affiliates in the United States. For this reason, we consider only the composition of U.S. outward trade or the ratio of U.S. exports sales to the sales of U.S. multinational affiliates by industry and country. To make our FDI data comparable to the data for exports, we aggregated the firm level multinational sales data to the level of the industry. Our export data are more familiar and have been taken from Feenstra (1997). The data have been concorded from 4 digit SITC industrial classifications into the BEA industry classifications shown in Table 1.

Finally, we consider two separate samples of countries, which can roughly be characterized as narrow and wide. The narrow sample consists of the 27 countries originally considered by Brainard (1997) while the wide sample includes 11 additional smaller and typically less developed countries. The country coverage is shown in Table 2. The benefit of the wider sample is that it includes a larger and more diverse set of countries while the drawback is that these countries are more likely to have fewer strictly positive

[24]We thank Bill Zeile of the Bureau of Economic Analysis for making this study possible.

levels of FDI, creating some concern about censoring.

3.2 Proximity-Concentration Variables

Our theoretical model relates the extent of FDI relative to exports as a function of relative costs of each activity. These costs take the form of unit costs of exporting and the size of the fixed cost to exporting relative to the fixed cost of investing abroad. These costs are not easily quantified so we discuss our proxies carefully.

We begin with the unit costs associated with international trade. Conceptually, unit costs to international trade can be due either to the physical cost of moving goods, i.e. shipping goods, or to barriers created by destination country governments; e.g., tariffs. We proxy for the two respectively with the variables FREIGHT and TARIFF, where FREIGHT is an ad-valorem measure of freight and insurance cost, and TARIFF is an ad-valorem measure of the size of trade taxes. FREIGHT is computed as the ratio of CIF imports into the United States to FOB imports, which is calculated from the data presented in Feenstra (1997). TARIFF is calculated at the BEA industry/country level from more finely disaggregated data. It is the unweighted average of tariffs across sub-industries within the BEA industry. Data are taken from Yeaple (2000) where the data are described in more detail.

While the unit costs of shipping goods are reasonably straightforward to measure, the same cannot be said for the fixed costs associated with exporting and doing foreign direct investment. In principle, these costs could vary by both industry and country but such measures do not exist in practice. To make progress, we begin by assuming that there is a country specific fixed cost associated with any form of commerce involving that country. This country specific fixed cost affiliates both exports and FDI. Having assumed that this measure is unobserved, country specific, and yet common to all industries, we subsume this measure into a country fixed effect.

We assume that any remaining cost associated with FDI stem from the cost of maintaining additional capacity. The difficulty associated with choosing a proxy for plant level fixed costs is that our model tells us that there is no such thing as the representative firm. To be consistent with our model, it is important that our measure be independent of any particular firm's size or level of productivity. This means that standard measures of plant level fixed cost, such as the number of production workers at a plant of median size, are not meaningful in our setting. Instead, we follow the model in choosing the number of non-production workers per establishment as reported in the 1997 Census of Manufacturing.[25] We calculate the average number of non-production workers at the NAICS level.[26] Our measure of plant-level fixed cost, FP, is computed as the average for each BEA sector, weighted by the NAICS level sales within each BEA sector.

3.3 Measures of Dispersion

The most novel feature of our model is that it relates the extent of intra-industry firm heterogeneity and the extent to which FDI subsidiary sales substitutes for exports. Everything else equal, international commerce in industries characterized by greater heterogeneity in firm productivity should tend to be skewed toward FDI and away from exports. To test this hypothesis, we require data that quantifies the extent of productivity dispersion by industry. This is a difficult measure to construct since we cannot directly observe the intra-industry distribution of productivity. Again, we rely heavily on guidance from the model to construct a measure.

According to the model, productivity differences across firms should be revealed by differences in firm size, since more productive firms sell more. There are several data sources that reveal the size distribution across firms within an industry. This mapping between the distribution of firm sizes and firm productivity is imperfect, however, because the distribution of firm sizes is a function of firm productivity and the elasticity of substitution among products within an industry. Fortunately, our comparative statics reveal that both are important in determining the extent of FDI relative to exporting.

To quantify the extent of dispersion within an industry, we assume that the sto-

[25] This meaure does not strictly conform to our modeling assumptions since the number of non-production workers is not independent of establishment size.

[26] The new 6 digit North American Industrial Classification System replaces the 4 digit Standard Industrial Classification, but provides roughly the same level of industry aggregation.

chastic process that determines firm productivity levels is Pareto across all industries and differs only in the distribution's shape parameter. This assumption is convenient because it suggests two conceptually equivalent ways to measure dispersion. The first is to regress the log rank of individual firms within the distribution on their log size. It can be shown that the estimated coefficient of such a regression is $k - (\varepsilon - 1)$, which is exactly the measure of dispersion as appears in the reduced form of the model.[27] The second method we employ to calculate dispersion is to compute the standard deviation of log firm sales, which, given our distributional assumption, is computationally equivalent to the slope of the conditional expectation of log rank on log size.[28]

While our distributional assumptions give us a precise methodology for computing dispersion, the choice of data is more problematic. We require disaggregated data on the distribution of sales across firm sizes that are representative of the population. We use two alternative data sources to compute these measures and gauge the robustness of our results. Since we are interested in dispersion measures of the size distribution of U.S. firms across sectors, the first data set we use is the publicly available data from the 1997 U.S. Census of Manufacturing. Unfortunately, these data reveal only the number of establishment that fall into 10 different size categories. Since the data do not reveal actual firm level data, we are unable to estimate size dispersion measures by regressing log rank on log sales. We can, however, compute the inverse of the standard deviation of log sales if we make a few additional assumptions. We assume that all establishments that fall within a size category have log sales equal to the center of the range of size categories. We then treat each of the size categories in the many sub-industries of the BEA industry classification as separate observations and calculate the inverse of the standard deviation of log sales using the number of firms in each size category as weights.

Although there are no publicly available firm level data sets for the U.S., Bureau van Dijck Electronic Publishing has recently made available a large data set of European

[27] It is comforting that the distribution of firm sizes does indeed closely follow a Pareto distribution. In fact, in the specifications that follow, we use the inverse of this measure since it is in fact the inverse that captures the degree of productivity dispersion within the industry.

[28] While the two methods of calculation should be equivalent in practice, there are moderate to small differences in the measures. We therefore calculate them both ways.

firms.[29] This database, named Amadeus, includes information on the consolidated sales, the national identity, and the main line of business by industry of a large number of European firms.[30] There are roughly 260 thousand firms with this data availability in Amadeus. We compute each of our two measures of firm dispersion by industry for two subsets of these data: all Western European firms and French firms only. We compute our firm dispersion measures using French firms only for two reasons. First, using data for multiple countries raises the issue of industrial composition. Within any BEA industries are many sub-industries for which countries might produce very different mixes. France's industrial structure is very similar to the U.S., and so might share most of the same distributional aspects of firm characteristics. Second, French firms are highly over-represented in the sample relative to all other Western European countries.[31] Our dispersion measures are based on a sample of 55,339 large Western European firms, and a subset of 15,148 French firms.[32]

There are four measures of dispersion calculated using the Amadeus data and one measure calculated from the U.S. data. The correlations between these measures are shown in Table 3 (along with our measure of plant-level fixed costs, FP, and the industries' capital-labor ratio, KL, and R&D intensity, RD). The table shows that all three measures from Amadeus are highly correlated with one another as one might expect. The table also reveals that the U.S. data is positively correlated across industries with the European data, but this correlation is not as high as among the purely European measures. There are at least two reasons that this might be so. First, the method of calculation is very different: the European measures are computed from actual firm level data while the American measure is calculated from semi-aggregated establish-

[29] This data set has recently been used by Budd, Konings and Slaughter (2002) who investigate international rent-sharing within multinational firms. We thank Matt Slaughter for bringing this data set to our attention.

[30] Both Western and Eastern European firms are represented.

[31] Due to national differences in reporting requirements, no information on UK firms are available, and only an extremely limited number of German firms appear in the sample.

[32] Because small firms are under-represented throughout the Amadeus database, we first drop firms with sales below a cutoff of U.S. $2.5 million per year. Note that, under the assumption of a Pareto firm size distribution, our measures of dispersion are invariant to the choice of lower bound cutoff. We computed the dispersion measures using several different cutoffs. Any cutoff above U.S. $2.5 million yielded firm size distributions across sectors with very close fits to the Pareto distribution and dispersion measures almost completely invariant to changes in the cutoff.

ment level data. Given the differences in methods of calculation, one might argue that the correlations are surprisingly high. Second, there is an additional issue associated with aggregation. If the composition of output varies across countries according to comparative advantage, then within each BEA industry, the product mix of goods produced in the U.S. may differ from that produced in Europe.

4 Specifications and Results

We estimate a linearized version of (18) using OLS, and regress the logarithm of the relative sales on our measure of dispersion, the logarithm of transport and tariff costs, and the logarithm of our proxy for plant fixed costs. We use country fixed effects to control for the differences in f_X and ω across countries. Of course, this linearization precludes any structural interpretation of the estimated parameters. Our goal is therefore limited to test the sign and significance of the estimated coefficients implied by the partial derivatives of (18).

Our methodology is to use all five of the alternative measures of productivity dispersion in order to increase our confidence that our results are robust. We also show the estimating results for each of our two country samples: narrow and wide. Note that all specifications below are estimated via ordinary least squares with dummy variables for each country in the sample.

We begin our analysis by considering the raw specification in which we do not attempt to control for any variables that might affect the trade-off between exporting and FDI. The results across specifications for our two samples and our five measures of dispersion are shown in Table 4. The columns correspond to different measures of dispersion beginning with the U.S. standard deviation of log sales, proceeding to the European and French only standard deviation measures, and ending with the estimated distribution parameters for Europe and the French only sample respectively. Note that the estimated country fixed effects have been suppressed.

We begin with the results obtained from the narrow country sample of relatively large countries considered by Brainard (1997). In each of the five specifications, the coefficients on FREIGHT and TARIFF are both negative and statistically significant. This result is consistent with that of Brainard (1997). The coefficient of FP is positive in all specifications and also always statistically significant. We therefore confirm the robust predictions of the proximity-concentration trade-off: firms substitute FDI for exports when costs associated with international trade are relatively large and when returns to scale are relatively weak.

Now consider the coefficients on the five measures of dispersion. Note that an increase in each of the measures is consistent with an increase in the degree of firm size dispersion so a negative coefficient is consistent with the predictions of the model. The most striking feature of the results is that the coefficient on the dispersion measure is consistently negative and statistically significant for all five measures. Industries in which firm size is highly dispersed are associated with relatively more FDI than exports, precisely as the model predicts. None of these results changes significantly when the set of countries is expanded to include the 11 smaller countries (the wide country sample).[33]

Although all measures of dispersion yield highly significant coefficients, the method used to obtain these measures seem to have a noticeable impact on the results. Both measures based on the parametrized fit to the Pareto firm size distribution yield substantially lower coefficients and higher standard errors (in absolute value) relative to the results obtained using the non-parametric dispersion measures (the standard deviation of log sales). This pattern is driven, in large part, by five sectors exhibiting the largest difference between the two measurement methods for the same set of firms (i.e. regression fit versus standard deviation measure for both European and French firms). These sectors have the lowest number of firms represented in the data and yield – without exception – the worst regression fits to the Pareto distribution (lowest R-squares). In these cases, we believe the non-parametric measures (standard deviations) better capture the level of dispersion within the sectors. When these sectors are dropped from the sample, the results obtained using the two different measurement methods become

[33] The magnitude of the coefficients on TARIFF and the dispersion measures are lower in each case in the wide sample. This raises the possibility that the process generating FDI in the smaller, developing countries is somewhat different from the process generating FDI in the larger more developed countries.

much more consistent, and all the dispersion measures still yield coefficients significant beyond the 99% confidence level.[34]

Overall, these results strongly support the theoretical model's predicted link between firm level heterogeneity and FDI. Nevertheless, caution should be exercised when interpreting results from such cross-industry regressions as they may also reflect industry characteristics that are not captured by the parsimonious theoretical model. Cross-industry variations in capital and R&D intensity may also contribute to the observed variations in relative export and FDI sales: both measures capture relevant characteristics of an industry's technology that are not captured by our model. Furthermore, as shown in table 3, these measures are also correlated with all the different dispersion measures – although the correlations with the U.S. dispersion measure is very weak.[35] We therefore re-run our previous specification including the sector level measures for both capital and R&D intensity. The results in table 5 show that all the dispersion measures remain highly significant. As was the case in the baseline specification, the measurement problems associated with the regression-based dispersion measures affect the results for these variables (the magnitude of the coefficients is significantly lower). When the same five sectors are removed from the sample, the difference in the coefficients shrinks considerably while all coefficients remain significant beyond the 99% confidence level.

Of course, differences in capital intensity may not be the only source of heterogeneity across sectors that might also affect the relative export and FDI measures (in a way that is independent from the effect of size dispersion). In order to address the possibility that some other unmeasured characteristics of sectors fall into this category, we estimate the previous specification (with the capital and R&D intensity controls) adding random industry effects. To validate this specification, we assume that these unmeasured industry characteristics are uncorrelated with our right hand side variables. This is a strong assumption. However, we feel that it is most likely to hold for

[34] The specific sectors are 210 - tobacco, 369 - other electronics, 379 - other transport equipment, 381 - scientific and measuring equipment, and 386 - optical and photographic equipment.

[35] Capital intensity is measure as the industry's aggregate capital to labor ratio (from the NBER productivity database) and R&D intensity is measured as the ratio of R&D expenditures to sales.

the dispersion measures, which are the focus of our empirical analysis. The results are reported in table 6. As could be predicted, the standard errors are now higher, although the coefficients for all the dispersion measures remain highly significant. The magnitude of their point estimates actually increases.[36] On the other hand, the magnitude of the coefficients on FREIGHT and TARIFF are greatly reduced, and the coefficient on TARIFF is no longer significant.

Our final robustness check addresses the potential inter-dependence of the residuals across countries – even after we control for country fixed effects. This type of inter-dependence pattern could be created by the ability of affiliates to re-export a portion of their production to a third country. In this case, a firm's decision to operate an affiliate in - say - Belgium would not be independent from its decision to locate affiliates in other neighboring European countries. In the appendix, we show that the predicted link between firm level heterogeneity in sectors and relative FDI-export sales is theoretically consistent with an extended version of the model that explicitly allows for re-exports by affiliates. However, we agree that the pattern of inter-dependence will be particularly strong among the over-represented Western European countries. To address this concern, we treat all the Western European countries as a single aggregate country and re-run the specification with the industry controls (capital and R&D intensity) and industry random effects. These results are shown in table 7. Once again, all the dispersion measures remain highly significant.

In summary, the results presented in this section show a robust relationship between the degree of firm size dispersion by industry and a tendency for firms to substitute FDI for exports. We take this evidence as confirmation of the relevance of firm-level heterogeneity predicted by our theoretical model.

[36] The same caveat concerning the coefficients on the regression-based measures of dispersion applies.

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Table 1: BEA 3-Digit Manufacturing Sectors

Meat Products	Stone, Minerals, and Ceramics
Dairy Products	Ferrous metals
Vegetables and Preserves	Non-Ferrous metals
Grain Mill Products	Metal Cans, Fabricated Metal
Bakery Products	Cutlery
Beverages	Heating and Plumbing Equipment
Other Food	Metal Services
Tobacco	Engines and Turbines
Textiles	Farm Machinery
Apparel	Construction Machinery
Wood and Lumber	Metalworking Machinery
Furniture	Special Industrial Machinery
Pulp and Paper	General Industrial Machinery
Processed Paper	Computers
Newsprint	Refrigeration Equipment
Other publishing	Other Industrial Equipment
Commercial Printing	Household Appliances
Industrial Chemicals	Audio, Video, Communications Equipment
Drugs	Electronic Components
Soap and Cleansing Products	Other Electronics
Agricultural Chemicals	Motor Vehicles
Other Industrial Chemicals	Other Transport Equipment
Rubber	Scientific and Measuring Equipment
Miscellaneous Plastics	Medical Equipment
Leather	Optical and Photographic Equipment
Glass	Miscellaneous Manufacturers

Table 2: Countries (by continent)

Austria*	Argentina*
Belgium*	Brazil*
Denmark*	Canada*
France*	Chile*
Finland	Colombia
Germany*	Mexico*
Greece	Peru
Ireland*	Venezuela*
Italy*	
Netherlands*	Australia*
Norway*	New Zealand*
Portugal	Hong Kong*
Spain*	Indonesia
Sweden*	Japan*
Switzerland*	Malaysia
Turkey	Philippines*
United Kingdom*	Singapore*
	South Korea*
Israel	Taiwan*
South Africa	Thailand

* Indicates Narrow Sample

Table 3: Correlation Between Alternative Measures of Dispersion

	U.S. Std. Dev.	Europe Std. Dev.	France Std. Dev.	Europe Reg. Coef	France Reg. Coef	FP	RD	KL
U.S. S.D.	1							
Europe S. D.	0.507	1						
France S. D.	0.567	0.895	1					
Europe Reg.	0.526	0.959	0.919	1				
France Reg.	0.541	0.973	0.905	0.984	1			
FP	0.455	0.621	0.508	0.652	0.624	1		
RD	0.134	0.445	0.354	0.438	0.475	0.498	1	
KL	0.129	0.585	0.500	0.507	0.523	0.515	0.365	1

Table 4: Exports versus FDI - Baseline Results

Narrow Sample (N=962)

	U.S. Std. Dev.	Europe Std. Dev.	France Std. Dev.	Europe Reg. Coeff.	France Reg. Coeff.
FREIGHT	-1.241	-1.146	-1.193	-1.173	-1.176
	(-9.018)	(-8.489)	(-9.049)	(-8.582)	(-8.609)
TARIFF	-0.354	-0.512	-0.410	-0.555	-0.542
	(-2.506)	(-3.732)	(-3.203)	(-3.901)	(-3.855)
FP	0.580	0.794	0.767	0.731	0.702
	(6.011)	(6.747)	(7.006)	(5.845)	(5.675)
DISPERSE	-2.052	-2.727	-2.396	-1.935	-1.899
	(-6.903)	(-7.024)	(-8.273)	(-5.667)	(-5.545)

Wide Sample (N=1176)

	U.S. Std. Dev.	Europe Std. Dev.	France Std. Dev.	Europe Reg. Coeff.	France Reg. Coeff.
FREIGHT	-1.184	-1.094	-1.107	-1.114	-1.115
	(-9.545)	(-8.950)	(-9.411)	(-8.981)	(-8.979)
TARIFF	-0.241	-0.398	-0.311	-0.434	-0.424
	(-1.851)	(-3.106)	(-2.570)	(-3.297)	(-3.234)
FP	0.579	0.734	0.727	0.669	0.630
	(6.421)	(6.662)	(6.975)	(5.773)	(5.491)
DISPERSE	-1.968	-2.370	-2.123	-1.667	-1.574
	(-7.267)	(-6.587)	(-7.408)	(-5.259)	(-4.978)

T-statistics in parentheses (calculated on the basis of White standard errors).
Constant and country dummies are suppressed.

Table 5: Exports Versus FDI - Controls

Narrow Sample (N=961)

	U.S. Std. Dev.	Europe Std. Dev.	France Std. Dev.	Europe Reg. Coeff.	France Reg. Coeff.
FREIGHT	-1.040	-0.959	-1.019	-0.935	-0.944
	(-7.392)	(-6.749)	(-7.328)	(-6.526)	(-6.594)
TARIFF	-0.365	-0.512	-0.421	-0.545	-0.539
	(-2.644)	(-3.636)	(-3.917)	(-3.781)	(-3.775)
FP	1.177	0.932	0.927	0.947	0.934
	(10.159)	(7.827)	(8.059)	(7.453)	(7.450)
DISPERSE	-2.343	-2.153	-2.061	-1.503	-1.491
	(-8.374)	(-5.250)	(-6.664)	(-4.535)	(-4.470)
KL	-0.868	-0.495	-0.456	-0.628	-0.626
	(-7.790)	(-4.529)	(-4.256)	(-5.876)	(-5.859)
RD	-0.104	0.007	0.007	0.006	-0.002
	(-2.197)	(0.150)	(0.144)	(0.125)	(-0.047)

Wide Sample (N=1175)

	U.S. Std. Dev.	Europe Std. Dev.	France Std. Dev.	Europe Reg. Coeff.	France Reg. Coeff.
FREIGHT	-1.011	-0.935	-0.960	-0.915	-0.919
	(-7.968)	(-7.246)	(-7.714)	(-7.040)	(-7.053)
TARIFF	-0.241	-0.384	-0.306	-0.411	-0.407
	(-1.876)	(-2.964)	(-2.457)	(-3.073)	(-3.057)
FP	1.133	0.861	0.868	0.867	0.848
	(10.428)	(7.719)	(7.994)	(7.318)	(7.243)
DISPERSE	-2.248	-1.866	-1.833	-1.284	-1.215
	(-8.611)	(-4.919)	(-5.982)	(-4.132)	(-3.924)
KL	-0.793	-0.454	-0.412	-0.569	-0.576
	(-7.483)	(-4.347)	(-3.982)	(-5.574)	(-5.636)
RD	-0.086	0.017	0.021	0.015	0.007
	(-1.914)	(0.367)	(0.446)	(0.326)	(0.153)

T-statistics in parentheses (calculated on the basis of White standard errors). Constant and country dummies are suppressed.

Table 6: Exports versus FDI - Random Effects
(With Controls)

Narrow Sample (N=961)

	U.S. Std. Dev.	Europe Std. Dev.	France Std. Dev.	Europe Reg. Coeff.	France Reg. Coeff.
FREIGHT	-0.430	-0.398	-0.428	-0.397	-0.397
	(-2.554)	(-2.344)	(-2.533)	(-2.336)	(-2.334)
TARIFF	-0.113	-0.127	-0.105	-0.136	-0.133
	(-0.922)	(-1.033)	(-0.857)	(-1.107)	(-1.085)
FP	1.376	1.132	1.096	1.154	1.137
	(5.145)	(4.128)	(4.233)	(4.107)	(4.093)
DISPERSE	-2.623	-2.763	-2.445	-2.031	-1.991
	(-4.897)	(-3.459)	(-4.761)	(-3.098)	(-3.180)
KL	-1.106	-0.613	-0.570	-0.757	-0.758
	(-4.652)	(-2.238)	(-2.168)	(-2.891)	(-2.896)
RD	-0.002	0.126	0.116	0.133	0.119
	(-0.020)	(1.029)	(0.970)	(1.081)	(0.972)

Wide Sample (N=1175)

	U.S. Std. Dev.	Europe Std. Dev.	France Std. Dev.	Europe Reg. Coeff.	France Reg. Coeff.
FREIGHT	-0.331	-0.322	-0.328	-0.320	-0.320
	(-2.296)	(-2.230)	(-2.278)	(-2.215)	(-2.215)
TARIFF	-0.004	-0.018	-0.004	-0.022	-0.021
	(-0.038)	(-0.155)	(-0.035)	(-0.193)	(-0.187)
FP	1.361	1.110	1.081	1.127	1.103
	(4.123)	(3.455)	(3.475)	(3.377)	(3.369)
DISPERSE	-2.518	-2.559	-2.265	-1.864	-1.786
	(-3.824)	(-2.733)	(-3.706)	(-2.398)	(-2.424)
KL	-1.069	-0.599	-0.561	-0.734	-0.739
	(-3.660)	(-1.871)	(-1.789)	(-2.373)	(-2.408)
RD	0.006	0.123	0.116	0.129	0.115
	(0.042)	(0.862)	(0.811)	(0.894)	(0.805)

Z-statistics in parentheses. Constant and country dummies are suppressed.

Table 7: Exports versus FDI - Aggregated Europe
(With Controls and Random Effects)

Wide Sample (N=680)

	U.S. Std. Dev.	Europe Std. Dev.	France Std. Dev.	Europe Reg. Coeff.	France Reg. Coeff.
FREIGHT	-0.493	-0.485	-0.487	-0.485	-0.483
	(-2.882)	(-2.810)	(-2.837)	(-2.806)	(-2.795)
TARIFF	-0.005	-0.044	-0.032	-0.058	-0.052
	(-0.030)	(-0.254)	(-0.183)	(-0.335)	(-0.299)
FP	1.216	0.926	0.922	0.929	0.928
	(4.683)	(3.713)	(3.874)	(3.620)	(3.663)
DISPERSE	-2.242	-1.845	-1.748	-1.301	-1.322
	(-4.351)	(-2.595)	(-3.765)	(-2.217)	(-2.371)
KL	-0.989	-0.636	-0.588	-0.740	-0.737
	(-4.339)	(-2.560)	(-2.447)	(-3.105)	(-3.102)
RD	-0.023	0.076	0.073	0.078	0.071
	(-0.208)	(0.692)	(0.671)	(0.706)	(0.648)

Z-statistics in parentheses. Constant and country dummies are suppressed.