Exports versus FDI[*]

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PRELIMINARY AND INCOMPLETE DRAFT

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, a growing part of the trade literature has sought to incorporate the mode of foreign market access into the "new" trade theory. This branch of the literature recognizes that firms can service foreign consumers through a variety of channels: as usual, firms can directly export their products to foreign customers; alternatively they can also reach these customers through a foreign subsidiary by engaging in foreign direct investment (FDI); lastly, they can also license or contract with a foreign firm to produce and sell their products.

Our work focuses on the firm's choice between exports and FDI sales.[1] We develop a model in which sectors are populated by heterogenous firms. The model predicts

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

a link between the degree of heterogeneity of such firms and the trade-off between exports and FDI. In the empirical part we examine the consistency of this prediction with data.

The paper contributes to a literature that has identified industry and country characteristics that affect the extent to which firms trade-off these two modes of foreign market access. Our analysis deals with "horizontal" FDI; namely, FDI that replicates the entire production process in a foreign country. We therefore exclude "vertical" motives for FDI that involve the fragmentation of the production process across countries (see Helpman (1984) and Markusen (1996) for treatments of this form of FDI in general equilibrium).[2] We will mainly follow the previous literature on horizontal FDI (e.g. Horstmann and Markusen (1992), Brainard (1993), and Markusen and Venables (2000)) by assuming that foreign affiliate production is predominantly intended for the local market. However, we also show how the horizontal model of FDI can be extended to incorporate exports by foreign affiliates. This adds a new motive for FDI based on the advantages of operating an affiliate as an "export platform". Nevertheless, in all these cases, our model relies on the same motivating forces highlighted in the previous models of horizontal FDI: firms invest abroad when the gains from avoiding transport costs outweigh the costs of maintaining capacity in multiple markets. The literature often refers to this 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 decision of heterogeneous firms to serve foreign markets through exports or local subsidiary sales. As in standard proximity-concentration models, these modes of market access involve different relative costs, some of which are sunk (in both cases) while others vary with sales volume (such as transport costs and tariffs). Relative to FDI, exporting involves lower sunk costs but higher per-unit costs.[3]

[2]This fragmentation of production across countries also subsumes international differences in factor endowments.

[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

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.[4] Second, of those firms that do serve foreign markets, only the most productive firms 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 between countries. Hence, we identify a new industry characteristic, the dispersion of productivity levels across firms, as a determinant of the composition of trade. The dispersion of productivity levels across firms can be thought of as an additional technological characteristic, such as sunk cost and transport cost, that plays a role in influencing the trade-off between exports and FDI.

We believe that this result provides a new insight into the proximity-concentration trade-off. First, we show that the traditional proximity-concentration variables provide only a partial explanation of the volume of FDI relative to the volume of exports. Standard proximity-concentration variables determine only the productivity levels that a firm must achieve to make its international activity 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 requires additional information about the technology of the industry; i.e., the degree of dispersion of productivity levels across firms within an industry.[5]

Another desirable feature of our model is that it avoids the knife-edge conditions as-

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, for instance, Melitz (2002) and Bernard, Eaton, Jenson and Kortum (2000) for theoretical models, and Tybout (2002) for a recent survey of the empirical literature.

[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 like 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 as a technological variable.

sociated with existing general equilibrium models of FDI based on representative firms. In a number of these models, exogenous industry characteristics mandate that either all firms do FDI if transport costs are sufficiently large or that none do.[6] In contrast, in our model standard proximity-concentration variables determine only the firm cutoff productivity levels. Firm heterogeneity then ensures that there will be a determinant number of firms that export and firms that invest abroad. In our opinion, this provides a more appealing and realistic explanation for the concomitant use of export and FDI sales to the same country by firms in the same sector. With representative firms, this can only be explained by the indifference of firms with respect to the choice of export versus FDI. In our model, the heterogeneous firms are far from indifferent about this decision and have strong economic incentives to choose either one or the other.

Finally, our model also predicts a new "home market bias" force whereby the number of firms that locate their headquarters in a particular country rises disproportionately with market size. In conjunction with this effect, small markets are disproportionately served by local multinational affiliates and exports from other countries.

We test the predictions of the model on U.S. outward export and FDI data using the model's equilibrium conditions. Using data covering 52 manufacturing industries and 38 countries, we show that the productivity dispersion measures by industry 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. In addition, we confirm some, although not all, of the proximity-concentration trade-off predictions. In particular, we find that firms tend to substitute FDI for exports when transport costs are relatively high. We then conclude that intra-industry firm heterogeneity plays an important role in the composition of international trade.

The remainder of this paper is composed of four sections. In section 2, we elaborate the model and solve for its equilibrium. In section 3, we map the theoretical results into an empirical strategy for testing the basic hypotheses concerning the proximity-

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

concentration trade-off between exports and FDI and the role played by firm heterogeneity. In section 4, we describe the data used in our empirical analysis. Finally, in section 5, we report and interpret the empirical results.

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 wages are equalized across countries. The homogeneous product is produced with one unit of labor per unit output. As a result, the 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 draws a labor per unit output coefficient a from a distribution $G(a)$ on the support $[0,+\infty)$. If this firm chooses to produce, it bears an additional fixed labor cost f_D. These are all the fixed costs in case the firm sells in country i only. If, however, the firm also chooses to export, it bears an additional fixed cost f_X per foreign market, and if it chooses foreign direct investment, it bears an additional fixed cost f_I in every foreign market.[7] Goods that are exported to country j are subject 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.

Preferences over varieties of product h have the standard CES form, with an elastic-

[7]Presumably, the cost f_I includes all the same overhead production costs represented by f_D, as well as the additional initial fixed costs of setting up the foreign subsidiary.

ity of substitution $\varepsilon = 1/(1-\alpha) > 1$.[8] These preferences generate a demand function $A^i p^{-\varepsilon}$ in country i, where the demand level A^i for sector h brands is exogenous from the point of view of the individual supplier.[9] In this case the brand of a producer with the labor coefficient a is offered for sale for the price $p = a/\alpha$. As a result the effective consumer price is a/α for domestically produced goods — be they supplied by domestic firms or foreign multinationals — and $\tau^{ji} a/\alpha$ for imported products from country j, where a is the labor coefficient of the exporter.

A firm from country i that chooses to produce serves only the domestic market, or it serves the domestic market and exports to some market j, or it serves the domestic market and forms a subsidiary in foreign country j to serve that foreign market.[10] In equilibrium, no firm engages in both exports to and FDI (foreign direct investment) in country j. We assume

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

The first inequality assumes that FDI costs are high enough to preclude at least some firms from undertaking this activity. The second inequality similarly assumes that the export costs are high enough (given ε) to preclude at least some firms from entering the export market.

Profits from serving the domestic market are

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

[8]The utility function is

$$u = \left(1 - \sum_{h=1}^{H} \beta_h\right) \log z + \sum_{h=1}^{H} \frac{\beta_h}{\alpha_h} \log\left(\int_0^{n_h} x_h(v)^{\alpha_h} dv\right),$$

where z is consumption of the homogenous good, $x_h(v)$ is consumption of variety v from sector h, and n_h is the number (measure) of varieties in sector h.

[9]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 and $p^i(v)$ is the consumer price of variety v.

[10]For now, we exclude the possibility of exports by the foreign affiliates to other markets.

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

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

and the additional profits from FDI in country j are

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

If follows from these profit functions and from (1) that the most productive firms engage in FDI while the least productive firms serve only the domestic market.

Let firms with $a = a_D^i$ break even by just serving the domestic market in country i. Namely,

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

Then all firms with $a > a_D^i$ exit upon learning their productivity while firms with higher productivity levels remain in the industry. Firms with a close to a_D^i do not find it profitable to export nor to invest in foreign countries. But there exists a value $a_X^{ij} < a_D^i$ at which exports just break even. Namely,

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

And there exists a value $a_I^{ij} < a_X^{ij}$ at which FDI in country j is just as profitable as exporting to country j. This cutoff satisfies

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

In summary, firms with $a > a_D^i$ exit, firms with $a \in \left(\max_j a_X^{ij}, a_D^i\right]$ serve only the domestic market, firms with $a \in \left(a_I^{ij}, a_X^{ij}\right]$ serve the domestic market and export to country j, and firms with $a \leq a_I^{ij}$ serve the domestic market and form a subsidiary in country j.

Using these profit conditions we an calculate the expected profits of a potential entrant. In equilibrium these expected profits have to cover the entry costs f_E.[11] This condition can be expressed as

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

where

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

Equations (2)-(5) provide implicit solutions for the cutoff coefficients a_D^i, a_X^{ij}, a_I^{ij} and the B^is. 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 lead 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 empirical application. Before we describe our empirical application, however, we examine some properties of this equilibrium.

2.1 Market Shares

It is useful to examine a special case — where technologies and costs are symmetric across countries — in order to understand the determinants of market shares, which will be the focus of our empirical analysis. Assume for this purpose that all fixed cost coefficients are the same in every country, that the distribution function $G(\cdot)$ is the same in every country, and that transport costs per product are the same across 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 in these characteristics across sectors. Moreover, countries can differ in size.

[11] The expected profits could be negative for some sectors, in which case no domestic firm would enter that industry. This can only be possible in a trading/investment equilibrium where consumers satisfy their consumption share for that sector's goods from foreign owned firms.

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

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

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

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

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

Having solved the cutoffs and the Bs, we can also solve for the number of entrants in every country. This number depends on country size.

To characterize the number of entrants in country i (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 in equilibrium there are no pure profits, spending equals labor income: $E^i = L^i$. All brands that are produced in country i, by domestic or foreign firms, have a consumer price of a/α when the producer's labor cost is a, and all imported brands have a consumer price of $\tau a/\alpha$ when the exporter's labor cost is a. It then follows from (11) that the numbers of entrants in country i, n^i, $i = 1, 2, ..., N$, is the solution of the linear system

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

where $v_D = V(a_D) > v_{IX} = V(a_I) + \tau^{1-\varepsilon}[V(a_X) - V(a_I)]$. So long as the differences in the L^is are not too large, the number of entrants that solve this system is positive in every country, and is given by

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

were $\det(v)$ is the determinant of the matrix v that has v_D as the diagonal elements and v_{IX} as the off diagonal elements. Since $v_D > v_{IX}$ this determinant is positive. Evidently, n^i is positive when all countries are of equal size. We assume that the difference in size is small enough so as to ensure $n^i > 0$ for every country.[12]

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, it follows that 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 related coefficient B is also the same in all countries. Therefore aggregate sales of country-i based firms are proportional to n^i. Moreover, their sales in the domestic market are proportional to n^i, their exports are proportional to n^i, and foreign sales of subsidiaries of their multinationals are proportional to n^i. It follows that larger countries have proportionately larger sales in each one of these categories.

Now define $n_O^i = G(a_D)n^i$ as the number of active firms owned by country i and $n_B^i = G(a_X)\sum_{j\neq i} n^j + G(a_D)n^i = G(a_X)\sum_{j=1}^N n^j + [G(a_D) - G(a_X)]\,n^i$ as the number of firms doing business in country i. Then the ratio n_O^i/n_B^i is higher in larger countries. Namely, the larger a county the larger the number of its active firms relative to the number of firms that operate in the country.

[12]This assumption is not essential. 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.

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. Then

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

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.

Now, 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. Then the relative size of these market shares is

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

This ratio is independent of i and j, which implies that every country has the same relative sales of its exporters and its affiliates in every other country. And these relative sales are larger the larger is the exporting cutoff coefficient a_X and the smaller is the FDI cutoff coefficient a_I. These cutoff coefficients depend on the fixed cost parameters and on transport costs.

From (7)-(10) we find that B rises with increases in any of the fixed costs f_E, f_D, f_X, and f_I.[13] An increase in the entry costs f_E therefore raises all the cutoff coefficients a_l, $l = D, X, I$, by the same factor of proportionality and the response of the relative market shares s_X^{ij}/s_I^{ij} depends on the shape of distribution function $G(\cdot)$. In case

[13] 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 the fixed costs and transport costs.

labor productivity $1/a$ is drawn from a Pareto distribution with shape k, the ratio $V(a_1)/V(a_2)$ equals $(a_1/a_2)^{k-(\varepsilon-1)}$, for every $a_1, a_2 \geq 0$. In this event the relative sales of country i exporters and multinational firms in country j do not change.

We will use the Pareto distribution as a benchmark. With labor productivity distributed Pareto with shape k, the natural logarithm of firm sales will have an exponential distribution with parameter $1/[k-(\varepsilon-1)]$. As a result the standard deviation of the distribution of the logarithm of firm sales equals $1/[k-(\varepsilon-1)]$, implying that the dispersion in sales and firm size is larger the smaller is k and the smaller the elasticity of demand ε.

An increase in f_D raises B less than proportionately. It then follows from (8) and (9) that a_X and a_I rise by the same factor of proportionality. As a result exports sales do not change relative to sales of affiliates when labor productivity is distributed Pareto. On the other hand, an increase in f_I, which also raises B less than proportionately, raises a_X and reduces a_I. In response, export sales rise relative to sales of affiliates for all distribution functions $G(\cdot)$. Finally, an increase in f_X reduces B and the fall in B is less than proportional to the fall in $f_I - f_X$. In this event a_X falls and a_I rises. As a result export sales decline relative to sales of affiliates for all distribution functions $G(\cdot)$.

It remains to examine the effects of transport costs. An increase in τ raises B, but the product $\tau^{1-\varepsilon}B$ declines. As a result a_X declines and a_I rises, implying a fall in export sales relative to sales of affiliates.

These are sensible comparative statics results that predict the cross sectoral variation in relative sales as a function of the underlying parameters. Naturally, we expect the relative sales of exporters to be larger in sectors with higher fixed costs of exporting or higher transport costs. By the same token we expect the relative sales of exporters to be lower in sectors in which it is more expensive to form subsidiaries of multinationals. A non trivial implication of our model is, however, that the relative sales of exporters is higher in sectors with larger dispersion of labor productivity. This is a major implication that we will test.

3 Testable Implications

For empirical testing, we focus on export sales versus affiliate sales. Equations (8) and (9) describe the cutoffs and (13) describes the relative sales for a case in which wages, transport costs and technology are the same in all countries. Empirical analysis requires, however, to account for cross country variations in wages, transport costs and technology. We therefore extend these conditions in order to accommodate such cross country variations.

Consider the decision by US firms in sector h to serve country j via export sales versus affiliate sales. The equilibrium cutoff levels must now satisfy:

$$\left(\tau_h^{Uj} w^U a_{hX}^{Uj}\right)^{1-\varepsilon_h} B_h^j = w^j f_X^j \ , \tag{14}$$

$$\left[\left(w^j\right)^{1-\varepsilon_h} - \left(w^U \tau_h^{Uj}\right)^{1-\varepsilon_h}\right] \left(a_{hI}^{Uj}\right)^{1-\varepsilon_h} B_h^j = w^j \left(f_{hI}^j - f_X^j\right) \ , \tag{15}$$

where w^U and w^j are the wage levels in the US and country j, respectively, τ_h^{Uj} is the trade cost (transport and tariff) from the US to country j in sector h, ε_h is the elasticity of substitution across varieties in sector h (common across 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 FDI in and exporting to country j, respectively. 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 US firms. These costs would also be incurred by US 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 $f_{hP} = f_{hI}^j - f_X^j$ reference these costs. Then equations (14) and (15) imply:

$$\left(\frac{a_{hX}^{Uj}}{a_{hI}^{Uj}}\right)^{\varepsilon_h - 1} = \frac{f_{hP}}{f_X^j}\left[\left(\frac{w^U}{w^j}\tau_h^{Uj}\right)^{\varepsilon_h-1} - 1\right]^{-1} . \tag{16}$$

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 US 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;
- $w^j \tau_h^{jU} / w^U > 1$, which ensures that there exist firms that choose to locate in the US.[14,15]

3.1 Comparative Statics

We now drop the h subscripts and the U, j superscripts, and define $\omega = w^U / w^j$ as the relative wage in the US. Equation (16) then implies that the ratio of cutoff coefficients a_X / a_I declines with the demand elasticity ε and transport costs τ, and it increases with the fixed cost differential f_P.

Parallel to (13), we now obtain the relative sales of US exporters and affiliates of US multinationals in country j:

$$\frac{s_X}{s_I} = (\omega\, \tau)^{1-\varepsilon} \left[\frac{V(a_X)}{V(a_I)} - 1 \right] . \tag{17}$$

Assuming that $1/a$ is drawn from a Pareto distribution with shape k, we obtain

$$\frac{V(a_X)}{V(a_I)} = \left(\frac{a_X}{a_I} \right)^{k-(\varepsilon-1)} = \left[\frac{f_P}{f_X} \frac{1}{(\omega\tau)^{\varepsilon-1} - 1} \right]^{\frac{k-(\varepsilon-1)}{\varepsilon-1}} , \tag{18}$$

where the last equality results from (16). Since the term in the brackets must be greater than 1,[16] it follows from the last two equations that relative sales s_X / s_I decrease with decreases in k (an increase in the dispersion of productivity levels) and increases in ε.

[14] 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 deviations from one of this relative wage is bounded by trade costs between the US and country j.

[15] The fixed cost differential f_{hP} can be measured as the average number of non-production workers per firm in the US (or per plant, if data were available). We could also use the non-production wage bill, and normalize it with the production wage to obtain a number of "equivalent" production workers. Ideally, we do not want corporate costs (independent of the number of foreign and domestic plants) to be included in this measure. In practice, however, some corporate costs are most likely proportional to the number of plants (foreign or domestic).

[16] Given our initial assumptions on the relative trade costs that ensure that at least some firms choose to export over doing FDI.

Note that both decreases in k and increases in ε will increase the dispersion of firm size (measured by sales). We cannot separately measure k and ε. We can, however, measure their difference, $k - (\varepsilon - 1)$, under the benchmark of a Pareto distribution for labor productivity, because $1/[k - (\varepsilon - 1)]$ then indexes the measured dispersion of firm size. Although the relative sales s_X/s_I is a non-linear function of this index and the costs parameters, we wish to test the predicted signs of the partial derivatives of the relative sales with respect to the dispersion index and the available cost data.

4 Data

To test our multi-industry, 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, data that measures the proximity-concentration trade-off facing firms, and data that captures the importance of intra-industry productivity differences across firms. 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.

4.1 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).[17] 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

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

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 (1991) 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 levels of FDI, creating some concern about censoring.

4.2 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 the non-production workers per establishment as reported in the 1992 Census of Manufacturing. In doing so we are making the perhaps heroic assumption that this measure is independent of establishment size.

4.3 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 stochastic 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.[18] The second method we employ to calculate dispersion is to compute the standard deviation of the log of firm sales, which, given our distributional assumption, is computationally equivalent to the slope of the conditional expectation of log rank on log size.[19]

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

[18] 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.

[19] 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.

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 firms.[20] 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.[21] 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.[22] Our dispersion measures are based on a sample of 55,326 large Western European firms, and a subset of 15,144 French firms.[23]

[20]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.

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

[22]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.

[23]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

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. 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 establishment 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 mixture of goods produced in the United States might be very different mixture from the mixture of goods produced in Europe.

5 Results

The equilibrium conditions (17) and (18) imply the following relationship between the relative export and FDI sales to a given country for any given sector:

$$\frac{s_X}{s_I} = -\left(\omega\tau\right)^{1-\varepsilon} + \left(\frac{f_P}{f_X}\frac{1}{1-\left(\omega\tau\right)^{1-\varepsilon}}\right)^{\frac{k-(\varepsilon-1)}{\varepsilon-1}} \left(\omega\tau\right)^{-k}. \tag{19}$$

We estimate a linearized version of this relationship 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

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.

implied by the partial derivatives of (19).

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 results of estimating the model for each of our two 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 an 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 has been suppressed.

We begin with the results obtained when the sample is constrained to the relatively large countries considered by Brainard (1991). 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 (1991): firms appear to substitute FDI for exports when costs associated with international trade are relatively large. Note that the coefficient on plant scale economies (FP) is generally indistinguishable from zero. This result is not consistent with the model, which predicts that plant scale economies should encourage firms to substitute exports for FDI. As noted earlier, however, measuring plant scale economies is not an easy task and this disappointing result might simply reflect a poor proxy for plant scale economies.

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. Note that the strongest results correspond to the two measures of dispersion that are calculated with data using only a single country's firm-size distribution (US and French measures).

We now turn to the wider sample that includes an additional 11 smaller, developing countries. These results are shown in the bottom portion of Table 4. The magnitude of the coefficients on FREIGHT and TARIFF are slightly lower in each case than in the narrower sample, suggesting that smaller, developing countries may in fact enjoy less proximity motivated FDI. As in the narrow sample, the coefficient on plant scale economies remains negative but is not statistically significant. Finally, the coefficients on all five measures of dispersion are consistently negative in keeping with the results obtained from the narrow sample. They are also somewhat smaller, however, raising 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.[24]

In general, these results are highly supportive of a link between firm level productivity dispersion and FDI. One needs to be careful in interpreting cross industries regressions, however. In such exercises, there is always the possibility that the results might simply reflect unobserved heterogeneity across industries that is correlated with other industry specific measures, such as the degree of size dispersion.

A potentially relevant manner in which industries might differ is in their factor intensity, which could well be expected to influence the type and composition of activities due to U.S. comparative advantage relative to the rest of the world. Moreover, an industry's capital intensity is associated with the degree of firm size dispersion as can be seen in Table 3. In general, more capital-intensive industries appear to have a larger degree of firm size dispersion, although the extent of this correlation varies with our measure of dispersion. The correlation is particularly high with our all Europe measure of dispersion. The source of the positive correlation between dispersion and capital intensity cannot be explained in the context of our one factor model.

[24] It is also possible that the inclusion of a larger number of smaller countries in which FDI is more likely to be zero makes the selection issue relatively more important. If so, it is possible that these coefficients are smaller simply because of attenuation.

In the next set of specifications we repeat our analysis attempting to control for factor intensity differences across industries. We calculate the capital to labor ratio of each of the 52 industries in the sample and repeat our exercises for both the wide and narrow samples.[25] The results are shown in Table 5.

Looking over the ten different sets of results, three important observations can be made that are common to all specifications. First, with the exception of the specification based on the French measure of dispersion, the coefficient on KL is negative and statistically significant. This result suggests a tendency for firms in sectors that are relatively capital intensive to substitute FDI for exports. Second, the coefficients on FREIGHT and DISPERSE are moderately smaller when KL is included relative to when it is not. Interestingly, there is a moderately high positive correlation between KL and our measures of dispersion. This effect is very moderate, however, leaving the coefficients both large and statistically 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. While the results are promising, more needs to be done. In future work, we hope to expand the set of industry controls to include other measures of technology. Additional controls will help us further access the robustness of our results. Another important extension planned for this paper is to move beyond reporting the partial correlations in the data to formally estimating the structural model. This additional exercise will allow us to estimate the deep parameters of the model such as the elasticity of substitution by industry and the fixed cost of trade by country, while allowing for all of the interaction between variables imposed by theory.

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[25] These ratios are calculated from the NBER productivity database.

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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*	Costa Rica
Greece	Mexico*
Ireland*	Peru
Italy*	Venezuela*
Netherlands*	
Norway*	Australia*
Portugal	New Zealand*
Spain*	Hong Kong*
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

	US Std. Dev.	Europe Std. Dev.	France Std. Dev.	Europe Reg. Coeff.	France Reg. Coeff.
US Std. Dev.	1.00				
Europe Std. Dev.	0.40	1.00			
France Std. Dev.	0.57	0.88	1.00		
Europe Reg. Coeff.	0.47	0.95	0.88	1.00	
France Reg. Coeff.	0.41	0.86	0.95	0.85	1.00
Capital Intensity, KL	0.12	0.53	0.50	0.46	0.34

Table 4: The Trade-Off Between Exports and FDI

Narrow Sample

	US Std. Dev.	Europe Std. Dev.	France Std. Dev.	Europe Reg. Coeff.	France Reg. Coeff.
FREIGHT	-1.31	-1.19	-1.35	-1.23	-1.28
	(-9.61)	(-8.96)	(-10.05)	(-9.20)	(-9.65)
TARIFF	-0.45	-0.61	-0.48	-0.6	-0.54
	(-3.29)	(-4.36)	(-3.71)	(-4.35)	(-4.19)
FP	-0.05	-0.09	0.01	-0.06	-0.06
	(-0.58)	(-1.02)	(0.10)	(-0.68)	(-0.69)
DISPERSE	-1.37	-0.98	-1.62	-0.84	-0.77
	(-5.17)	(-3.66)	(-6.31)	(-4.20)	(-5.27)
N	985	985	985	985	985

Wide Sample

	US Std. Dev.	Europe Std. Dev.	France Std. Dev.	Europe Reg. Coeff.	France Reg. Coeff.
FREIGHT	-1.19	-1.07	-1.18	-1.10	-1.12
	(-10.04)	(-9.03)	(-10.30)	(-9.47)	(-9.95)
TARIFF	-0.36	-0.50	-0.40	-0.50	-0.45
	(-2.82)	(-3.96)	(-3.34)	(-3.97)	(-3.77)
FP	-0.00	-0.05	0.04	-0.03	-0.02
	(-0.05)	(-0.60)	(0.47)	(-0.30)	(-0.24)
DISPERSE	-1.34	-0.85	-1.41	-0.71	-0.67
	(-5.58)	(-3.50)	(-5.83)	(-3.88)	(-4.90)
N	1,204	1,204	1,204	1,204	1,204

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

Table 5: The Trade-Off Between Exports and FDI

Narrow Sample

	US Std. Dev.	Europe Std. Dev.	France Std. Dev.	Europe Reg. Coeff.	France Reg. Coeff.
FREIGHT	-1.28	-1.14	-1.33	-1.18	-1.24
	(-9.28)	(-8.65)	(-9.88)	(-8.86)	(-9.40)
TARIFF	-0.46	-0.61	-0.48	-0.60	-0.54
	(-3.35)	(-4.31)	(-3.75)	(-4.32)	(-4.20)
FP	-0.03	-0.10	0.01	-0.07	-0.05
	(-0.28)	(-1.22)	(0.06)	(-0.85)	(-0.61)
DISPERSE	-1.25	-0.62	-1.55	-0.61	-0.68
	(-4.80)	(-2.18)	(-5.07)	(-2.96)	(-4.47)
KL	-0.35	-0.29	-0.06	-0.27	-0.23
	(-3.86)	(-3.09)	(-0.55)	(-2.96)	(-2.57)
N	985	985	985	985	985

Wide Sample

	US Std. Dev.	Europe Std. Dev.	France Std. Dev.	Europe Reg. Coeff.	France Reg. Coeff.
FREIGHT	-1.17	-1.04	-1.18	-1.06	-1.11
	(-9.86)	(-9.09)	(-10.22)	(-9.23)	(-9.80)
TARIFF	-0.36	-0.51	-0.40	-0.50	-0.45
	(-2.87)	(-3.92)	(-3.36)	(-3.93)	(-3.78)
FP	0.02	-0.07	0.04	-0.04	-0.01
	(-0.05)	(-0.79)	(0.43)	(-0.47)	(-0.17)
DISPERSE	-1.24	-0.55	-1.37	-0.51	-0.60
	(-5.25)	(-2.14)	(-4.78)	(-2.73)	(-4.18)
KL	-0.29	-0.24	-0.03	-0.23	-0.18
	(-3.46)	(-2.68)	(-0.32)	(-2.68)	(-2.19)
N	1,204	1,204	1,204	1,204	1,204

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