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# Intra-Firm and Arm's-Length Trade: How Distance Matters? \*

Pamela Bombarda<sup>†</sup>

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## Abstract

Multinational and exporting firms play a key role in trade patterns. To highlight the importance of intra-firm trade in share of world trade, this paper develops a model of trade and intra-firm trade with heterogeneous firms. In this set up, trade costs apply to both exports and multinational production because both involve transportation. However, the magnitude will differ. The introduction of intra-firm trade generates a complementarity between FDI and Exports. Using data for 1999-2004, we test the gravity equations delivered by the model. Quantitatively, we find that exports within the boundaries of the firms are less sensitive to geographical barriers than arm's length trade.

*JEL classification:* F12; F23;

*Keywords:* intra-firm trade, multinational firms, export, gravity.

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## 7.1 Introduction

Intra-firm trade and arm's length trade play an important role in trade arena.<sup>1</sup> Dunning (1994) shows that a large part of international trade is conducted by MNEs. He estimated that MNEs together with their subsidiaries are responsible for 75 percent of the world's trade commodity. UNCTAD (2000) reports that one-third of world trade is intra-firm trade (trade between MNEs' headquarters and subsidiaries, or simply among subsidiaries). More recently, Bernard, Jensen and Schott (2007) document that 90 percent of U.S. exports and imports occurs through multinational firms. Recent studies try to analyze the different behavior of related-party versus arm's-length trade (Irrazabal, Moxnes and Oromolla (2009), Corcos et al. (2009), Bernard et al. (2010) among others). The notion of openness should therefore include trade as well as multinational production.

This paper develops a model of trade that features heterogeneous firms, multinational firms, exporters and intra-firm trade in a general equilibrium framework. Its main contribution is to explain the different impact of geographical distance on related-party versus arm's-length trade. It also provides stylized facts to support the model's main predictions using 1999-2004 data from Bureau of Economic Analysis (henceforth BEA) and from the Center for International Data (henceforth

CID) at UC Davis.<sup>2</sup>

The theoretical framework offers a possible explanation of the puzzling larger effect of distance on trade rather than on intra-firm trade and on complementarity *versus* substitutability debate. Globalization boosts both export and affiliate revenues. However, certain intermediate goods are more complements than others. In these sectors, foreign affiliates take advantage from globalization and thus the effect of distance should be important.

In this paper a trade policy intervention affects the trading activity of firms which occurs both within and outside the boundaries of the firm and across different sectors. Globalization should increase the volume of trade. Measuring the response of arm's length and related-party trade to globalization pressures is important to define specific policy intervention. For example, a reduction in trade barriers will increase multinational activity the higher is the share of intra-firm trade between the headquarter and the affiliate.

To provide a more appealing explanation for the coexistence of national and multinational firms, we extend the Melitz model to allow for intra-industry firm heterogeneity in productivity, which avoid the coexistence of different type of firms only as knife-edge case. This extended model can explain the within-industry variation across firms in their decisions about export and FDI.

To account for intra-firm trade, we claim each foreign affiliate has to import an intermediate input from the home headquarter. Thus, differently from Helpman, Melitz and Yeaple (2004, henceforth HMY), trade costs apply to both exports and multinational production because both involve transportation (the first of a finished good, the second of an intermediate good). The model suggests that the more productive firms enter a larger number of markets, undertake a large part of intra-firm trade and sell more in each market that they enter than less productive firms. In a similar way, countries with characteristics that are more attractive to U.S. multinationals should attract relatively less productive firms.

In this model, heightening of trade barriers affects in two opposite ways the FDI mode of supply. First, it increases the threshold productivity cutoff: the need to import intermediate goods from the headquarter makes more difficult to enter as a foreign affiliate when trade costs increase. This result is opposite to HMY, where an increase in trade costs makes FDI strategy easier. Second, sales of the existing foreign affiliates decrease (new margin of adjustment for MNFs). By contrast, in absence of traded intermediates a change in trade costs translate into a change in the number of MNFs entering the market, while the profit of the already existing foreign affiliates is left unaffected.

To consider the different behavior of related-party and arm's-length trade,

we try to connect the model to the data. The empirical section studies the gravity equations for U.S. intra-firm exports (aggregated at the sectoral level) and U.S. arm's-length exports (aggregated at the sectoral level) to quantify the different role of geographical distance. This part describes how the model can deliver the features of the data related to foreign sales which are observed for U.S multinational and exporting firms. Using BEA and CID data at the sectoral level, we are able to confirm that geographical distance is more important for arm's-length trade than for intra-firm trade.

This paper contributes to the growing literature on intra-firm trade by focusing on the boundaries of the firm, an important topic for both international business (IB) and international economics (IE) literature. As Rugman and Nguyen suggest in the overview chapter, different are the aspects related to a IB understanding of trade and FDI patterns.

Although this chapter has a more IE orientation, it is also connected to IB literature in terms of the focal unit of analysis and the determinance of firms' boundaries.

Trade and FDI literature has grown over time. Hanson, Mataloni, and Slaughter (2001), using detailed data on U.S. multinationals, find that vertical FDI is common, and that affiliates respond to policies and foreign countries' characteristics in different ways. Keller and Yeaple (2008) embody in a trade model two crucial elements: product's technological

complexity and distance between the buyer and the seller. In their model, the interaction of these elements determines the size of the costs of reaching foreign markets. Their empirical results confirm the existence of gravity for weightless goods (complex technology products). Irarrazabal, Moxnes and Opromolla (2009) structurally estimate a model of trade and multinational production with firms heterogeneity. Their results reject the proximity versus concentration hypothesis which did not consider intra-firm trade. Corcos et al. (2009), using French firm-level data, investigate the main determinants of the internalization choice. Their findings highlight the role of capital, skill and productivity in explaining the choice of intra-firm.

Although we will not consider the choice between internalizing or not the production process, it is important to remember that intra-firm *versus* arm's length trade strategies are at the heart of the classical "make or buy" decision literature. This literature combines elements from international trade theory and from the theory of the firm. The issues of where locate the different stages of the value chain as well as the control exerted on these process have being studied, among others, by Eicher (1986), Grossman and Helpman (2002), Antràs (2003, 2005) and Antras and Helpman (2004).

The attempt of this paper is to shed new light on firms' global sourcing strategies focusing more on the role of distance and trade costs while

omitting the issue of incomplete contracts. In the present framework, geographical distances will be crucial in explaining how firms reshape their global sourcing strategies.

The rest of the paper is organized as follows. Section 7.2 provides a description of facts on U.S. multinational firms. Section 7.3 describes the theoretical framework that rationalizes the main features of the data. Section 7.4 characterizes the equilibrium. Section 7.5 presents the empirical analysis. Section 7.6 concludes.

## **7.2 Facts on U.S. Multinational Firms**

Data on U.S. multinational firms are obtained from the direct investment data set accessible from the BEA website.<sup>3</sup> Among different types of information provided by BEA, this paper will focus on the following data: number of US foreign affiliates in different destination countries; local affiliate sales; volume of U.S. intra-firm trade, i.e. U.S. Exports of Goods Shipped to Affiliates by U.S. Parents, by Country of Affiliate.

### **U.S. Affiliates and Market Entry**

Figures 7.1 to 7.2 plot the number of U.S. affiliates selling to a market across 200 destination markets in 2004. More precisely, Figure 7.1 plots the number of U.S. affiliates against total absorption in that market. Since the data are matched with production data, the sample is here



restricted to 50 countries. The number of firms selling to a market tends clearly to increase with the size of the market.

In Figure 7.2 the relationship is more neat: here the number of US affiliates is normalized by the U.S market share in a destination.

Following Eaton, Kortum and Kramarz (2008), the  $x$  axis of Figure 3 reports market size across the 50 destinations. While the  $y$  axis replaces the number of US affiliates in a market with that number divided by U.S. market share. U.S. market share is defined as total US affiliate sales to that market,  $X_{us,j}^M$ , divided by the market's total absorption,  $X_j$ ,

$$\pi_{us,j} = \frac{X_{us,j}^M}{X_j}$$

The relationship in Figure 7.2 is tight. Canada is pull from the position of a positive outlier to a negative one. A regression line as a slope of 0.93.

Figures 7.1 and 7.2 confirm that the number of sellers in a market varies with market size.<sup>4</sup>

## **Intra-Firm trade and Affiliate Sales**

Figure 7.3 plots the relationship between U.S. exports of goods shipped to affiliates by U.S. parents, by country of affiliate against total affiliate sales in a market. Figure 7.4 shows the increase in the value of the good sold by the U.S. affiliate in  $j$ : all points lie below the 45 degree line.

## 7.3 Theoretical Framework

In what follows we propose a model of export and FDI as well as intra-firm trade. Following Chaney, we do not assume free entry.<sup>5</sup> This set up allows to study the supply mode decision between FDI and export in a multi-country framework.

### 7.3.1 Preferences

Consumers in each country share the same preferences over the final good. The preferences of a representative consumer are given by C.E.S. utility function over a continuum of goods indexed by  $v$ ,

$$U = \left[ \int_{v \in V} c(v)^{(\sigma-1)/\sigma} dv \right]^{\frac{\sigma}{\sigma-1}}$$

where  $\sigma > 1$  represents the elasticity of substitution between any two products within the group and  $V$  is the set of available varieties.

### 7.3.2 Supply

In the following set up we have one final good, two intermediate goods and one factor. Each country is endowed with labor,  $L$ , which is supplied inelastically. There are  $N$  potentially asymmetric countries that produce goods using only labor. Country  $n$  has a population  $L_n$ .

There is one differentiated sector which produces a continuum of

horizontally differentiated varieties,  $q(v)$ , from two intermediate goods (or tasks),  $y_1$  and  $y_2$ . Both  $y_1$  and  $y_2$  are produced with one unit of labor, but  $y_1$  can only be made at home, due to technological appropriability issues. Each variety is supplied by a Dixit-Stiglitz monopolistically competitive firm which produces under increasing returns to scale which arise from a fixed cost. We assume the fixed cost is paid in units of labor in the country where the good is produced.

We consider three modes of supply in the differentiated sector; firms which sell only domestically (D-mode); firms who export (X-mode), and firms who supply the foreign market via FDI (M-mode). Hence, when a firm decides to serve the foreign market, it chooses whether to export domestically produced goods or to produce in foreign country via affiliate production. In making those decisions, they consider the net profits from selling in a given market, and they compare the profits from exports and from FDI.

As in Helpman, Melitz and Yeaple (2004), this choice is affected by the classical scale versus proximity trade-off. Nevertheless, in our model, the introduction of intra-firm trade makes the M-model of supply sensitive to geographical distance between countries. The fact that  $y_1$  can only be made at home plays an important role. If a firm chooses to supply the foreign market via local sales of its affiliates, the affiliate must import the intermediate good  $y_1$  from the home nation. This implies that the

M-mode does not entirely avoid trade costs. The trade link between the home parent and the affiliate captures the complementary relationship between trade and FDI. In this model, the existence of asymmetric countries implies that there is not a one for one mapping between the productivity of a firm and the scale of its production.

Upon drawing its own parameter  $a$  from a cumulative density function  $G(a)$  that is common to every country, each firm decides to exit (this happens if it has a low productivity draw), or to produce. In this case, the firm must face additional fixed costs linked to the mode of supply chosen. If it chooses to produce for its own domestic market, it pays the additional fixed market entry cost,  $f_{ii}$ . If the firm chooses to export, it bears the additional costs  $f_{ij}$  of meeting different market specific standards (for example, the cost of creating a distribution network in a new country). Finally, if the firm chooses to serve foreign markets through FDI, there would be two types of fixed costs: a fixed cost of creating a distribution network as well as building up new capacities in the foreign country.<sup>6</sup> We call these fixed costs  $f_{M,ij}$ . In the following analysis we allow for the fixed costs to differ across countries.

### 7.3.3 Intermediate Results

#### Demand

Given preferences across varieties have the standard C.E.S. form, the demand of a representative consumer from country  $i$  for a type  $a$  good is given by

$$c_i(a) = A_i p_i(a)^{-\sigma} \quad \text{where } A_i \equiv \frac{Y_i}{P_i^{1-\sigma}}$$

where the subscript  $i$  indicates the country,  $a$  the unit labor coefficient,  $A_i$  is the demand shifter and  $p_i(a)$  is the consumer price index paid to a firm with marginal cost  $a$ .  $A_i$  is exogenous from the perspective of the firm and composed by the aggregate level of spending on the differentiated good,  $Y_i$  divided by the CES price index,  $P_i^{1-\sigma}$ .

#### Organization and Product Variety

We assume the production of the final good combines the two intermediates,  $y_1$  and  $y_2$ , in the following Cobb-Douglas function,

$$q_i(a) = \frac{1}{a} \left( \frac{y_1}{\eta} \right)^\eta \left( \frac{y_2}{1-\eta} \right)^{1-\eta}, \quad 0 < \eta < 1 \quad (1)$$

where  $1/a$  represents the firm specific productivity parameter and  $\eta$  is the Cobb-Douglas cost share of  $y_1$ , common across all nations. When trade is possible, firms that produce decide whether to sell to a particular market and how, *i.e.* via export or FDI strategies. This will depend on their own

productivity, on trade costs between the origin and the destination country and on the fixed costs.<sup>7</sup>

The marginal costs in the exporting sector will be higher than the one in the FDI sector. Since  $y_1$  and  $y_2$  are produced with  $L$ , the marginal cost for domestic as well as export production is linear in  $\tau$ ,

$$mc_{ij} = aw_i\tau_{ij}$$

where when  $i = j$  then  $\tau_{ij} = 1$ . The marginal cost for supplying the foreign market  $j$  via local sales of foreign affiliates is concave in  $\tau$ ,

$$mc_{M,ij} = aw_j^{1-\eta} (w_i\tau_{ij})^\eta$$

This last marginal cost combines inputs from home and host country. More precisely,  $w_j^{1-\eta}$  is the labor cost for input produced in country  $j$ , while  $w_i^\eta$  is the labor cost for input imported in country  $j$  from the home country  $i$ .<sup>8</sup> Note that in this last marginal cost trade costs matter but only in relation to cost share,  $\eta$ , of the intermediate good  $y_1$  used in the production of the final good. Using the mark up,  $\sigma/(\sigma - 1)$ , we can easily derive the price for each particular mode of supply decisions.

## Mode of Supply Decisions

The mode of supply decision choice will involve the comparison of profit levels taking into account the various fixed and variable trade costs. A firm can decide to: (i) not supply a market, (ii) supply it via exports, or (iii) supply it via local sales of foreign affiliates.<sup>9</sup>

The optimal mode of supply depends on a firm's productivity. As described above, three cases are relevant.

*Case (i)*. If the firm decides not supply a market and exits, the operating profits are zero.

*Case (ii)*. If the firm in country i decides to supply market j via exports, the profits from exporting to market j are linearly decreasing in  $\tau_{ij}$ ,

$$\pi_{ij} = [p_{ij}(a) - aw_i\tau_{ij}]q(a)_{ij} - w_j f_{ij}$$

where  $q(a)_{ij}$  represents the quantity exported. Substituting the equilibrium price and quantity we have,

$$\pi_{ij} = \frac{1}{\sigma} \left( \frac{\sigma}{\sigma - 1} \right)^{(1-\sigma)} Y_j (w_i a \tau_{ij})^{1-\sigma} / P_j^{1-\sigma} - w_j f_{ij} \quad (2)$$

where the fixed cost of exporting,  $f_{ij}$ , is evaluated at the foreign wage rate,  $w_j$ .<sup>10</sup>

*Case (iii)*. If the firm in country i decides to supply market j via FDI,

the profits realized by a subsidiary located in the  $j$  country depend on  $\tau_{ij}$ ,

$$\pi_{M,ij} = [p_M(a) - aw_j^{1-\eta} (w_i \tau_{ij})^\eta] q(a)_{M,ij} - w_j f_{M,ij} \quad (3)$$

where  $q(a)_{M,ij}$  represents the quantity supplied by the foreign affiliate.

Substituting the equilibrium price and quantity we have,

$$\pi_{M,ij} = \frac{1}{\sigma} \left( \frac{\sigma}{\sigma - 1} \right)^{(1-\sigma)} Y_j (aw_j^{1-\eta} (w_i \tau_{ij})^\eta)^{1-\sigma} / P_j^{1-\sigma} - w_j f_{M,ij}$$

where  $\tau_{ij}^\eta$  is the trade costs associated with the intermediate good,  $y_1$ , imported from the home country. The foreign affiliate has to face both the fixed cost  $f_{M,ij}$ , evaluated at the foreign wage rate, and the trade costs that hit the imported intermediate.

To focus on the central case, we set parameters so that we get the same ranking as in HMY when there are only two nations. Namely, firms with sufficiently high productivity will supply the foreign market at all, with the most productive supplying it via FDI rather than exports. Hence, the regularity condition we need is,

$$(w_i \tau_{ij})^{(\sigma-1)} w_j f_{ij} < (w_j^{1-\eta} (w_i \tau_{ij})^\eta)^{\sigma-1} w_j f_{M,ij}$$



Rearranging terms we get:

$$f_{ij} < f_{M,ij} \frac{(w_j^{1-\eta} (w_i \tau_{ij})^\eta)^{\sigma-1}}{(w_i \tau_{ij})^{(\sigma-1)}} \quad (4)$$

The fact that the price index depends on the probability distribution implies that in order to have explicit solutions for this model, we need to assume a particular functional form for  $G(a)$ . Following the empirical literature on firm size distribution (see Axtell 2001 and Chaney 2008), we assume unit labor requirement are drawn from a Pareto distribution. The cumulative distribution function of a Pareto random variable  $a$  is:

$$G(a) = \left( \frac{a}{a_0} \right)^k \quad (5)$$

where  $k$  and  $a_0$  are the shape and scale parameter, respectively. The shape parameter  $k$  represents the dispersion of cost draws. An increase in  $k$  would imply a reduction in the dispersion of firm productivity-draws.

Hence, the higher is  $k$  the smaller is the amount of heterogeneity.

The support of the distribution  $[0, \dots, a_0]$ , is identical for every country, where  $a_0$  represents the upper bound of this distribution. The productivity distribution of surviving firms will also be Pareto with shape  $k$ . More precisely, since a firm will start producing only if it has at least a productivity of  $1/a_{ij}$ , the probability distribution of supplying as an

exporter, or as a foreign affiliate, is conditioned on the probability of successful entry in each market,

$$G(a/a_{ii}) = \left( \frac{a}{a_{ii}} \right)^k$$

The above truncated cost distribution exploits the fractal nature of the Pareto. Here the support is  $[0, \dots, a_{ii}]$ . Given the assumed parameterization, we can explicitly solve for the price index.

The total mass of potential entrants in country  $i$  is proportional to its labor income,  $w_i L_i$ . Hence, larger and wealthier countries have more entrants. The absence of free entry implies that firms generate net profits, which have to be redistributed. Following Chaney (2008), each worker owns  $w_i$  shares of the global fund. This fund collects profits from the firms and redistributes them to its shareholders.

### **Demand for Differentiated Goods**

Total income in country  $j$ ,  $Y_j$ , is the sum of workers' labor income in country  $j$ ,  $w_j L_j$ , and of the dividends they get from their portfolio,  $\pi w_j L_j$ , where  $\pi$  is the dividend per share.

Given the optimal pricing of firms and the demand by consumers, we can find the export value from country  $i$  to country  $j$  by a firm with unit

labor requirement  $a$ ,

$$x_{ij}^X = p_{ij}^X q_{ij}^X = Y_j (p_{ij}^X)^{1-\sigma} / P_j^{1-\sigma}$$

where  $p_{ij}^X = [\sigma / (\sigma - 1)] a w_i \tau_{ij}$  and  $q_{ij}^X = (p_{ij}^X)^{-\sigma} \beta Y_i / P_j^{1-\sigma}$ . While affiliate sales by a firm located in  $j$  are

$$x_{ij}^M = p_{ij}^M q_{ij}^M = Y_j (p_{ij}^M)^{1-\sigma} / P_j^{1-\sigma}$$

where  $P_j$  represents the price index of good  $q$  in country  $j$ . The value of export and of total production in  $j$ 's foreign affiliates are therefore similar to the one derived from homogeneous firms set up. They provide basis for gravity equations of export and of affiliate sales.<sup>11</sup>

Since only firms with  $a \leq \bar{a}_{kj}$  can start producing, the ideal price index in country  $j$  is<sup>12</sup>

$$P_j^{1-\sigma} = \sum_{k=1}^N w_k L_k \left[ \int_0^{\bar{a}_{M,kj}} (w_j^{1-\eta} (w_k \tau_{kj})^\eta)^{1-\sigma} a^{1-\sigma} dG(a) + \int_{\bar{a}_{M,kj}}^{\bar{a}_{kj}} (w_k \tau_{kj})^{1-\sigma} a^{1-\sigma} dG(a) \right]$$

The dividend per share,  $\pi$ , are defined as

$$\pi = \frac{\sum_{k,l=1}^N w_k L_k \left[ \int_0^{\bar{a}_{M,kl}} \pi_{M,kl} dG(a) + \int_{\bar{a}_{M,kl}}^{\bar{a}_{kl}} \pi_{kl} dG(a) \right]}{\sum_{n=1}^N w_n L_n}$$

where in the square parenthesis we have the profits that a firm with a specific threshold level in country  $k$  earns from a specific mode of supply in country  $l$ .<sup>13</sup> A similar analysis can be extended to H sectors. In Appendix 7.C.3 we derive solutions for the profits.

## 7.4 Equilibrium with Heterogeneous Firms

To compute the equilibrium of the overall economy, we solve for the selection of firms into different modes of supply. We generate predictions for aggregate bilateral trade and FDI flows.

### Productivity Threshold

From the profit a firm earns from exporting we can derive the productivity threshold of the least productive firm in country  $i$  able to export to country  $j$ ,

$$a_{ij}^{1-\sigma} = \lambda_1 \frac{w_j f_{ij}}{Y_j} \frac{P_j^{1-\sigma}}{(w_i \tau_{ij})^{1-\sigma}} \quad (6)$$

where  $\lambda_1 = \sigma \left( \frac{\sigma-1}{\sigma} \right)^{(1-\sigma)}$ .<sup>14</sup> While the productivity threshold of the least productive firm in country  $i$  able to open a foreign affiliate to country  $j$  is obtained by equating the operating profits from doing FDI, (3), with the

operating profit from doing export (2),

$$a_{M,ij}^{1-\sigma} = \lambda_1 \frac{w_j (f_{M,ij} - f_{ij})}{Y_j} \frac{P_j^{1-\sigma}}{(w_j^{1-\eta} (w_i \tau_{ij})^\eta)^{1-\sigma} - (w_i \tau_{ij})^{1-\sigma}} \quad (7)$$

## Equilibrium Price Indices

Since price index adjusts depending on country characteristics, it is possible to find tractable solutions for it. Thanks to the fact that the number of potential entrants,  $n_E$ , is exogenously given, the price index will depend only on country  $j$ 's characteristics,

$$P_j^{1-\sigma} = (\sigma/(\sigma - 1))^{1-\sigma} \times k/(k - \sigma + 1) \times$$

$$\sum_{k=1}^N w_k L_k \left[ a_{M,kj}^{k-\sigma+1} (w_j^{1-\eta} (w_k \tau_{kj})^\eta)^{1-\sigma} + (a_{kj}^{k-\sigma+1} - a_{M,kj}^{k-\sigma+1}) (w_k \tau_{kj})^{1-\sigma} \right]$$

Plugging the productivity thresholds from (6) and (7) we can solve for the price index in the destination country  $j$  as follows,

$$P_j = \lambda_2 Y_j^{\frac{b-1}{b(1-\sigma)}} \theta_j \left( \frac{Y}{1 + \pi} \right)^{\frac{1}{b(1-\sigma)}} \quad (8)$$

where  $b = k/(\sigma - 1)$ ,  $w_k$  is the wage paid to workers in country  $k$  for firms which are exporting the good, while  $w_j$  is the wage paid to the workers in country  $j$  which are producing the domestic varieties or the foreign

affiliate varieties. In the expression above  $\theta_j$  collects the following terms

$$\theta_j^{b(1-\sigma)} = \sum_{k=1}^N \frac{Y_K}{Y} \left[ (w_j (f_{M,kj} - f_{kj}))^{1-b} \left[ (w_j^{1-\eta} (w_k \tau_{kj})^\eta)^{1-\sigma} - (w_k \tau_{kj})^{1-\sigma} \right]^b \right. \\ \left. + [w_j f_{kj}]^{1-b} ((w_k \tau_{kj})^{1-\sigma})^b \right]$$

where  $Y$  is the world output, and  $\lambda_2$  a constant.<sup>15</sup>  $\theta_j$  is an aggregate index of  $j$ 's remoteness from the rest of the world. It can be thought as the “multilateral trade resistance” introduced by Anderson and van Wincoop (2003). It takes into consideration the role of the fixed cost as well as trade costs and intermediate input traded. Notice that since total income,  $Y$ , will depend on the dividends received from the global fund, in equilibrium it turns out that dividend per share is a constant.

### Equilibrium variables

The mode of supply choice depends on each firm productivity, the trade costs it has to face, aggregate demand, the amount of intermediates it needs, the set of competitors. Using the general equilibrium price index from (23) into (6) and (7) we can solve for the productivity threshold.

$$\bar{a}_{ij}^{1-\sigma} = \lambda_4 \frac{w_j f_{ij}}{(w_i \tau_{ij})^{1-\sigma}} \theta_j^{1-\sigma} \left( \frac{Y}{Y_j} \right)^{\frac{1}{b}} (1 + \pi)^{-\frac{1}{b}} \quad (9)$$

$$\bar{a}_{M,ij}^{1-\sigma} = \lambda_4 \frac{w_j (f_{M,kj} - f_{ij})}{(w_j^{1-\eta} (w_i \tau_{ij})^\eta)^{1-\sigma} - (w_i \tau_{ij})^{1-\sigma}} \theta_j^{1-\sigma} \left( \frac{Y}{Y_j} \right)^{\frac{1}{b}} (1 + \pi)^{-\frac{1}{b}} \quad (10)$$

where  $\lambda_4$  is a constant.<sup>16</sup> The productivity threshold in (9) is unambiguously positively affected by the wage rate in the origin country, and trade costs. On the other side, the productivity threshold in (10) is ambiguously affected by the wage rate in  $i$ ,  $\eta$  and distance trade costs. A large  $w_j$  increases the productivity to be a MNFs.

The share of imported intermediates plays an important role in determining the substitutability or the complementarity between trade and FDI strategies. A low amount of imported intermediates,  $\eta$ , makes the FDI strategy better off when distance increases; while a high  $\eta$  fades out the source of ambiguity.<sup>17</sup> The lower is the  $\eta$  the more destination countries a firm can reach via HFDI when trade cost increases.

Then using the demand function, the equilibrium price as well as (23), we can find the firm level exports and the firm level affiliate sales, aggregate output and dividends per share  $\pi$ .

$$x_{ij}^X = p_{ij}^X q_{ij}^X = \lambda_3 \times \theta_j^{\sigma-1} \times \left(\frac{Y_j}{Y}\right)^{\frac{1}{b}} \times (1 + \pi)^{\frac{1}{b}} \times (w_i \tau_{ij})^{1-\sigma} \times a^{1-\sigma} \quad (11)$$

$$x_{ij}^M = p_{ij}^M q_{ij}^M = \lambda_3 \times \theta_j^{\sigma-1} \times \left(\frac{Y_j}{Y}\right)^{\frac{1}{b}} \times (1 + \pi)^{\frac{1}{b}} \times (w_j^{1-\eta} (w_i \tau_{ij})^\eta)^{(1-\sigma)} \times a^{1-\sigma} \quad (12)$$

$$\pi = \lambda_5 \quad (13)$$

$$Y_j = (1 + \pi)w_j L_j = (1 + \lambda_5)w_j L_j \quad (14)$$

where  $\lambda_3$  and  $\lambda_5$  are constants.<sup>18</sup> The equations above are functions of fundamentals only: the size  $L_j$ , the wages, the trade barriers  $\tau_{ij}$ , the fixed costs  $f_{M,ij}$  and  $f_{ij}$ , the proportion of intermediate imported,  $\eta$ , and the measure of the  $j$ 's location with respect to the rest of the world,  $\theta_j$ .

Similarly to Chaney (2008) exports by individual firms depend on the transportation cost  $\tau_{ij}$  with an elasticity  $1 - \sigma$ . Here we also have the sales by a foreign affiliate, which depend on the share of intermediate produced in the foreign location,  $y_2$ , and imported from the home country,  $y_1$ . Firm level FDI, (12), are unambiguously linked to trade costs: an increase in trade costs reduces the firm level FDI.

Firm level trade is the same as in Chaney (2008). Firm level affiliate sales depend on the interaction between imported and locally produced inputs. The behavior of single firm is similar to what a traditional model of trade and FDI with representative firms would predict for aggregate bilateral trade flows and affiliate sales.

Similarly to Chaney (2008) and Irarrazabal et al. (2008), we can derive gravity equations using equations (11) and (12). In the present model aggregate bilateral trade and overseas affiliate sales will be different from traditional models.



**Proposition 1 (aggregate trade)** Using the firm level exports we can derive the total export (f.o.b.),  $X_{ij}^X$ , from country  $i$  to country  $j$ ,

$$X_{ij}^X = \frac{Y_i Y_j}{Y} \theta_j^{b(\sigma-1)} (w_i \tau_{ij})^{1-\sigma} \times \left[ \left( \frac{w_j f_{ij}}{(w_i \tau_{ij})^{1-\sigma}} \right)^{1-b} - \left( \frac{w_j (f_{M,ij} - f_{ij})}{(w_j^{1-\eta} (w_i \tau_{ij})^\eta)^{1-\sigma} - (w_i \tau_{ij})^{1-\sigma}} \right)^{1-b} \right] \quad (15)$$

**Proof.** See Appendix 7.C.1 ■

The gravity equation for export in (15) suggests that exports are a function of country sizes,  $Y_i$  and  $Y_j$ , wages, bilateral trade costs and fixed costs, and the measure of  $j$ 's remoteness from the rest of the world.<sup>19</sup> In this equation wages are endogenous, thus they will respond to changes in trade policy. By neglecting this interaction and using partial equilibrium analysis, we conclude that aggregate export is negatively affected by trade costs and origin country wage rate.

To highlight the role of share of imported intermediates,  $\eta$ , consider the simplifying assumption of  $w_i = w_j$ . The cost of doing FDI is clearly proportional to the magnitude of  $\eta$ . Hence, the second element in the square bracket of (15) decreases with  $\eta$ . This implies that aggregate exports are increasing with the proportion of inputs being imported from the headquarter.

**Remark 1** *Aggregate export sales decrease with distance,  $\tau_{ij}$ . These*

exports decrease faster the larger are the elasticity of substitution,  $\sigma$ , and the wage rate in the origin country,  $w_i$ . These effects are slightly reduced if a large share of intermediate inputs is traded ( $\eta \rightarrow 1$ ).

To conclude, aggregate exports increase with  $\eta$  and  $w_j$ , while decrease with  $w_i$  and  $\tau$ . Differently from Chaney (2008), this aggregate trade equation take into consideration the interaction between arm's length and intra-firm trade.

**Proposition 2 (aggregate affiliate sales)** Using the firm level affiliate sales we can derive the total affiliate sales,  $X_{ij}^M$ , in country j,

$$X_{ij}^M = \frac{Y_i Y_j}{Y} \theta_j^{b(\sigma-1)} (w_j^{1-\eta} (w_i \tau_{ij})^\eta)^{1-\sigma} \times \left( \frac{w_j (f_{Mij} - f_{ij})}{(w_j^{1-\eta} (w_i \tau_{ij})^\eta)^{1-\sigma} - (w_i \tau_{ij})^{1-\sigma}} \right)^{1-b} \quad (16)$$

**Proof.** See Appendix 7.C.2 ■

The gravity equation for affiliate sales in (16) suggests that affiliate sales are a function of country sizes,  $Y_i$  and  $Y_j$ , wages, bilateral trade costs and fixed costs, intra-firm trade between affiliates and the measure of j's remoteness from the ROW.<sup>20</sup> The last term of (16) is responsible for ambiguous reactions of affiliate sales.

Increase in trade costs reduces both total trade and intra-firm trade, but the magnitude differs in relation to the amount of intermediate

imported.<sup>21</sup> In general equilibrium, the increase in trade costs will also affect wages. The final effect of trade policy on affiliate sales depends on how wages respond to  $\tau$ . Different wage responses will generate different affiliate sales reactions.

Changes in trade barriers differently affect aggregate affiliate sales depending on how wages respond to trade liberalization. Increase in trade barriers might create an incentive to ship production to the foreign market to avoid a part of the trade costs.<sup>22</sup> This will increase the demand for labor in the destination country relatively to the home country. When trade costs are sufficiently small and the difference between the wages is not too big, anti-globalization forces lead to an increase in aggregate local sales. This effect is boosted by lower share of intra-firm trade.

**Remark 2** *Aggregate affiliate sales are non-monotonically related to distance. Different level of trade costs,  $\tau_{ij}$ , elasticity of substitution,  $\sigma$ , and share of intermediate inputs traded,  $\eta$ , change the way distance affects equation (16). Notice that the response of wages to trade policy will be crucial to determine the overall effect.*

Notice that it is straightforward to derive a similar expression for aggregate intra-firm trade since in this model aggregate intra-firm trade is a fraction of affiliate sales. Thus, gravity equation in (16), also includes aggregate intra-firm trade.

**Proposition 3 (Number of Affiliates)** The aggregate number of foreign affiliates is given by

$$\begin{aligned} n_{M,ij} &= w_i L_i \int_0^{\bar{a}_{M,ij}} dG(a) \\ &= \frac{Y_i Y_j}{Y} \theta_j^{b(\sigma-1)} \lambda_4^{-b} \left( \frac{(w_j^{1-\eta} (w_i \tau_{ij})^\eta)^{1-\sigma} - (w_i \tau_{ij})^{1-\sigma}}{w_j (f_{M,ij} - f_{ij})} \right)^b \end{aligned} \quad (17)$$

where we used the productivity threshold in (10).

If trade costs are sufficiently low, a change in distance initially increases the number of affiliates. Nevertheless, when distance becomes important the number of firms decreases. This non-monotonicity is lost if the trade cost and/or the elasticity of substitution are particularly high. On the contrary, low levels of  $\sigma$  and/or  $\tau$  generate a more persistent increase in the number of affiliates.

**Remark 3** *The aggregate number of foreign affiliates has a non-monotonic behavior with respect to distance. Low levels of  $\eta$  exacerbate this non-monotonicity. The reverse is true for high  $\sigma$  and/or  $\tau$ .*

In this model, a decreasing number of firms continue to supply via FDI when  $\tau_{ij}$  increases. More precisely, only the more productive firms continue to supply via FDI to the remote location. This result is in sharp contrast with the literature on proximity *versus* concentration, where the number of affiliates is increasing with distance. The introduction of this

intra-firm linkage between headquarter and affiliate, makes the FDI strategy sensitive to trade issues.

**Proposition 4 (Number of Exporters)** The aggregate number of exporters is

$$\begin{aligned}
n_{X,ij} &= w_i L_i \int_{\bar{a}_{M,ij}}^{\bar{a}_{ij}} dG(a) = w_i L_i (\bar{a}_{ij}^k - \bar{a}_{M,ij}^k) \\
n_{X,ij} &= \frac{Y_i Y_j}{Y} \theta_j^{b(\sigma-1)} \lambda_4^{-b} \times \\
&\left[ \left( \frac{(w_i \tau_{ij})^{1-\sigma}}{w_j f_{ij}} \right)^b - \left( \frac{(w_j^{1-\eta} (w_i \tau_{ij})^\eta)^{1-\sigma} - (w_i \tau_{ij})^{1-\sigma}}{w_j (f_M - f_{ij})} \right)^b \right] \quad (18)
\end{aligned}$$

where we used the productivity thresholds in (9) and (10). Interpreting the role of key variables in equation (18) is far from straightforward due to wage differentials, share of intra-firm trade and elasticity of substitution.

**Remark 4** For high trade costs,  $\tau_{ij}$ , and low level of intra-firm trade,  $\eta$ , the aggregate number of exporting firms is unambiguously decreasing with trade costs.

### Relationship between Trade and FDI

The share of intermediate inputs traded within the boundary of the firm,  $\eta$ , characterizes the cost of doing FDI: it captures the interaction between FDI and trade. From equations (15) and (16), the following effects can be

established. A reduction in  $\eta$  is responsible for an increase in affiliate sales and a decrease in trade. Nevertheless, a decrease in  $\eta$  does not unambiguously determine what will happen to intra-firm trade. A smaller  $\eta$  shifts production so that more host country national input,  $y_2$ , is used. Since the decrease in  $\eta$  increases affiliate sales, the use of home as well as host input increases. Let's consider the Hicksian factor demand for the intermediate good,  $y_1$ , imported from  $i$  to  $j$ . This Hicksian demand depends on the overall quantity produced in the foreign affiliate,  $q_{Mij}(a)$ , as well as on the share of intermediate good,  $\eta$ , used in the overseas affiliate final good production,

$$y_1^* = q_{Mij}(a) a \eta \left( \frac{w_j}{w_i \tau_{ij}} \right)^{1-\eta}$$

The overall effect of a decrease in  $\eta$  on this Hicksian factor demand and thus on intra-firm trade, depends on which of these two effects dominate. The larger is the share of intermediate input traded (high  $\eta$ ) more similar will be the behavior of aggregate affiliate sales and arm's length trade to changes in trade costs.<sup>23</sup> To stress the difference between this result and the proximity *versus* concentration result, we define this relationship the *complementarity relationship*.

This complementarity relationship between arm's length and affiliate sales is captured by gravity equation in (16).<sup>24</sup> Low level of intermediate input

needed in the production of the overseas affiliate, confirms the substitution between arm's length and intra-firm trade. On the contrary, high levels trigger a complementarity between arm's length and intra-firm trade: trade costs reduce both affiliate and export sales.

## 7.5 Empirical Evidence

In this section, we propose a description of the data and then we connect the data to the main predictions of the model. The empirical exercise is made of two parts. First, using aggregate data over the period 1999-2004, we analyze how geographical barriers differently affect arm's length and intra-firm trade flows. Second, using disaggregated data at the NAICS 3 digits, we give a role to sectoral differences and we analyze how the role of distance might be linked to the specific sector considered.

For what concern the relationship between MNF's productivity and the proportion of intra-firm trade undertaken, which implicitly emerge from the model, lack of data availability prevent from possible tests.

Nevertheless, exploiting empirical findings on exporters, it seems reasonable to expect that intra-firm trade is important and concentrated across MNFs. In this scenario, a trade policy liberalization event might affect differently various groups of final good producers.

### 7.5.1 Data Description

Our analysis is based on two databases. The first set of data are collected by U.S. Bureau of Economic Analysis (henceforth BEA). These data contain U.S. exports of goods by U.S. parents to majority-owned foreign affiliates by country and industry (NAICS) over the period 1999 to 2004.<sup>25</sup> Some BEA data can be suppressed to avoid disclosure of data of individual companies or are not available or are not defined. Moreover, these data on exports of goods by U.S. parents to majority-owned foreign affiliates also report zeros trade flows. This leaves us with 2118 observation at the NAICS 3 digits level.<sup>26</sup>

The second set of data are collected by the Center for International Data at UC Davis. These information concern U.S. export flows over the period 1990-2004. These trade data are then aggregated at the NAICS 3 digits. To make trade data comparable with BEA data, we reduce the sample to the same group of countries and sectors.<sup>27</sup> To obtain a more reliable measure of arm's-length trade, we subtract intra-firm trade from export values.

Our main explanatory variable is geographical distance, for which we use data from the CEPII database on bilateral distances. This measure will proxy the key variable in our theoretical model,  $\tau_{ij}$ . More specifically, we use weighted distances, for which data on principal cities in each country



are needed.<sup>28</sup> We complete our set of country variables with other controls. To control for trade openness we include a dummy for regional trade agreement (RTA) and GATT/WTO membership of different US's partners. These measures of trade openness RTAs and GATT/WTO membership come from CEPII dataset.<sup>29</sup>

### 7.5.2 Empirical Specification

In this section we test the empirical validity of the main results of the paper. We use a panel data approach to characterize the main determinants of intra-firm and arm's length export flows. The model predicts that, other thing being equal, intra-firm trade and related party trade are both decreasing with distance. The magnitude of the distance coefficient should be different between these two types of trade flows.

According to Propositions 1 and 2, intra-firm trade is expected to be less sensitive than arm's length trade to change in trade policy. Indeed, the internal linkages between the parent and the foreign affiliate should reduce the role played by geography as well as trade costs.

To examine how intra-firm trade and arm's length export react to geographical barriers we consider U.S. industry data. We follow the standard practice in assuming that the trade costs,  $\tau_{ij}$ , is linear in log of geographic distance and a set of variables indicating trade link between

origin and destination country, i.e. language and legal system.

$$\ln \tau_{ij} = \delta \ln D_{ij} - \lambda L_{ij}$$

The baseline specification for the aggregate value of intra-firm trade from U.S. parent to the  $j$  destination country is:

$$\ln VA_{ij}^{IF} = \beta_0 + \underbrace{\beta_1}_{=\eta(1-\sigma)} \ln(\tau_{ij}) + \beta_2 \ln Y_j + \beta_3 \ln(W_j) + \varepsilon_j \quad (19)$$

where  $VA_{ij}^{IF}$  is overall intra-firm trade from the U.S. headquarter to the foreign subsidiary,  $Y_j$  is the GDP in the destination country,  $W_j$  is a vector of controls, and  $\varepsilon_j$  is an orthogonal error term. The model predicts that  $\beta_1$  and  $\beta_3$  should be negative and  $\beta_2$  to be one.

The baseline specification for the value of intra-firm trade from U.S. parent to the  $j$  destination country is:

$$\ln X_{ij} = \alpha_0 + \underbrace{\alpha_1}_{=(1-\sigma)} \ln(\tau_{ij}) + \alpha_2 \ln Y_j + \varepsilon_j \quad (20)$$

where  $X_{ij}$  represents arm's-length trade from the U.S. to a particular destination country  $j$ ,  $Y_j$  is the GDP in the destination country,  $W_j$  is the same vector of controls used for aggregate intra-firm trade, and  $\varepsilon_j$  is an orthogonal error term. Our theory predicts the  $\alpha_1$  coefficient to be bigger than  $\beta_1$  in equation (19).

The elasticity of intra-firm trade with respect to the relative cost of FDI depends on firm heterogeneity. In more homogeneous sectors (high  $k$ ) there is a smaller fraction of highly productive firms (MNFs). In this case, the aggregate intra-firm sales should be more sensitive to change in relative FDI costs. Hence, when  $k$  is high the overall effect of trade costs is bigger. While in more heterogeneous sector ( $k$  small) the second element is smaller.

As a general strategy, we run OLS regressions on aggregated and then on disaggregated NAICS 3 digits data. We will focus on overall as well as sectoral effects of distance on both type of trade flows. Due to the presence of zeros in intra-firm trade data, OLS estimates will be biased. To account for that, we perform a Heckman selection procedure, where we use as excluded variable the quality of the legal system. This variable is proxied with the rule of law index from the Worldwide Governance Indicator (World Bank).<sup>30</sup> The Heckman selection model allows us to use information from zero intra-sector trade flows so to improve the estimates of the parameters in the regression model. This model provides consistent, asymptotically efficient estimates for all parameters in the model.

### **7.5.3 Results**

Tables 7.1 and 7.2 report estimation results for the effect of geographical barriers on aggregate intra-firm and arm's-length data. Columns (1) to

(3) show the results when adding controls to our main explanatory variable, distance. Coefficients have the expected sign. An increase in the level of trade barrier (geographical distance) is negatively associated with both types of trade flows. Nevertheless, the magnitude of the distance coefficient is not in line with our theoretical predictions: the effect of distance is stronger for arms's length trade than for intra-firm trade. This result might be driven by the dominant role of a particular sector. To account for sector specific effects, a set of additional regressions are proposed in the Tables 7.3 to 7.5.

Tables 7.3 and 7.4 try to disentangle the importance of sectoral differences using OLS procedure. Estimation results are obtained from disaggregated data at the NAICS 3 digits for both intra-firm and arms's length trade.

Columns (1) to (4) in both Tables show the results when adding controls to the main explanatory variable. In particular, column (4) in Table 7.3 shows the results when interacting distance with sector specific effect.

While the average effect of distance decreases intra-firm trade by 1.73, sector-distance interactions highlight that this effect differs across sectors.

For example, in the transportation equipment sector, intra-firm trade flows decline by 1 percent, while in computer and electronic sector decline only by 0.08 percent. Similarly, column (4) in Table 7.4 shows that arm's length trade declines on average by 0.72 percent, and again sector-distance effects are quite heterogeneous. In the transportation

equipment sector, arm's length trade flows decline by 0.01 percent, while in computer and electronic sector increase by 0.027 percent.

Controlling for sector disaggregation we find that the magnitude of distance is smaller for intra-firm trade flows but only in the chemical sector. These results are only partially in line with the theoretical predictions. However they confirm the importance of geographical distance in the organizational choices of the firm. It should be stressed though that results presented in Table 7.3 tend to be biased due to the presence of zeros in NAICS 3 digits data.

To control for the presence of zeros in intra-firm data, Table 7.5 presents robustness checks with Heckman two step procedure. The Heckman selection procedure proposed uses the quality of the legal system as the excluded variable. Column (4) shows that the average effect of distance is now reducing intra-firm trade flows by 1.6 percent. Accounting for sectoral differences, generates results more strongly in line with the theoretical predictions. In the transportation equipment sector, intra-firm trade flows decline by 0.58 percent, while increase by 0.57 percent for the computer and electronic sector. For the transportation sector, the interacted distance coefficient is not significantly different from its average effect. To sum up, correcting for the presence of the zeros produces a distance coefficient that plays a smaller role for three out of four sectors: chemicals, computer and electronic and machinery.

## 7.6 Conclusion

This paper develops a model of trade that features heterogeneous firms, multinational firms, exporters and intra-firm trade in a general equilibrium framework. Its main contribution is to explain the different impact of geographical distance on related-party versus arm's length trade. It also provides empirical evidence to support the model's main predictions using BEA and CID data from different NAICS sectors over the period 1999-2004.

In this paper a trade policy intervention affects the trading activity of firms which occurs both within and outside the boundaries of the firm and across different sectors. Globalization should increase the volume of trade. However, two types of trade will be affected by change in trade barriers: arms length and related-party trade. Measuring the response of arm's length trade *versus* related-party trade to globalization pressures might be important to define specific policy intervention. As a consequence of a reduction in trade barriers, multinational activity increases more the higher is the percentage of intra-firm trade involved in MNF. While trade in final goods increases by a larger proportion than intra-firm trade.

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## Appendices

Appendix 7.A provides data information while appendix 7.B presents some stylized facts. Appendix 7.C provides proofs of the propositions and equilibrium variables. Finally, appendix A.7 provides regressions results.

### 7.A: Information on Database

Data	
Exports	CDI
Export from P to A	BEA Database
GDP (current USD)	CEPII Database
Distance	CEPII Database
Data Period	1999-2004

**Table of Countries**

Argentina	Greece	Philippines
Australia	Guatemala	Poland
Austria	Hong Kong	Portugal
Bahamas	Honduras	Russian Federation
Barbados	Hungary	Saudi Arabia
Belgium	India	South Africa
Bermuda	Indonesia	Singapore
Brazil	Ireland	Spain
Canada	Israel	Sweden
Chile	Italy	Switzerland
China	Jamaica	Taiwan
Colombia	Japan	Thailand
Costa Rica	Korea, Republic of	Trinidad and Tobago
Czech Republic	Luxembourg	Turkey
Germany	Mexico	
Denmark	Malaysia	
Dominican Republic	Nigeria	
Ecuador	Netherlands	
Egypt	Norway	
Finland	New Zealand	
France	Panama	
United Kingdom	Peru	

**Table of Sectors: NAICS 2 Industry Classification**

21	Mining, Quarrying, and Oil and Gas Extraction
22	Utilities
31-33	Manufacturing
42	Wholesale Trade
51	Information
52	Finance and Insurance
54	Professional, Scientific, and Technical Services

**Table of Sectors: NAICS 3 Industry Classification**

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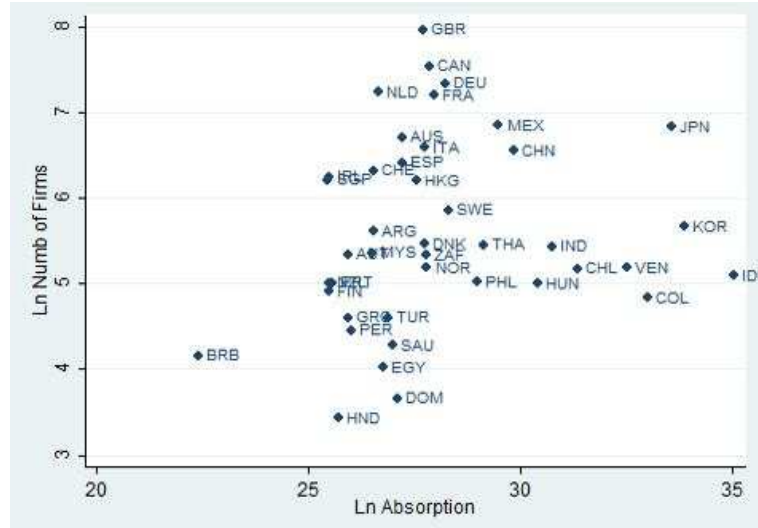
311	Food Manufacturing
325	Chemical Manufacturing
333	Machinery Manufacturing
334	Computer and Electronic Product Manufacturing
335	Electrical Equipment, Appliance, and Component Manufacturing
336	Transportation Equipment Manufacturing

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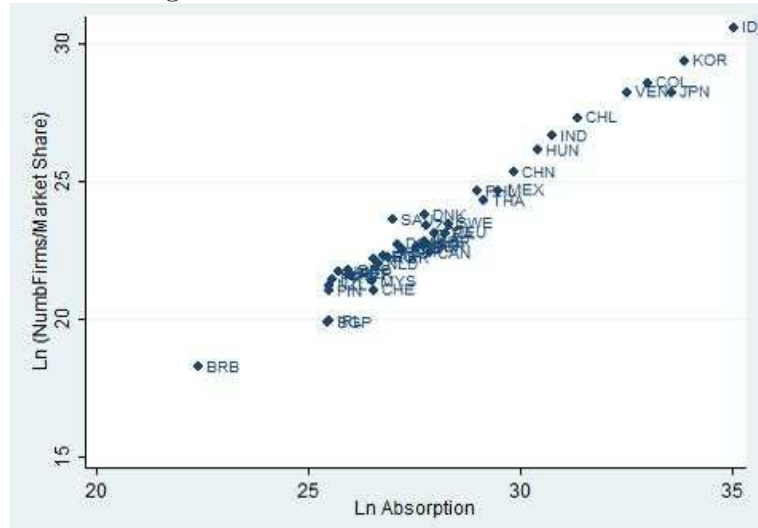
## 7.B: Figures

Figure 7.1: Number of U.S. Affiliates



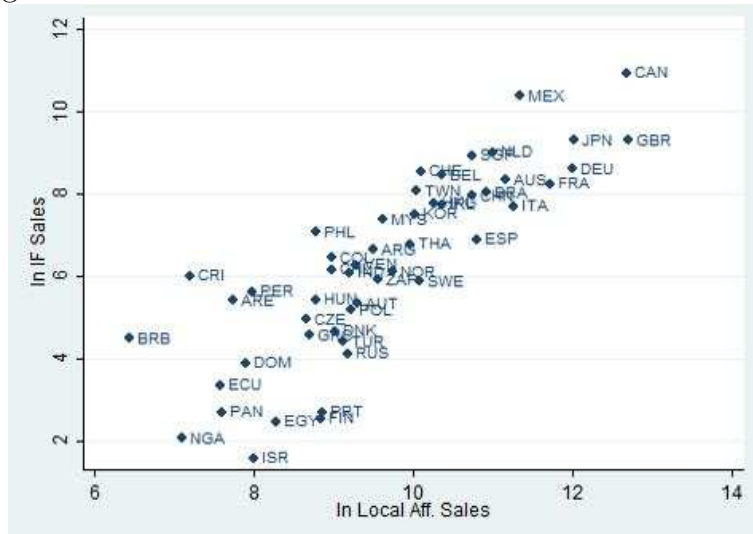
Note: author calculations based on BEA dataset for 2004.

Figure 7.2: Number of U.S. Affiliates



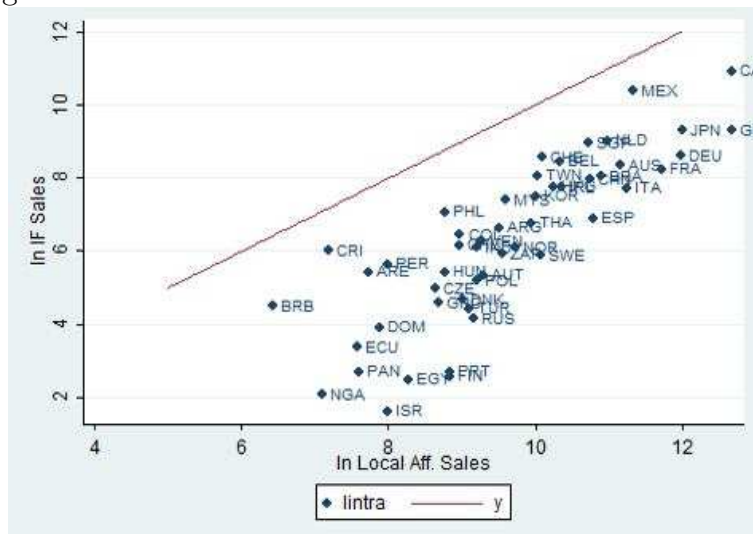
Note: author calculations based on BEA dataset for 2004.

Figure 7.3: Intra-firm trade and Local Affiliate Sales in 2004



Note: Data on Local Sales in the destination market from BEA (Majority-Owned Nonbank Foreign Affiliates of Nonbank U.S. Parents).

Figure 7.4: Intra-firm trade and Local Affiliate Sales in 2004



Note: Data on Local Sales in the destination market from BEA (Majority-Owned Nonbank Foreign Affiliates of Nonbank U.S. Parents).

## 7.C: Proofs

In what follows we provide proofs of the propositions and equilibrium variables.

### 7.C.1 Proposition 1

**Proof.** Total exports from i to j are given by:

$$X_{ij}^X = w_i L_i \int_{\bar{a}_{M,ij}}^{\bar{a}_{ij}} x_{ij}^X dG(a)$$

a firm will be exporting if  $a(v) \leq \bar{a}_{ij}$ . Using (11), (12), (9) and (10) and the specific assumption about the distribution of the labor unit requirement,  $a$ , we obtain:

$$X_{ij}^X = w_i L_i \int_{\bar{a}_{M,ij}}^{\bar{a}_{ij}} \lambda_3 \times \theta_j^{\sigma-1} \times \left(\frac{Y_j}{Y}\right)^{\frac{1}{b}} \times (1+\pi)^{\frac{1}{b}} \times (w_i \tau_{ij})^{1-\sigma} \times a^{1-\sigma} dG(a)$$

$$\text{with } \bar{a}_{ij}^{1-\sigma} = \lambda_4 \frac{w_j f_{ij}}{(w_i \tau_{ij})^{1-\sigma}} \theta_j^{1-\sigma} \left(\frac{Y}{Y_j}\right)^{\frac{1}{b}} (1+\pi)^{-\frac{1}{b}}$$

$$\text{and } \bar{a}_{M,ij}^{1-\sigma} = \lambda_4 \frac{w_j f_M - w_j f_{ij}}{(w_j^{1-\eta} (w_i \tau_{kj})^\eta)^{1-\sigma} - (w_i \tau_{ij})^{1-\sigma}} \theta_j^{1-\sigma} \left(\frac{Y}{Y_j}\right)^{\frac{1}{b}} (1+\pi)^{-\frac{1}{b}}$$

Using the assumption of the Pareto distribution and the productivity thresholds, we can then solve the integral and find (15). ■

### 7.C.2. Proposition 2

**Proof.** Total affiliate sale in country j are given by:

$$X_{ij}^M = w_i L_i \int_0^{\bar{a}_{M,ij}} x_{ij}^M dG(a)$$

a firm will open a subsidiary in country j if  $a(v) \leq \bar{a}_{M,ij}$ . Using (12) and (7) and the specific assumption about the distribution of the labor unit requirement,  $a$ , we obtain:

$$X_{ij}^M = w_i L_i \int_0^{\bar{a}_{M,ij}} \lambda_3 \times \theta_j^{\sigma-1} \times \left(\frac{Y_j}{Y}\right)^{\frac{1}{b}} \times (1+\pi)^{\frac{1}{b}} \times (w_j^{1-\eta} (w_i \tau_{ij})^\eta)^{(1-\sigma)} \times a^{1-\sigma} dG(a)$$

$$\text{with } \bar{a}_{M,ij}^{1-\sigma} = \lambda_4 \frac{w_j f_M - w_j f_{ij}}{(w_j^{1-\eta} (w_i \tau_{kj})^\eta)^{1-\sigma} - (w_i \tau_{ij})^{1-\sigma}} \theta_j^{1-\sigma} \left( \frac{Y}{Y_j} \right)^{\frac{1}{b}} (1 + \pi)^{-\frac{1}{b}}$$

then solving the integral we get (16). ■

### 7.C.3. Profits

In what follows we determine the dividend per share in the economy. In order to do this we use the total profits from exporting from  $i$  to  $j$  (including also trade within a country):

$$\begin{aligned} \Pi_{ij} &= w_i L_i \left[ \int_{\bar{a}_{M,ij}}^{\bar{a}_{ij}} \frac{1}{\sigma} x_{ij} dG(a) - \int_{\bar{a}_{M,ij}}^{\bar{a}_{ij}} w_j f_{ij} dG(a) \right] \\ &= \frac{X_{ij}}{\sigma} - w_j f_{ij} w_i L_i \int_{\bar{a}_{M,ij}}^{\bar{a}_{ij}} dG(a) \end{aligned}$$

Note that when  $i = j$ , this expression represents domestic profit.<sup>31</sup> Since  $n_{ij} = w_i L_i \int_{\bar{a}_{M,ij}}^{\bar{a}_{ij}} dG(a)$ , the expression above can be rewritten as

$$\Pi_{ij} = \frac{X_{ij}}{\sigma} - n_{ij} w_j f_{ij} \quad (21)$$

The total profits for country  $j$ 's affiliates are:

$$\begin{aligned} \Pi_{ij}^M &= w_i L_i \int_0^{\bar{a}_{M,ij}} \frac{1}{\sigma} x_{ij}^M dG(a) - \int_0^{\bar{a}_{M,ij}} w_j f_{Mj} dG(a) \\ &= \frac{X_{ij}^M}{\sigma} - n_M w_j f_{Mj} \end{aligned} \quad (22)$$

since  $n_M = w_i L_i \int_0^{\bar{a}_{M,ij}} dG(a)$ .

Total profits in this economy are

$$\begin{aligned} \Pi &= \sum_i \sum_j (\Pi_{ij} + \Pi_{ij}^M) \\ &= \sum_i \sum_j \left[ \left( \frac{X_{ij}}{\sigma} + \frac{X_{ij}^M}{\sigma} \right) - (n_{ij} w_j f_{ij} + n_M w_j f_{Mj}) \right] \end{aligned}$$



this expression is the sum of the overall profits produced by domestic, exporting and FDI firms in every country. Remember that country  $j$  is receiving varieties from  $N-1$ . More specifically, total sales in country  $j$  are determined by varieties sold by domestic firms, varieties exported to  $j$ , and varieties produced locally by foreign affiliates. Hence, total import in country  $j$  are  $\sum_i (X_{ij} + X_{ij}^M) = Y_j$ , where we used the fact that trade is balanced. Substituting the equilibrium number of exporters and affiliates we can rewrite the worldwide profits as:

$$\Pi = \sum_j \left[ \frac{Y_j}{\sigma} - c_4^{-b} Y_j \right] = Y \frac{1 - c_4^{-b}}{\sigma}$$

Hence dividends per share are:

$$\begin{aligned} \pi &= \frac{\Pi}{\sum_i w_i L_i} = \frac{\Pi}{Y} (1 + \pi) = \frac{1 - c_4^{-b}}{\sigma} (1 + \pi) \\ &= \frac{\frac{1 - c_4^{-b}}{\sigma}}{\left(1 - \frac{1 - c_4^{-b}}{\sigma}\right)} \end{aligned}$$

#### 7.C.4. Price Index

The price index is

$$P_j^{1-\sigma} = (\sigma/(\sigma - 1))^{1-\sigma} \times k/(k - \sigma + 1) \times$$

$$\sum_{k=1}^N w_k L_k \left[ a_{M,kj}^{k-\sigma+1} \left[ (w_j^{1-\eta} (w_k \tau_{kj})^\eta)^{1-\sigma} - (w_k \tau_{kj})^{1-\sigma} \right] + a_{kj}^{k-\sigma+1} (w_k \tau_{kj})^{1-\sigma} \right]$$

Plugging the productivity thresholds from (6) and (7) we can solve for the price index in the destination country  $j$ ,

$$P_j^{1-\sigma} = (\sigma/(\sigma - 1))^{1-\sigma} \times k/(k - \sigma + 1) \times \sum_{k=1}^N w_k L_k \times$$

$$\left\{ \left[ \lambda_1 \frac{w_j f_{M,kj} - w_j f_{kj}}{Y_j} \frac{P_j^{1-\sigma}}{(w_j^{1-\eta} (w_k \tau_{kj})^\eta)^{1-\sigma} - (w_k \tau_{kj})^{1-\sigma}} \right]^{1-b} \times \right. \\ \left. [(w_j^{1-\eta} (w_k \tau_{kj})^\eta)^{(1-\sigma)} - (w_k \tau_{kj})^{1-\sigma}] + \left[ \lambda_1 \frac{w_j f_{kj}}{Y_j} \frac{P_j^{1-\sigma}}{(w_k \tau_{kj})^{1-\sigma}} \right]^{1-b} (w_k \tau_{kj})^{1-\sigma} \right.$$

where  $b = k/(\sigma - 1)$ ,  $w_k$  is the wage paid to workers in country k for firms which are exporting the good, while  $w_j$  is the wage paid to the workers in country j which are producing the domestic varieties or the foreign affiliate varieties. Then solving for  $P_j^{1-\sigma}$

$$P_j^{b(1-\sigma)} = (\sigma/(\sigma - 1))^{1-\sigma} \times k/(k - \sigma + 1) \times \lambda_1^{1-b} \times (Y_j)^{b-1} \times \\ \sum_{k=1}^N w_k L_k \left[ (w_j f_{M,kj} - w_j f_{kj})^{1-b} \left[ (w_j^{1-\eta})^{1-\sigma} w_k^{\eta(1-\sigma)} \phi_{kj}^\eta - (w_k)^{1-\sigma} \phi_{kj} \right]^b + \right. \\ \left. [w_j f_{kj}]^{1-b} ((w_k)^{1-\sigma} \phi_{kj})^b \right]$$

where  $\phi_{kj} = \tau_{kj}^{1-\sigma}$ .

$$P_j = [(\sigma/(\sigma - 1))^{1-\sigma} \times (k/(k - \sigma + 1)) \times \lambda_1^{1-b}]^{\frac{1}{b(1-\sigma)}} \times (Y_j)^{\frac{b-1}{b(1-\sigma)}} \times \\ \left[ \sum_{k=1}^N \frac{Y_K}{Y} \frac{Y}{1 + \pi} \left[ (w_j f_{M,kj} - w_j f_{kj})^{1-b} \left[ (w_j^{1-\eta})^{1-\sigma} w_k^{\eta(1-\sigma)} \phi_{kj}^\eta - (w_k)^{1-\sigma} \phi_{kj} \right]^b + \right. \right. \\ \left. \left. [w_j f_{kj}]^{1-b} ((w_k)^{1-\sigma} \phi_{kj})^b \right]^{\frac{1}{b(1-\sigma)}} \right]$$

which after rearrangements becomes:

$$P_j = \lambda_2 Y_j^{\frac{b-1}{b(1-\sigma)}} \theta_j \left( \frac{Y}{1 + \pi} \right)^{\frac{1}{b(1-\sigma)}} \quad (23)$$

## 7.D: Regression Results

In what follows we present all the tables with different specifications.

Table 7.1: Aggregate Intra-Firm Trade

Dependent variables	Log Intra-Firm Trade to country $j$ in year $t$		
	(1)	(2)	(3)
GDP <sub><math>jt</math></sub>	0.985*** (0.051)	0.944*** (0.055)	0.980*** (0.054)
Dist <sub><math>ij</math></sub>	-1.067*** (0.216)	-0.828*** (0.245)	-0.692*** (0.239)
RTA		1.127** (0.537)	1.067* (0.545)
GATT/WTO member			2.548*** (0.536)
Constant	4.108** (1.638)	2.386 (1.833)	-1.604 (1.913)
Year fixed effects	Yes	Yes	Yes
Observations	319	319	319
R-squared	0.430	0.444	0.514

*Notes:* The regressions are OLS estimations of equation (16) for the period 1999-2004. The dependent variable is the logarithm of U.S. intra-firm trade to country  $j$  in year  $t$ . Fixed effects by year and a constant are included. GDP <sub>$jt$</sub>  is the natural log of the GDP of country  $j$  from the CEPII data. Heteroskedasticity-robust standard errors are reported in parentheses. \*\*\*, \*\*, and \* indicate significance at the 1, 5 and 10 percent levels respectively.

Table 7.2: Aggregate Arm's Length Trade

Dependent variables	Log of Arm's Length Trade to country $j$ in year $t$		
	(1)	(2)	(3)
GDP <sub><math>jt</math></sub>	0.685*** (0.032)	0.618*** (0.027)	0.621*** (0.027)
Dist <sub><math>jt</math></sub>	-0.671*** (0.129)	-0.406*** (0.101)	-0.405*** (0.102)
RTA		1.453*** (0.187)	1.468*** (0.187)
GATT/WTO member			-0.349*** (0.125)
Constant	20.009*** (0.879)	18.351*** (0.743)	18.636*** (0.763)
Year fixed effects	Yes	Yes	Yes
Observations	329	329	329
R-squared	0.568	0.627	0.630

*Notes:* The regressions are OLS estimations of equation (15) for the period 1999-2004. The dependent variable is the logarithm of U.S. arm's length trade to country  $j$  in year  $t$ . The dependent variable excludes intra-firm trade. Fixed effects by year, and a constant are included. GDP <sub>$jt$</sub>  is the natural log of the GDP of country  $j$  from the CEPII data. Heteroskedasticity-robust standard errors are reported in parentheses. \*\*\*, \*\*, and \* indicate significance at the 1, 5 and 10 percent levels respectively.

Table 7.3: Intra-Firm Trade (NAICS 3)

Dependent variables	Log Intra-Firm Trade to country $j$ in year $t$			
	(1)	(2)	(3)	(4)
GDP <sub><math>jt</math></sub>	1.071*** (0.031)	0.998*** (0.030)	0.998*** (0.030)	0.998*** (0.030)
Dist <sub><math>jt</math></sub>	-1.225*** (0.109)	-0.927*** (0.103)	-0.931*** (0.103)	-1.726*** (0.107)
RTA		1.644*** (0.229)	1.575*** (0.230)	1.575*** (0.229)
GATT/WTO member			1.035*** (0.158)	1.035*** (0.157)
dist_chem				1.398*** (0.181)
dist_machn				1.093*** (0.176)
dist_comput				1.646*** (0.262)
dist_transp				0.635** (0.288)
Constant	-0.476 (0.781)	-2.360*** (0.742)	-3.273*** (0.762)	3.817*** (0.898)
Year fixed effects	Yes	Yes	Yes	Yes
Sector fixed effects	Yes	Yes	Yes	Yes
Observations	2,118	2,118	2,118	2,118
R-squared	0.453	0.472	0.482	0.498

*Notes:* The regressions are OLS estimations of equation (16) for the period 1999-2004. The dependent variable is the logarithm of U.S. intra-firm trade to country  $j$  in year  $t$ . Fixed effects by year, manufacturing sector NAICS 3 digits and a constant are included. Manufacturing sectors available are: 311, 325, 333, 334, 335, 336. GDP <sub>$jt$</sub>  is the natural log of the GDP of country  $j$  from the CEPII data. Distance is interacted with NAICS 3 digits. Heteroskedasticity-robust standard errors are reported in parentheses. \*\*\*, \*\*, and \* indicate significance at the 1, 5 and 10 percent levels respectively.

Table 7.4: Arm's Length Trade (NAICS3)

Dependent variables	Log Arm's Length Trade to country $j$ in year $t$			
	(1)	(2)	(3)	(4)
GDP <sub><math>jt</math></sub>	0.721*** (0.016)	0.650*** (0.014)	0.653*** (0.014)	0.653*** (0.013)
Dist <sub><math>ij</math></sub>	-0.624*** (0.058)	-0.341*** (0.047)	-0.339*** (0.048)	-0.720*** (0.068)
RTA		1.552*** (0.089)	1.572*** (0.089)	1.572*** (0.089)
GATT/WTO member			-0.458*** (0.079)	-0.458*** (0.075)
dist_chem				0.320*** (0.092)
dist_machn				0.506*** (0.092)
dist_comput				0.747*** (0.126)
dist_transp				0.710*** (0.118)
Constant	15.821*** (0.418)	14.050*** (0.369)	14.423*** (0.381)	17.814*** (0.578)
Year fixed effects	Yes	Yes	Yes	Yes
Sector fixed effects	Yes	Yes	Yes	Yes
Observations	1,974	1,974	1,974	1,974
R-squared	0.609	0.653	0.657	0.666

*Notes:* The regressions are OLS estimations of equation (15) for the period 1999-2004. The dependent variable is the logarithm of U.S. arm's length trade to country  $j$  in year  $t$ . The dependent variable excludes intra-firm trade. Fixed effects by year, sector NAICS 3 digits and a constant are included. Manufacturing sectors considered are: 311, 325, 333, 334, 335, 336. GDP <sub>$jt$</sub>  is the natural log of the GDP of country  $j$  from the CEPII data. Distance is interacted with NAICS 3 digits. Heteroskedasticity-robust standard errors are reported in parentheses. \*\*\*, \*\*, and \* indicate significance at the 1, 5 and 10 percent levels respectively.

Table 7.5: Intra-Firm Trade: Heckman two step procedure

Dependent variables	Log Intra-Firm Trade to country $j$ in year $t$			
	(1)	(2)	(3)	(4)
GDP <sub><math>jt</math></sub>	1.234*** (0.141)	1.336*** (0.143)	1.381*** (0.144)	1.330*** (0.135)
Dist <sub><math>ij</math></sub>	-1.273*** (0.110)	-0.689*** (0.130)	-0.625*** (0.134)	-1.620*** (0.233)
mills ratio	1.794*** (0.491)	1.994*** (0.523)	1.861*** (0.530)	1.261*** (0.512)
RTA		2.127*** (0.287)	2.131*** (0.283)	2.020*** (0.266)
GATT/WTO member			1.674*** (0.426)	1.584*** (0.408)
dist_chem				1.387*** (0.339)
dist_machn				1.433*** (0.407)
dist_comput				2.196*** (0.404)
dist_transp				0.094 (0.412)
Constant	-2.038 (2.144)	-9.167*** (2.577)	-11.947*** (2.958)	-2.185*** (2.247)
Year fixed effects	Yes	Yes	Yes	Yes
Sector fixed effects	Yes	Yes	Yes	Yes
Observations	2,118	2,118	2,118	2,118

*Notes:* The regressions are estimations of equation (16) for the period 1999-2004 using Heckman selection model with rule of law the excluded variable. In the first step, the dependent variable is the probability of intra-firm trade to country  $j$  in year  $t$ . In the second step, the dependent variable is the logarithm of U.S. intra-firm trade to country  $j$  in year  $t$ . Fixed effects by year, sector NAICS 3 digits and a constant are included. Manufacturing sectors available are: 311, 325, 333, 334, 335, 336. GDP <sub>$jt$</sub>  is the natural log of the GDP of country  $j$  from the CEPII data. Distance is interacted with NAICS 3 digits. Standard errors are reported in parentheses. \*\*\*, \*\*, and \* indicate significance at the 1, 5 and 10 percent levels respectively.

## Notes

<sup>1</sup>In the literature, intra-firm trade refers to trade between U.S. companies and their foreign subsidiaries as well as trade between U.S. subsidiaries of foreign companies and their foreign affiliates. In this paper, the word intra-firm trade is sometimes used interchangeably with related-party trade. Notice that, for exports, the term related-party trade is far less stringent than intra-firm: firms are considered related if either party owns, directly or indirectly, 10 percent or more of the other party.

<sup>2</sup>Data are disaggregated at NAICS 3 digits. Further details are provided in section 7.5.1.

<sup>3</sup>Data on inward and outward direct investment, including data on direct investment positions and transactions and on the financial and operating characteristics of the multinational companies involved are available at <http://www.bea.gov/international/index.htm>.

<sup>4</sup>This also confirms the use of a model of firms heterogeneity, where the number of firms depends on country size.

<sup>5</sup>Bombarda (2007) proposes a model of intra-firm trade as well as distant dependent fixed cost. However, a model with only intra-firm trade is sufficient for the purpose of our study. In fact, the present model is



isomorphic to a model with distant dependent fixed cost.

<sup>6</sup>In our model when a firm chooses to serve foreign markets via FDI it means local production of the intermediate good,  $y_2$ , only.

<sup>7</sup>In this paper the trade costs,  $\tau$ , will be then proxied with geographical distance.

<sup>8</sup>When  $\eta = 0$  the model delivers the HMY framework.

<sup>9</sup>The export cutoff also includes the situation in which the local market is supplied by domestic firm sales.

<sup>10</sup>Note that this model of supply collapses to domestic production when  $i = j$ , since  $\tau_{ii} = 1$ .

<sup>11</sup>See Redding and Venables (2004) and Kleiner and Toubal (2005).

<sup>12</sup>Since we are not conditioning,  $G(a/a_{ij})$  the number of firms will be the number of entrants and not the number of active firms. Moreover, we consider  $a_{ij}$  to be the unit labor requirement for exporting. Note that when  $i=j$ ,  $\tau_{ii} = 1$  and so  $a_{ij} = a_{ii}$ , which corresponds to the cutoff of domestic firms.

<sup>13</sup>Note that when  $i = j$ ,  $\tau_{ij} = 1$  and so  $\pi_{M,kl}(a_M) = \pi_{kl}(a_M)$ . When  $i = j$  we are considering the domestic firms.

<sup>14</sup>We interpret  $a^{1-\sigma}$  as a measure of productivity.

$$^{15}\lambda_2^{b(\sigma-1)} = (\sigma/(\sigma-1))^{\sigma-1} \times (k-\sigma+1)/k \times \lambda_1^{b-1}.$$

$$^{16}\lambda_4 = \lambda_1/\lambda_2^{\sigma-1}.$$

<sup>17</sup>Low  $\eta$  makes FDI and Export act as substitutes. For certain parameter restrictions, the productivity threshold in (10) is decreasing in distance when  $\eta$  is low. For high  $\eta$  the productivity threshold in (10) is increasing with distance. Therefore, FDI and export become complements for sufficiently high  $\eta$ : both strategies require a higher productivity level when distance increases.

$$^{18}\lambda_3 = \lambda_2^{\sigma-1}(\sigma/(\sigma-1))^{1-\sigma}, \lambda_5 = ((1-\lambda_4^{-b}\sigma)/\sigma) / (1-(1-\lambda_4^{-b}\sigma)/\sigma).$$

<sup>19</sup>Note that if both the intermediates are produced at home,  $\eta = 1$ , the FDI will be too costly, and every firm will end up being an exporter, since it is more profitable. The gravity in this case will be like in Chaney (2008):  $X_{ij}^X = \beta \frac{Y_i Y_j}{Y} \theta_j^{b(\sigma-1)} f_{ij}^{1-b} (w_i \tau_{ij})^{-k}$ . When all the intermediates are produced in the foreign location,  $\eta = 0$ , we are back in the HMY framework. Hence the gravity equation for export in HMY setup is:  $X_{ij}^X = \beta \frac{Y_i Y_j}{Y} \theta_j^{b(\sigma-1)} (w_i \tau_{ij})^{1-\sigma} \times \left[ \left( \frac{f_{ij}}{(w_i \tau_{ij})^{1-\sigma}} \right)^{1-b} - \left( \frac{f_{M,j} - f_{ij}}{w_j^{1-\sigma} - (w_i \tau_{ij})^{1-\sigma}} \right)^{1-b} \right]$ .

<sup>20</sup>Note that if both the intermediates are produced at home,  $\eta = 1$ , the FDI will be too costly, because it will incur in trade costs plus greater fixed cost,  $f_M > f_{ij}$ . In this case, there will be no firm supplying via FDI because the cost will be prohibitive, i.e.  $\bar{a}_{M,ij} \rightarrow 0$ , or  $\bar{a}_{M,ij}^{1-\sigma} \rightarrow \infty$ .

Hence the gravity for FDI,  $X_{ij}^M$ , will be 0. When all the intermediates are produced in the foreign location,  $\eta = 0$ , we are back in the HMY framework. Hence the gravity equation for FDI in HMY set up is:  $X_{ij}^M = \beta \frac{Y_i Y_j}{Y} \theta_j^{b(\sigma-1)} w_j^{1-\sigma} \times \left( \frac{f_{M,j} - f_{ij}}{w_j^{1-\sigma} - (w_i \tau_{ij})^{1-\sigma}} \right)^{1-b}$ . In this set up there is no role for complementarity between trade and FDI.

<sup>21</sup>Higher level of  $\eta$  make total trade and intra-firm trade look similar. In this circumstances, the existence of wage differential will be the key element.

<sup>22</sup>Since intra-firm trade also incurs in trade costs, this incentive will be greater the lower is the amount of intra-firm trade.

<sup>23</sup>See equation (16).

<sup>24</sup>The way in which the model is built is such that intra-firm trade is always a fraction of affiliate sales.

<sup>25</sup>A Majority-Owned Foreign Affiliate is a foreign affiliate in which the combined direct and indirect ownership interest of all U.S. parents exceeds 50 percent. Majority-owned foreign affiliates are the predominant type of investment, UNCTAD (2009) report.

<sup>26</sup>Information are available for 60 countries, 6 years and 6 NAICS 3 digits manufacturing sectors: Food, Chemical, Machinery, Computer and Electronic Product, Electrical Equipment and Transportation Equipment.

<sup>27</sup>See Appendix A.1 for NAICS 3 digits description.

<sup>28</sup>The distances between the biggest cities of two countries is weighted by the share of the city in the overall countrys population.

<sup>29</sup>Additional information in <http://www.cepii.fr/anglaisgraph/bdd/gravity.htm>.

<sup>30</sup>Rule of law captures perceptions of the extent to which agents have confidence in and abide by the rules of society, and in particular the quality of contract enforcement.

<sup>31</sup>If we are interested in the domestic profits from serving market  $i$  we should compute:  $\Pi_{ii} = w_i L_i \int_0^{\bar{a}_{ii}} \frac{1}{\sigma} x_{ii} dG(a) - \int_0^{\bar{a}_{ii}} f_{ii} dG(a)$ . We should proceed in the same way for computing the number of firms entering a particular market  $i$ :  $n_{ii} = w_i L_i \int_0^{\bar{a}_{ii}} dG(a)$ . This expression delivers the overall number of firms existing in  $i$ .