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Abstract

In this paper we provide a quantitative analytical framework for analyzing trade and multinational production (MP), consistent with a set of stylized facts for trade and MP, among them that both exports and MP adhere to a gravity model. We propose a heterogeneous firm trade model where firms choose endogenously whether to serve foreign markets through MP or exports, where headquarters and affiliates are vertically integrated, and where firms face stochastic entry and demand shocks in each market. Using a unique firm-level data set on production, trade and MP, we establish key regularities about the entry and sales patterns of multinationals that support the model building blocks. We develop a new maximum likelihood estimator that connects the theory directly to the data and that allows us to identify key parameters of the model, explore its plausibility and implications. Our main result is that intra-firm trade plays a crucial role in shaping the geography of MP. This conclusion is robust to any geographical distribution of fixed costs.

JEL Classification: F10
Keywords: Export, FDI, Multinational Production, Gravity, Intra-firm Trade

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1 Introduction

The growth in multinational production (henceforth, MP) is a central element of the economic globalization during the last three decades.[1] World inward foreign direct investment (henceforth, FDI) flows grew annually by 17 percent from 1990 to 2006. During the same period, world exports increased by only 8 percent. By 2006, the value added from multinational production amounted to 10 percent of world GDP.[2] This remarkable growth has led researchers to analyze the interaction between multinational activity and trade as well as to understand which forces determine the aggregate flows of MP.

Our work is motivated by a series of stylized facts about MP and exports. *First*, both MP and exports adhere to a gravity model. That is, distance dampens both exports and MP, after adjusting for source and destination market size (see, for example, Barba Navaretti and Venables (2004) and Section 2).[3] *Second*, the great majority of U.S. affiliate sales are intended for the destination market, suggesting that market access is an important motive for conducting MP (Chor, Foley, and Manova (2008) and Section 2).[4] *Third*, many of the firm-level exporter stylized facts uncovered by Eaton, Kortum, and Kramarz (2010), also apply for MP. For example, average sales in the home market rise with conducting MP to less popular destinations (Section 2), suggesting that heterogeneity in firm efficiency can explain variation in MP entry and sales. *Fourth*, almost half of U.S. imports are intra-firm (Bernard et al. (2010)).[5]

In this paper we provide a parsimonious quantitative analytical framework for both exports and MP, consistent with the stylized facts above. We build on the horizontal model of MP by Helpman, Melitz, and Yeaple (2004), but allow for vertical integration between headquarters and affiliates.[6] Specifically, affiliates are allowed to source firm-specific inputs from their headquarters. This will introduce a gravitational

[1] A multinational firm is 'an enterprise that controls and manages production establishments (plants) located in at least two countries. It is simply one subspecies of multiplant firm' (Caves (1996). Multinational production is here defined as output from subsidiaries located in a foreign country.

[2] Nominal figures, World Investment Report 2007, UNCTAD, Table I.4.

[3] The distance effect operates both at the extensive margin (number of exporters and MP parents) and at the intensive margin (within-firm exports across destinations and sales of affiliates located in different markets but belonging to the same parent firm).

[4] See also Markusen and Maskus (1999) and Markusen and Maskus (2002), Blonigen, Davies, and Head (2003), and Brainard (1997). Contrary to this trend in the literature, Alfaro and Charlton (2007), using four-digit level data, find that the share of vertical FDI (subsidiaries that provide inputs to their parent firms) is larger than commonly found using two-digit level data, even within developed countries.

[5] Moreover, Hanson, Mataloni, and Slaughter (2003) find that for the average U.S. affiliate in their sample, 11 percent of its total costs are accounted for by imports of intermediate inputs from the U.S. parent. Evidence on the importance of intra-firm trade exists for countries other than the U.S. as well. For example, see Corcos et al. (2009) for France and Ito and Matsuura (2009) for Japan. See also Bernard, Jensen, and Schott (2005).

[6] Horizontal MP refers to investment in foreign plants that are made to serve consumers in the destination market. Firms will then choose MP in markets where the gains from avoiding trade costs outweigh the costs of maintaining capacity in multiple markets.

force for MP.[7] We think of intra-firm trade not just in terms of physical inputs, but also in terms of headquarter services (Helpman (1984)), monitoring costs (Head and Ries (2008)) or communication costs.[8] Without doubt our model misses some other relevant features of MP, such as more complex sourcing strategies and export-platform MP. Nevertheless, we are confident that our simple extension of the existing theory captures key aspects of export and MP.

We move on to structurally estimating the model on a unique firm-level data set of Norwegian exports and affiliate sales, by destination. We use the stochastic structure of the model to derive firm-level gravity equations for export and MP and then estimate the model using maximum likelihood (henceforth, ML). We pay extra attention to biases arising due to unobserved selection.[9] We identify key features of the model, such as the magnitude of intra-firm trade, which is unobserved in the data. Identification is based on a difference-in-differences approach: we calculate the within-firm elasticities of exports and MP with respect to distance. The difference between the two elasticities informs us about the magnitude of intra-firm trade. We also identify the relative magnitude of variable and fixed trade barriers for both exports and MP. Fixed costs are identified by using the assumption that, at the firm-level, entry is affected by both fixed and variable trade costs, while (firm-level) sales are affected by variable costs exclusively. Intuitively, entry costs are obtained by subtracting the latter from the former. The use of within-firm variation for identification makes it clear that a firm-level approach to both theory and empirics is essential in our paper.

We make three main contributions to the literature. First, we uncover new firm-level facts about MP. Second, we propose a parsimonious model of exports and MP that extends, in a simple but nontrivial way, existing models of MP. Third, we develop a new ML estimator that connects the theory directly to the data and allows us to identify key parameters of the model. We use the estimates in order to explore and discuss the model's plausibility and implications.

Several strong conclusions emerge from the analysis. First, intra-firm trade plays a crucial role in shaping the geography of MP. Specifically, the point estimate of the affiliate's cost share related to purchases from the headquarters is roughly 9/10. This leads us to reject the standard horizontal model without vertical linkages. This conclusion is robust to any geographical distribution of fixed costs of export and MP. The relatively high cost share suggests that our model might also capture other

[7]A standard horizontal model of MP without intra-firm trade, such as Helpman, Melitz, and Yeaple (2004), will generate the opposite of gravity for MP, i.e. MP increases in trade barriers. An extended model that allows for destination-specific entry fixed costs would not be enough: it could be consistent with MP entry decreasing with trade barriers (a stylized fact shown in Section 2.2) but would not be consistent with the fact, shown in Section 2.3, that sales of affiliates *belonging to the same firm* are decreasing in distance.

[8]Keller and Yeaple (2009) explain the strong force of gravity for MP in knowledge-intensive sectors by focusing on the interaction between the difficulties of communicating technological knowledge from one person to another and the costs of moving goods internationally.

[9]For example, MP entrants may have unobserved characteristics that influence both entry and sales. Our ML estimator deals with this potential bias by incorporating the standard Heckman (1979) selection framework.

mechanisms that are dampening firm MP as trade costs increase. In that sense, the estimated cost share can be interpreted as an upper bound on the true cost share. Finally, our counterfactuals indicate that impeding MP has strong effects on trade flows but the decline in welfare is not particularly large: shutting down MP completely leads to welfare losses that, across countries, are not higher than 3.6 percent. Moreover, we find that the multinationals affected by these barriers cut their home employment by as much as 50 percent. Hence, reducing barriers to MP may have positive effects on the domestic labor market because outward MP entails a substantial amount of economic activity at home.

Besides Helpman, Melitz, and Yeaple (2004) and Eaton, Kortum, and Kramarz (2010), our paper is also related to the analysis of Kleinert and Toubal (2006b) and Ramondo and Rodríguez-Clare (2008). Kleinert and Toubal (2006b) compare a model with symmetric firms and parent-affiliate trade and a model with heterogeneous firms where the fixed cost of MP is increasing in distance.[10] They derive partial equilibrium reduced-form gravity equations for total affiliate sales, number of affiliates and average affiliate sales, and estimate them using aggregate data. Compared to their paper, we focus on a general equilibrium model with heterogeneous firms and parent-affiliate trade and we do not assume any particular structure on fixed costs. Ramondo and Rodríguez-Clare (2008) extend the Eaton and Kortum (2002) model of trade by introducing MP and diffusion of ideas and by allowing export-platform MP. In their model bilateral trade and MP flows can be correlated either because of a positive correlation between trade and MP costs or because of parent-affiliate trade. They calibrate their model using data on bilateral trade, MP and intra-firm trade flows and find that the gains from trade are significantly higher than the ones calculated in trade-only models, while the gains from MP are lower than those calculated in MP-only models.

Another important contribution is Feinberg and Keane (2006), who build a dynamic structural model of U.S multinational corporations and Canadian affiliates to study the growth of multinational-based trade. They assume that parents and affiliates produce different goods, each of which can be used as intermediate into the production process of the other. They model only the marginal (intensive margin) production and trade decisions of the multinational, while we also model and estimate entry into exports and MP. They suggest that the growth in intra-firm trade might be due to technical change and, in particular, to improvements in logistics management.

Finally, our work is related to a set of papers that investigate whether outwards FDI (or MP) and a firm's home activity are substitutes or complements. Most of these studies find that FDI and home activity are complements, which is consistent with our finding that higher FDI barriers reduce home employment. Blonigen (2001) examines product-level data and finds substantial evidence for both a substitution and a complementarity effects between affiliate production and exports with Japanese automobile parts for the US market. Clausing (2000) finds that multinational activity

[10] In the appendix of their paper they also consider a model with heterogeneous firms and parent-affiliate trade.

and trade are complementary activities, particularly multinational activity and intra-firm trade. The results in Svensson (1996) suggest that increased foreign production both replaces exports of finished goods and attracts intermediate goods from the parent. Head and Ries (2001) confirm the earlier result of complementarity between FDI and exports. However, for firms that are not vertically integrated, they find evidence for substitution. In a recent paper by Desai, Foley, and Hines (2009), the authors conclude that expansions abroad increase a firm's domestic activity.

The rest of the paper is organized as follows: in Section 2 we introduce some firm-level facts about exports and MP. In Section 3 we lay out our model, and in Section 4 we describe the estimation strategy. Section 5 and 6 present estimates and counterfactuals. Section 7 concludes.

2 Data and Firm-Level Facts

In this section, we introduce the firm-level data set used in this study and establish key regularities about the entry and sales patterns of multinationals across markets. Whenever possible, we also provide additional evidence from other data sets, usually at a more aggregate level, available for different countries. First, we show the relationship between total exports and total affiliate sales versus distance (controlling for market size) and decompose it into an extensive and intensive margin. Second, we review and extend the evidence on the importance of intra-firm trade. We argue that intra-firm trade, affecting both the extensive and intensive margins of MP, is likely to be an important determinant of aggregate trade/MP patterns. Third, we exploit the MP information in the firm-level data to replicate some facts that Eaton, Kortum, and Kramarz (2010) have shown for exports. These facts emphasize the importance of fixed cost of entry and of heterogeneity of firms' productivity, as well as firm- and destination-specific entry and sales shocks. Overall, this section provides support for the building blocks of the model proposed in Section 3 and the estimation strategy laid out in Section 4.

2.1 Data

Firm-level data for the Norwegian manufacturing sector are drawn from *Statistics Norway's Capital Database*, a panel of all joint-stock companies in the period 1993-2004. We choose to work on the 2004 cross-section, the most recent available to us, which includes approximately $8,000$ firms. The database provides detailed information on inputs and output and covers about 90 percent of Norwegian manufacturing revenue.[11] Firm-level trade data, by destination country, come from customs declarations. The data do not distinguish between intra-firm and arms-length trade transactions. About 40 per cent of the total number of firms are exporters and, among

[11] Only mainland Norway manufacturing, i.e. non-oil firms, is included in the database. Mainland manufacturing accounted for 14 percent of total mainland GDP in 2004. Statistics Norway's Capital Database is described in detail in Raknerud, Rønningen, and Skjerpen (2004).

exporting firms, the average number of destinations served is 6.9. Total manufacturing exports amount to approximately 140 billion NOK, or 29 percent of Norwegian manufacturing revenue in 2004. Information on firms' foreign operations is gathered from the *Directorate of Taxes' Foreign Company Report* and comprises all outward FDI stocks and associated affiliate sales by destination in the manufacturing sector.[12][13] Total affiliate sales amounted to over 60 billion NOK, or 13 percent of domestic manufacturing revenue in 2004, but only about 1.3 percent of the population of firms conducted MP.[14] Among firms conducting MP, the average number of MP destinations was 4.4.[15] MP and trade data have been merged with the capital database using a unique firm identifier. Even though over 200 export destinations and 59 MP destinations are present in the data set, in this paper we choose to work only with OECD countries: first, a theory of horizontal MP is more relevant in the OECD area; second, maximum likelihood estimation is relatively CPU intensive, and this restriction saves us a significant amount of processing time.[16] OECD export sales constitute 96.8 percent of total Norwegian exports, whereas OECD affiliate sales constitute 80.7 percent of total affiliate sales.

2.2 The Extensive Margin of Affiliate Sales

As is well known, the gravity model performs well in explaining bilateral trade flows. The top left panel of Figure 1 shows a negative linear in logs relationship between total export sales and distance, adjusted for destination country absorption. The top right panel shows that a similar relationship holds for total affiliate sales as well: they are negatively related with distance, adjusting for destination country size. The bottom panels show that these patterns are, in part, driven by the extensive margin (the number of exporters and firms conducting MP): both the number of exporters and the number of firms conducting MP are clearly decreasing in distance, after adjusting for destination absorption.[17]

[12] Affiliate sales are defined as total revenue of the affiliate adjusted by the parent's ownership share. A 20 percent ownership threshold is used to distinguish direct investment from portfolio investment. Direct investment comprises investors' share of equity in foreign companies and investors' debt to and claims on foreign companies.

[13] Foreign owned firms conducting outwards FDI from Norway are also present in the data, but their numbers are fairly small. About 10.6 percent of the affiliate-destination pairs in 2004 had a foreign-owned parent that was located in Norway. Foreign-owned parents employed 11.0 percent of the total outwards FDI workforce.

[14] Kleinert and Toubal (2006a) report that 0.21 percent of all German firms are multinationals and they account for 27 percent of total sales in Germany.

[15] Some firms only export to a particular destination, others only conduct FDI and others do both. Out of $22,236$ firm-destination pairs in our sample, 98.6 percent are export-only, 0.3 percent are FDI-only and 1.1 percent are export-FDI.

[16] Luxembourg is excluded since no Norwegian firm conducts FDI there.

[17] Figure 1 is not intended to provide an assessment of the validity of the gravity model, but makes it clear why we introduce intra-firm trade in the Helpman, Melitz, and Yeaple (2004) framework. As Anderson and van Wincoop (2003) showed, gravity theory tells us that after controlling for size, trade between two regions is decreasing in their bilateral trade barrier *relative* to the average barrier of the two regions to trade with all their partners. The model we develop in the next section and our

This pattern for the overall and the extensive margin of exports and MP is common to other source countries as well. We provide evidence from U.S. data in Table 1. For example (columns 2 and 3), U.S. data from the Bureau of Economic Analysis (BEA) and the U.S. Census reveal that, within industries and accounting for country size, (i) both total exports and total affiliate sales decrease with distance, and (ii) the elasticity of total exports to distance is higher than the elasticity of total affiliate sales to distance.[18] These results are again, in part, driven by the extensive margin since both the number of U.S. exporters and the number of U.S. MP parents are decreasing with distance (columns 4 and 5).[19] As we alluded to in the introduction, the strong dampening effect of distance on MP (both overall and on the extensive margin) presents a puzzle in horizontal models of MP (henceforth "HMP models"). These models imply a positive relationship between total affiliate sales and distance and between the number of MP parents and distance. The intuition is that, *ceteris paribus*, higher variable trade costs (as proxied by distance) increase the profitability of MP relative to exporting since the former allows firms to save on variable trade costs. A way to reconcile the patterns observed in Figure 1 with HMP models is to conjecture that fixed costs of MP are increasing in distance. In the next section we provide some initial empirical evidence that such a modified theory of MP is not sufficient.

2.3 Intra-firm Trade and the Intensive Margin of MP

Existing evidence. There is mounting empirical evidence on the importance of intra-firm trade. Bernard et al. (2010) find that in 2000 '...over 46 percent of U.S. imports are intra-firm' and '...for the average country, 23.8 percent of exports to the U.S. are intra-firm'. Moreover, they find that '74 percent of the imports from Japan were conducted by multinationals trading with related foreign divisions'. Using the same data source, but considering manufacturing in 2004 only (consistent with our econometric analysis below), we find that 33% and 53% of U.S. exports and imports, respectively, are intrafirm. Exploiting time variation, Desai, Foley, and Hines (2009) find that 10% higher growth of foreign sales is associated with 6.5% greater exports from U.S. parent companies to their foreign affiliates.[20]

Firm-level data. Our database does not provide direct information about intra-

estimation strategy take this into account.

[18]As a robustness check, in order to better account for heteroskedasticity in a log-log specification, we used the Poisson estimator proposed by Silva and Tenreyro (2006) as well. Results (available upon request) do not change in qualitative terms.

[19]Yeaple (2009), using firm-level BEA data also finds a negative correlation between total affiliate sales and distance and between the number of U.S. parents and distance.

[20]Evidence on intra-firm trade exists for countries other than the U.S. and Norway as well. For example, Corcos et al. (2009) cites evidence for French firms that '...around 36% of the total value of manufacturing imports is intrafirm'. Ito and Matsuura (2009) find that the intra-firm trade ratio (imports from headquarter to total affiliate purchases) of Japanese foreign affiliate ranges from 22% (affiliates based in Oceania) to 41% (affiliates based in China) in 2001. Across industries, it ranges from 27% (Chemical) to 48% (Precision). See also Bernard, Jensen, and Schott (2005).

firm trade, but it shows clear circumstantial evidence. First, the great majority of firm-destinations (80 percent) with positive MP also shows positive exports (to the same destination).[21] Among the firm-destination pairs with positive exports and MP, the median ratio of exports to affiliate sales is 0.23.[22] Hence, most headquarters are selling substantially less through exports than through affiliate sales (to the same destination).

Second, affiliates that belong to the same firm but are located in different countries sell less, on average, the further away (from Norway) they are located. In Table 1, column 7 we regress firm-level affiliate sales by destination (in logs) vs. distance (in logs), GDP (in logs) and firm fixed effects. The estimated distance coefficient is -0.25. Moreover, when performing a similar regression but with firm-level exports by destination (in logs) as dependent variable (in column 6) we find that the estimated distance coefficient is -0.58. A formal test rejects the hypothesis that the coefficients are identical. These results show that (i) both average (across firms) export sales and average affiliate sales fall with distance in part because within-firm sales fall and not just because of firm selection, and (ii) within-parent affiliates' sales are less elastic to distance than export sales, consistent with the hypothesis that variable trade costs affect more the latter. Overall, these results qualify the patterns shown above in Figure 1 implying that the differential impact of variable trade costs on export and MP is likely to play a crucial role. In Section 4.2, we exploit the differential impact of variable trade costs on export and MP in order to identify the degree of intra-firm trade implicit in the data.

2.4 Alternative hypotheses

Before proceeding, we explore other possible determinants of the data patterns we showed above. First, a horizontal model of MP with fixed costs increasing in distance would not be consistent with the fact, shown above, that sales of affiliates belonging to the same firm are decreasing in distance.[23] Second, as we do not know whether affiliate output is sold locally or not, from the outset we cannot reject the hypothesis that Norwegian MP is mostly intended for the home market (pure vertical MP) or intended for 3rd markets (export-platform MP). However, evidence both from our data and from other sources indicates that pure vertical MP or export-platform MP, though certainly relevant, are not likely to play a dominant role in our analysis.

Existing evidence. Chor, Foley, and Manova (2008), using BEA data for 1994, find

[21] Moreover, preliminary data show that no fewer than 20 percent of Norwegian multinationals have intra-firm sales from parent to foreign affiliates. Since these data are incomplete, we exclude them when estimating our model. Note that, as mentioned above, intra-firm trade in goods is only part of our definition of intra-firm trade.

[22] It is tempting to use exports/affiliate output as an upper bound of the share of intra-firm trade in affiliate output. However, we believe there are large measurement errors associated with intra-firm trade, due to (i) uncertainty related to transfer pricing and (ii) the fact that service exports are omitted in our export data.

[23] Nonetheless, in our econometric strategy below, we allow export and MP fixed costs to be firm- and destination-specific.

that over 70 percent of U.S. affiliate sales are intended for the destination market, 20 percent are intended for third countries, while less than 10 percent are shipped back to the U.S. Using a similar data set, we update these figures to 2004 and find that the great majority (62 percent) of total affiliate sales are indeed destined to the local market.[24][25]

Firm-level data. We also explore our firm-level data set. Several descriptive statistics suggest that pure vertical MP and export-platform MP are not widespread. First we look at Norwegian parents imports from destinations where they also conduct MP. Among firm-destination pairs with positive imports and MP, the median import/MP ratio is just 0.06. 70 percent of these firm-destination pairs have an import/MP ratio less than 0.3. This suggests that foreign plants are not primarily supplying inputs to the headquarters. Also, most MP occurs in countries similar to Norway in terms of wages and relative factor endowments. Finally, in the next subsection, we show that the number of entrants are increasing in the size of the destination market, suggesting that the size of the destination market itself, and not third countries, determines entry.

All in all, this evidence suggests the use of a model where multinational firms are allowed to provide inputs to their foreign affiliates and where market access is a main motive behind MP.

2.5 Regularities for MP at the Firm Level

Before laying out our model, we show that firm-level facts for MP are quite similar to those that Eaton, Kortum, and Kramarz (2010) found for exports, and that these facts are consistent with what heterogeneous firms models of trade would predict.[26]

Number of MP firms and size of the market. First, the number of Norwegian multinational enterprises (MNEs) selling to a market, relative to the Norwegian market share, increases with market size, indicating that fixed costs are important in MP. This is shown in Figure 2. The x-axis represents the size of the destination market, while the y-axis measures the number of Norwegian affiliates selling there, divided by Norwegian market share (in log scale). Norwegian market share is measured as total exports to destination n relative to country n absorption. We divide by market

[24]Specifically, we use BEA data but, unlike Chor, Foley, and Manova (2008), we have access only to data for majority-owned affiliates (instead of all affiliates) and for sales of goods (instead of total sales). The latter restriction is likely to downward bias the share of affiliate sales that is destined to the host market.

[25]More in general, it is important to remember that part of the production by affiliates is non-tradable and is therefore destined to the local market. Ramondo and Rodríguez-Clare (2008) find that 'A significant part of MP flows is in non-tradable goods. Around 50% of the value of production by U.S. affiliates of foreign multinationals is in sectors other than manufacturing, agriculture and mining (own calculations from Bureau of Economic Analysis). Additionally, according to the UNCTAD (2007), in 2007, Foreign Direct Investment stocks in the service sector represented more than 60% of the total stock in developed countries'.

[26]Firm-level facts for Norwegian exporters (which we do not report in this paper but are available upon request) are also consistent with those for French exporters shown in Eaton, Kortum, and Kramarz (2010).

share to subtract other factors determining the number of entrants, such as proximity to the market. For example, Norway's market share in Sweden is the highest among Norway's trading partners. Dividing by market share will adjust Swedish entry downwards in the graph.[27]

Market popularity and firm size. Second, average sales in Norway rise with selling to less popular destinations, although the relationship is a cloudy one. Figure 3 depicts average sales in Norway (in logs) on the y-axis of those firms selling to the nth most popular market, where n is reported on the x-axis. Market popularity is measured as the rank in terms of the number of Norwegian-based firms conducting MP to the destination. All in all, the relationship suggests that selling to less popular markets requires higher firm efficiency, which translates into higher domestic sales.[28]

Destinations hierarchy. Third, the data show that MP (and export) destinations follow in part a hierarchical structure, meaning that many firms engaging in MP to the $k+1$st most popular destination do so for the kth most popular as well.[29] As in Eaton, Kortum, and Kramarz (2010), we need a model that recognizes both a tendency for firms to export and engage in MP according to a hierarchy while allowing them significant latitude to depart from it. Figure 4 plots the number of firms engaging in MP in the kth most popular destination on the horizontal axis against the number of firms engaging in MP in k or more countries. If the choice of where to direct MP followed a strict hierarchy, the data would lie on the 45 degree line. The figure shows that there is a significant departure from the hierarchy, especially for the less popular destinations. In order to account for this departure we will introduce into the model firm- and destination-specific shocks to the fixed cost of entry into a market. This potentially allows the destination hierarchy to be firm-specific. Moreover, we will also introduce firm- and destination-specific sales shocks (as in Eaton, Kortum, and Kramarz (2010) in order to account for the widely documented heterogeneity in export intensity across firms for a given destination.

3 Model

In this section we present a theoretical model consistent with the data facts outlined above. The model is a parsimonious extension of Helpman, Melitz, and Yeaple (2004) model of horizontal MP, but crucially adds intra-firm trade as well as firm- and destination-specific sales and fixed cost shocks.

[27]Kleinert and Toubal (2006a) find that the same fact holds for German data: the number of German firms' foreign affiliates, normalized by German market share, increases regularly with market size.

[28]Yeaple (2009) finds that, consistently with our results, more efficient firms are more likely to own an affiliate in any given host country.

[29]Export entry data also partially follow a destination hierarchy. This is sometimes referred to as a "pecking order" (e.g. Yeaple (2009) and Manova (2008)).

3.1 Preferences

There are N countries that produce goods using only labor. Country i is populated by L_i consumers that maximize utility derived from the consumption of goods belonging to two sectors. One sector provides a homogeneous good and the other a continuum of differentiated goods. An exogenous fraction μ of income is spent on differentiated products and the remaining fraction $1-\mu$ on the homogeneous good. Preferences across varieties of the differentiated product have the standard CES form with an elasticity of substitution $\sigma > 1$. Each variety enters the utility function with its own country-specific weight η_i. These preferences generate a demand function $\mu\eta_i Y_i P_i^{\sigma-1} p_i^{1-\sigma}$ in country i for every brand of the product with price p_i. The demand level $\mu\eta_i Y_i P_i^{\sigma-1}$ is exogenous from the point of view of the individual supplier and depends on total expenditure Y_i and the consumption-based price index P_i.

3.2 Technology and Trade Barriers

The homogeneous good is freely traded and produced under constant returns to scale with one unit of labor producing w_i units of the good in country i. This sector is perfectly competitive, and the price is normalized to one so that if country i produces this good, the wage in the country is w_i. We consider equilibria only where every country produces some of the homogeneous good, which is used as *numéraire*. As long as the share of the homogeneous good, $(1-\mu)$, is large enough, or trade barriers in the other sector are large enough, this condition will hold.

A firm owns a technology, associated with productivity z, that can be used in any location.[30] A firm in country i can access the domestic market by sustaining a fixed cost f_{iiE} in units of the numéraire, and then produce a variety of the differentiated good with marginal cost w_i/z. There are two alternative ways of selling a good in foreign markets: exports or MP. A firm in country i that exports to country n must pay a fixed cost f_{inE}/ε_n where ε_n is a random shock that varies by firm and destination. Marginal costs for an exporter are,

$$c_{inE}(z) = \tau_{in} w_i / z \tag{1}$$

where $\tau_{in} > 1$ is a melting-iceberg transportation cost. A firm that instead decides to serve country n through foreign direct investment must pay a fixed cost f_{inI}/ε_n. Note that the entry shock is identical for export and MP entry.[31] We assume that the final good produced by the affiliate is assembled from intermediates and local labor with a Cobb-Douglas production function. Intermediates, which can be interpreted either as headquarters goods or as services, are supplied by the parent firm to the affiliate and

[30] Eaton, Kortum, and Kramarz (2010), Helpman, Melitz, and Yeaple (2004) and many others adopt the same assumption. Moreover, Yeaple (2009) finds that the logarithm of a foreign affiliate's sales is increasing in the logarithm of its parent firm's productivity, controlling for country and industry fixed effects.

[31] We explore the implications of this restriction in Section 4.1.1.

they are priced at marginal cost.[32] Every firm supplies its own requirements, they are not traded at arm's length. Implicitly, we assume that the headquarters service is produced by a constant returns to scale production function where one unit of labor yields z units of output. Hence, the competitive price of the intermediate is just equal to the unit cost of the intermediate $\tau_{in}w_i/z$. Marginal costs for an MP firm are then

$$c_{inI}(z) = (w_i \tau_{in})^{1-\alpha} w_n^{\alpha}/z \tag{2}$$

where α is the fixed ratio of affiliate labor expenditure to total variable costs.[33] Note that our model encompasses the Helpman, Melitz, and Yeaple (2004) model when α is equal to one, that is when the marginal cost of affiliate output no longer depends on variable trade barriers.[34]

Productivity z is Hicks-neutral, i.e. it affects domestic and foreign production identically. Note that variable trade costs will affect both exports and the transfer of intermediates. Producers of the differentiated good engage in monopolistic competition so that the price of a good is a markup $\sigma/(\sigma-1)$ on marginal costs.

We assume that the total mass of potential entrants in country i is proportional to labor income w_iL_i, so that larger and wealthier countries have more entrants. This assumption, as in Chaney (2008), greatly simplifies the analysis and it is similar to Eaton and Kortum (2002), where the set of goods is exogenously given. Without a free entry condition, firms generate net profits that have to be redistributed. We assume that all consumers own w_i shares of a totally diversified global fund and that profits are redistributed to them in units of the numéraire good. The total income Y_i spent by workers in country i, is the sum of their labor income w_iL_i and of the dividends they get from their portfolio $w_iL_i\pi$, where π is the dividend per share of the global mutual fund.

Given preferences and the optimal pricing of firms, profits from exporting (E) and MP (I) are

$$\pi_{inv}(z, \eta_n) = \frac{s_{inv}(z, \eta_n)}{\sigma} - \frac{f_{inv}}{\varepsilon_n}$$

where $v = \{E, I\}$ and $s_{inv}(z, \eta_n) = \mu\eta_n Y_n P_n^{\sigma-1} p_{inv}^{1-\sigma}(z)$ is sales from location i to destination n of a firm with productivity z and sales shock η_n. Firms enter market n only if they can earn positive profits there. Some low-productive firms may not generate sufficient revenue to cover their fixed costs. We define the productivity

[32] Garetto (2010), also assumes that intra-firm trade (unlike arm's length) is priced at marginal cost. She explains that this way of modeling the differences between intra-firm and arm's length pricing is consistent with (i) evidence on the existence of a large gap between the prices associated with arm's length transactions and the transfer prices associated with intra-firm transactions for the same firm-good-destination triplet (Bernard, Jensen, and Schott (2006)); (ii) evidence that arm's length prices are more responsive than intra-firm prices to price changes of competing firms (Neiman (2010)).

[33] The value of α is the focus of the second stage of the econometric analysis performed below.

[34] Yeaple (2009) finds a negative relationship between country-specific scale and distance, suggesting that marginal MP costs are increasing in trade costs.

threshold $\bar{z}_{inE}$ from $\pi_{inE}(\bar{z}_{inE}) = 0$ as the lowest possible productivity level consistent with non-negative profits in export markets

$$\bar{z}_{inE}\left(\varepsilon_n, \eta_n\right) = \delta_1 \left(\frac{f_{inE}}{\eta_n \varepsilon_n Y_n}\right)^{\frac{1}{\sigma-1}} P_n^{-1} w_i \tau_{in} \tag{3}$$

with δ_1 a constant.[35] Note that the cutoff $\bar{z}_{inE}$, being a function of the entry and sales shocks, is a stochastic version of the one found by Chaney (2008).

Similarly, we define the MP cutoff $\bar{z}_{inI}$ from $\pi_{inE}(\bar{z}_{inI}) = \pi_{inI}(\bar{z}_{inI})$ as the lowest possible productivity level such that the firm is indifferent between MP and exports,

$$\bar{z}_{inI}\left(\varepsilon_n, \eta_n\right) = \delta_1 \left(\frac{\Omega_{in}}{\eta_n \varepsilon_n Y_n}\right)^{\frac{1}{\sigma-1}} P_n^{-1} w_i \tau_{in} \tag{4}$$

where $\Omega_{in} = (f_{inI} - f_{inE}) / \left[(\omega_{in}\tau_{in})^{\alpha(\sigma-1)} - 1\right]$.[36] The term Ω_{in} is a measure of the difference between the fixed cost of opening an affiliate in country n and the fixed cost of exporting to country n relative to a measure of the marginal costs savings made possible by choosing to invest in country n. In this sense, Ω_{in} can be interpreted as the relative cost of FDI. When $f_{inI}/f_{inE} > (\omega_{in}\tau_{in})^{\alpha(\sigma-1)} > 1$ the MP cutoff in eq. (4) is bigger than the export cutoff. This inequality condition is similar to the one in Helpman, Melitz, and Yeaple (2004) and guarantees that the MP profits schedule (as a function of firm efficiency z) crosses the export profit schedule in the positive quadrant. Implicitly, we are assuming that (i) MP fixed costs are greater than export fixed costs ($f_{inI}/f_{inE} > 1$);[37] (ii) MP partially allows firms to save on variable trade costs ($(\omega_{in}\tau_{in})^{\alpha(\sigma-1)} > 1$),[38] and (iii) plant-level returns to scale are high enough ($f_{inI}/f_{inE} > (\omega_{in}\tau_{in})^{\alpha(\sigma-1)}$). In this case, firms are, *on average*, sorted as in Helpman, Melitz, and Yeaple (2004): low-productivity firms only serve the domestic market, medium-productivity firms export and high-productivity firms choose MP.[39] In the following, we assume that this sorting applies.

For any given firm-destination pair, the ratio between the MP and the export cutoff is

$$\frac{\bar{z}_{inI}}{\bar{z}_{inE}} = \left(\frac{\Omega_{in}}{f_{inE}}\right)^{\frac{1}{\sigma-1}} = \left(\frac{f_{inI} - f_{inE}}{f_{inE}} \frac{1}{(\omega_{in}\tau_{in})^{\alpha(\sigma-1)} - 1}\right)^{\frac{1}{\sigma-1}}. \tag{5}$$

[35] $\delta_1 = (\sigma/\mu)^{1/(\sigma-1)} \frac{\sigma}{\sigma-1}$.

[36] $\omega_{in} = w_i/w_n$ is the relative wage of country i with respect to country n. Below, we impose $(\omega_{in}\tau_{in})^{\alpha(\sigma-1)} > 1$, which will ensure that $\Omega_{in} > 0$ and some firms will choose MP.

[37] f_{inE} can be interpreted as the costs of forming a distribution and servicing network in a foreign country (similar costs for the home market are included in f_{iiE}). The fixed costs f_{inI} include the same types of costs, as well as the costs of forming a subsidiary in a foreign country and the duplicate overhead production costs embodied in f_{iiE}. The difference between f_{inI} and f_{inE} indexes plant-level returns to scale for the sector.

[38] In other words, we assume that $w_i > w_n/\tau_{in}$ which we believe to be a reasonable assumption in the case of Norway.

[39] In the model, all firms conducting MP also export to the same destination, consistent with the data presented in Section 2.1.

Consider the choice between export and MP within a given destination. First, intra-firm trade makes MP, ceteris paribus, relatively more difficult. The ratio between the MP and export cutoff is therefore increasing in the degree of intra-firm trade (i.e. decreasing in α). Second, higher τ_{in} (or ω_{in}) reduces $\bar{z}_{inI}/\bar{z}_{inE}$ since higher variable trade costs (or higher home wages) penalize exporting relative to MP. Third, the elasticity of substitution σ also reduces $\bar{z}_{inI}/\bar{z}_{inE}$, since the effect of cost differences is magnified when goods are very substitutable.

Next, we evaluate when the MP cutoff increases with τ_{in}. Differentiating $\bar{z}_{inI}$ with respect to τ_{in}, holding P_n constant, yields the elasticity χ_I of the MP cutoff to variable trade barriers,

$$\chi_I = \frac{(\omega_{in}\tau_{in})^{\alpha(\sigma-1)}(1-\alpha)-1}{(\omega_{in}\tau_{in})^{\alpha(\sigma-1)}-1} \lesseqgtr 0.$$

The MP cutoff is increasing with variable trade barriers (i.e. $\chi_I > 0$) if and only if

$$(\omega_{in}\tau_{in})^{\alpha(\sigma-1)}(1-\alpha) > 1. \tag{6}$$

This means that the number of multinationals (as well as total MP sales) falls with variable trade costs τ_{in} whenever equation (6) holds ("gravity for MP").[40] In the following, we provide the intuition for this result.

First, a high τ_{in} makes gravity for MP more likely. When trade barriers are large, latent variable profits generated from MP are much higher than latent profits generated from exports (see previous paragraph). A one percent increase in τ_{in} generates a smaller percentage fall in MP profits than export profits.[41] However, since MP is initially much more profitable, the *absolute* decline in MP profits may nevertheless be larger than the absolute decline in export profits. Hence, the MP cutoff will increase with τ_{in} when τ_{in} is initially high.

Second, more intra-firm trade (low α) makes gravity for MP more likely. When α is low, variable profits generated from MP are more similar to profits generated from exports. A one percent increase in τ_{in} generates a smaller percentage fall in MP profits than export profits, but the difference in the elasticity is not large. Since MP is initially more profitable, the absolute decline in MP profits is larger than the absolute decline in export profits. Hence, the MP cutoff will increase when α is high.

Third, a higher elasticity of substitution makes gravity for MP more likely. Higher σ magnifies the difference in profits between MP and exports. Hence, an increase in τ has a large impact on the level of MP profits. In Section A.1 we prove that the MP cutoff increases with τ as long as $\ln \tau_{in} > -\ln \omega_{in} - 1/\alpha\,(\sigma-1)\ln(1-\alpha)$.

Intra-firm trade is simply proportional to affiliate sales. We know that $(1-\alpha)$ is the expenditure share for the headquarters good, so intra-firm trade is a fraction

[40] In Section A.6.2, we show that endogenizing the price index P_n will not alter this result.

[41] Comparing (1) and (2) and recalling the firm's pricing rule, it is easy to show that the elasticity of latent export profits to τ_{in} is $|1-\sigma|$ while the elasticity of latent MP profits to τ_{in} is only $|1-\sigma+\alpha(\sigma-1)|$.

$(1-\alpha)$ of total variable costs (i.e. excluding fixed costs). Since gross profits are a fraction $1/\sigma$ of sales, intra-firm trade can be written as

$$(1-\alpha)\,\frac{\sigma-1}{\sigma}s_{inI}. \tag{7}$$

3.3 General Equilibrium

So far we have not taken into account changes in the price index. The price index is

$$P_n^{1-\sigma} = E_{\varepsilon_n,\eta_n}\sum_i w_i L_i\left[\int_{\bar{z}_{inE}(\varepsilon_n,\eta_n)}^{\bar{z}_{inI}(\varepsilon_n,\eta_n)}\eta_n p_{inE}(z)^{1-\sigma}dG_i(z)+\int_{\bar{z}_{inI}(\varepsilon_n,\eta_n)}^{\infty}\eta_n p_{inI}(z)^{1-\sigma}dG_i(z)\right].$$

Note that $\bar{z}_{iiE}$ is the domestic exit cutoff in country i and $\bar{z}_{iiI}=\infty$ (no firm conducts MP at home).[42] As in Helpman, Melitz, and Yeaple (2004), Chaney (2008) and others, we assume that productivity is distributed as a Pareto, along $[w_i,+\infty)$, that is $dG_i(z) = \gamma w_i^{\gamma} z^{-\gamma-1}dz$ where γ is an inverse measure of heterogeneity. [43] The Pareto assumption greatly simplifies the analysis in that all general equilibrium expressions can be solved in closed form. Also, recent evidence (e.g. Luttmer (2007), suggests that it approximates the distribution of firm sizes in the U.S. fairly well. Given that $\gamma > \sigma-1$,[44] the equilibrium price index is

$$P_n = \delta_2 Y_n^{1/\gamma-1/(\sigma-1)}\theta_n\left(\frac{1+\pi}{Y}\right)^{1/\gamma}, \tag{8}$$

where $\theta_n^{-\gamma} = \sum_i (Y_i/Y)\,\tau_{in}^{-\gamma}\left\{\Omega_{in}^{1-\gamma/(\sigma-1)}\left[(\omega_{in}\tau_{in})^{\alpha(\sigma-1)}-1\right]+f_{inE}^{1-\gamma/(\sigma-1)}\right\}$, δ_2 is a constant and Y is world income.[45] Note that θ_n can be interpreted as a multilateral resistance variable as in Anderson and van Wincoop (2003). It is a weighted average of i) country n trade barriers, ii) wages in the source countries and iii) the fixed costs of selling to n, where the weights are the economic sizes of the trading partners. It remains to determine total income Y_i, which will depend on the dividends received from the global fund. It turns out that dividends per share π are a constant in equilibrium.[46] After solving for the price index we can write latent export sales of a firm with productivity z and sales shock η_n as

$$s_{inE}\left(z,\eta_n\right) = \delta_3\left(1+\pi\right)^{(\sigma-1)/\gamma}\left(\frac{Y_n}{Y}\right)^{(\sigma-1)/\gamma}\left(\frac{\theta_n}{w_i\tau_{in}}\right)^{\sigma-1}z^{\sigma-1}\eta_n, \tag{9}$$

[42]Because $\omega_{ii}\tau_{ii}=1$, $\Omega_{ii}=\infty$, so $\bar{z}_{iiI}=\infty$ in (4).

[43]The country-specific lower bound of the Pareto, w_i, implies that the location of the productivity density in the differentiated sector is determined by the productivity level in the homogeneous sector. We have also solved the model with identical Pareto location parameters in every market. All the substantive theoretical and empirical results in this paper remain valid in both specifications.

[44]The assumption that $\gamma > \sigma-1$ ensures that, in equilibrium, the size distribution of firms has a finite mean.

[45]$\delta_2^{-\gamma} = \delta_1^{\sigma-\gamma-1}\left(\frac{\sigma}{\sigma-1}\right)^{1-\sigma}\frac{\gamma}{\gamma-(\sigma-1)}E_{\eta_n,\varepsilon_n}\left[(\eta_n\varepsilon_n)^{\gamma/(\sigma-1)-1}\eta_n\right]$.

[46]In Section A.2 we prove that $\pi = [\sigma\gamma/\mu\,(\sigma-1)+1]^{-1}$.

where δ_3 is a constant.[47]

Similarly, we obtain latent affiliate sales of a firm with productivity z and sales shock η_n as

$$s_{inI}(z,\eta_n) = \delta_3 \left(1+\pi\right)^{(\sigma-1)/\gamma} \left(\frac{Y_n}{Y}\right)^{(\sigma-1)/\gamma} \left[\frac{\theta_n}{\left(w_i\tau_{in}\right)^{1-\alpha} w_n^{\alpha}}\right]^{\sigma-1} z^{\sigma-1}\eta_n. \tag{10}$$

Note that export and affiliate sales in a market increase less than proportionally to the size of the market Y_n. As in Eaton, Kortum, and Kramarz (2010), the intuition is that a larger market attracts more entry, so that the price index is lower.

The following proposition states expressions for the extensive margin for both exports and affiliate sales.

Proposition 1 (Extensive Margin) *The equilibrium number of country i firms exporting to country n is*

$$n_{inE} = \delta_4^{-\gamma}\delta_5 \frac{Y_iY_n}{Y}\left(\frac{\theta_n}{\tau_{in}}\right)^{\gamma}\left[f_{inE}^{-\gamma/(\sigma-1)} - \left(\frac{f_{inI}-f_{inE}}{\left(\omega_{in}\tau_{in}\right)^{\alpha(\sigma-1)}-1}\right)^{-\gamma/(\sigma-1)}\right] \tag{11}$$

while the number of country i firms conducting MP in country n is

$$n_{inI} = \delta_4^{-\gamma}\delta_5 \frac{Y_iY_n}{Y}\left(\frac{\theta_n}{\tau_{in}}\right)^{\gamma}\left[\frac{f_{inI}-f_{inE}}{\left(\omega_{in}\tau_{in}\right)^{\alpha(\sigma-1)}-1}\right]^{-\gamma/(\sigma-1)}. \tag{12}$$

where δ_4 and δ_5 are constants.[48]

Proof. See Section A.2. ■

The extensive margin of foreign market access, represented by both the number of exporters and the number of MP firms, depends on the extent of intra-firm trade. Both the number of exporters and the number of MP firms are a decreasing function of variable trade barriers, as long as (6) holds.[49] Specifically,

$$\frac{\partial \ln n_{inE}}{\partial \ln \tau_{in}} = -\gamma\left(1+\frac{1-\chi_I}{(\frac{\bar{z}_{inI}}{\bar{z}_{inE}})^{\gamma}-1}\right), \text{ and}$$

$$\frac{\partial \ln n_{inI}}{\partial \ln \tau_{in}} = -\gamma\chi_I,$$

where both $\bar{z}_{inI}/\bar{z}_{inE}$ and χ_I have been shown, in the previous section, to be positively related with the degree of intra-firm trade $(1-\alpha)$. Without intra-firm trade (i.e. when

[47] $\delta_3 = \sigma\left(\delta_2/\delta_1\right)^{\sigma-1}$.

[48] $\delta_4 = \delta_1/\delta_2$ and $\delta_5 = E_{\eta_n,\varepsilon_n}\left[\left(\eta_n\varepsilon_n\right)^{\gamma/(\sigma-1)}\right]$

[49] Both elasticities are derived in Section A.6.2. In general equilibrium, the number of MP firms declines with τ_{in} as long as destination $n's$ other (than i) partners are sizeable, meaning that source i must not be important enough to affect the price index P_n by much.

$\chi_I < 0$) the number of MP firms is instead increasing in variable trade barriers, in clear contrast with the pattern showed in Figure 1.

Using firm-level sales equations (9) and (10), we can aggregate over the set of firms which exports and conducts MP to obtain aggregate sales equations. These expressions are shown in the following proposition.

Proposition 2 (Aggregate Sales) *Aggregate exports from country i to country n are*

$$S_{inE} = \mu \frac{Y_i Y_n}{Y} \left(\frac{\theta_n}{\tau_{in}}\right)^{\gamma} \left[f_{inE}^{-1-\gamma/(\sigma-1)} - \left(\frac{f_{inI} - f_{inE}}{(\omega_{in}\tau_{in})^{\alpha(\sigma-1)} - 1} \right)^{1-\gamma/(\sigma-1)} \right],$$

whereas affiliate sales are

$$S_{inI} = \mu \frac{Y_i Y_n}{Y} \left(\frac{\theta_n}{\tau_{in}}\right)^{\gamma} (\omega_{in}\tau_{in})^{\alpha(\sigma-1)} \left(\frac{f_{inI} - f_{inE}}{(\omega_{in}\tau_{in})^{\alpha(\sigma-1)} - 1} \right)^{1-\gamma/(\sigma-1)}.$$

Both exports and affiliate sales are a function of country size (Y_i and Y_n), workers' productivity (w_i and w_n), variable trade costs (τ_{in}), fixed trade costs (f_{inE} and f_{inI}), and the measure of n's remoteness from the rest of the world (θ_n).[50]

Proof. See Section A.2. ■

We decompose the elasticity of total exports into an intensive and extensive margin.[51] While the intensive margin is the same as in Chaney (2008), the extensive margin is modified by the presence of MP and intra-firm trade. The intuition is the following. Whenever variable trade barriers increase, the mass of exporters is affected both by an increase in the export cutoff and by an increase in the MP cutoff. While some firms switch from export to selling on the domestic market only, other firms switch from MP to export. This makes the extensive margin effect less negative than in Chaney (2008). This effect is associated to the term "Extensive margin MP". However, since the set of exporters is initially smaller (given that the most productive firms choose MP), the percentage change in the number of exporters is higher (than in Chaney (2008)). This effect corresponds to the "Extensive margin Export" term in the equation below. The latter effect dominates so that, overall, the extensive margin effect is higher than in Chaney (2008).[52]

$$\frac{d \ln S_{inE}}{d \ln \tau_{in}} = - \underbrace{(\sigma - 1)}_{\text{Intensive Margin}} - (\gamma - \sigma + 1) \left[- \underbrace{\frac{\chi_I}{\left(\frac{n_{inE}}{n_{inI}} + 1\right)^{1-\frac{1}{\gamma}} - 1}}_{\text{Extensive Margin MP}} + \underbrace{\frac{1}{1 - \left(\frac{n_{inE}}{n_{inI}} + 1\right)^{\frac{1}{\gamma}-1}}}_{\text{Extensive Margin Export}} \right]$$

[50] Aggregate exports do not include intra-firm trade which, as we have shown above, is proportional to affiliate sales. Moreover, this facilitates the comparison with the results in Chaney (2008).

[51] See Section A.6.3 for derivations.

[52] As mentioned above, $\lim_{\alpha \longrightarrow 0} \bar{z}_{inI}/\bar{z}_{inE} = +\infty$ or, equivalently, $\lim_{\alpha \longrightarrow 0} n_{inI}/n_{inE} = 0$ and the gravity equation for exports becomes the same as in Chaney (2008). Note also that, because of eq. (7), the elasticity of aggregate intra-firm exports to τ_{in} is the same as the elasticity of aggregate affiliate sales.

The gravity equation for MP is even more interesting. The overall effect of an increase in variable trade barriers on total affiliate sales can be decomposed into an intensive and an extensive margin,

$$\frac{d\ln S_{inI}}{d\ln \tau_{in}} = -\underbrace{(1-\alpha)(\sigma-1)}_{\text{Intensive Margin}} - \underbrace{(\gamma-\sigma+1)\chi_I}_{\text{Extensive Margin}} .$$

As long as there is intra-firm trade, affiliate sales of any firm are negatively affected by an increase in variable trade barriers through an increase in the cost of transferring intermediate goods from the parent to the affiliate (intensive margin effect).[53] The higher the degree of intra-firm trade and the higher the elasticity of substitution the stronger the intensive margin effect. Aggregate affiliate sales also depend on the location of the MP cutoff and therefore on the number of affiliates. The extensive margin term in the decomposition captures this effect. As long as condition (6) holds, the elasticity χ_I is positive so that when variable trade barriers increase, the MP cutoff increases as well, while the number of firms engaged in MP decreases.[54] As shown above the elasticity of the MP cutoff to variable trade barriers is increasing in the degree of intra-firm trade. Therefore, ceteris paribus, higher intra-firm trade is associated to a more powerful (negative) extensive margin effect. When there is no intra-firm trade ($\alpha = 1$), the intensive margin effect is null, while the extensive margin effect is positive.[55] In this case, total affiliate sales (and the number of firms conducting MP) are increasing in variable trade barriers. This is again in clear contrast with the pattern showed in Figure 1.

Finally, the ratio of total exports relative to affiliate sales is decreasing in trade barriers[56]

$$\frac{S_{inE}}{S_{inI}} = (\omega_{in}\tau_{in})^{\alpha(1-\sigma)} \left[\left(\frac{\Omega_{in}}{f_{inE}} \right)^{\frac{\gamma}{\sigma-1}-1} - 1 \right].$$

It is interesting to note that the main prediction of Helpman, Melitz, and Yeaple (2004) still holds. Whereas in their paper export declines and MP increases when τ_{in} increases, our model predicts decreasing exports and decreasing MP (for some parameter values), with the decrease in MP being smaller than the decrease in exports.

4 Empirical Implementation

In the theory section, we laid out a parsimonious framework for thinking about trade and multinational production jointly. This framework emphasizes the role played by

[53]In general equilibrium, an increase in variable trade barriers also implies a rise in the price index in the destination country. This indirect effect dampens the negative direct effect but is relatively unimportant as long as the source country holds a small market share in the destination country.

[54]We have shown above that, even in general equilibrium, the number of MP firms declines with variable trade barriers as long as the destination country has a sufficient number of trading partners.

[55]When $\alpha = 1$ condition (6) never holds and the elasticity of the MP cutoff with respect to variable trade barriers is always negative.

[56]The ratio between the number of exporters and MNEs is also decreasing in τ_{in}.

productivity heterogeneity and intrafirm trade. We showed that if intra-firm trade between headquarters and affiliates is important, then the model is consistent with the stylized fact (shown in Section 2) that both trade and MP adhere to a gravity model. The other stylized facts shown in Section 2 suggest that while productive firms are, on average, able to enter into more difficult markets, fixed costs definitely play an important role, since the number of MP firms increases with the size of the destination market (controlling for Norwegian market share). Moreover, there is an imperfect tendency for a "pecking order" of MP. In this section, we analyze how heterogeneity in productivity, intra-firm trade and the geographical distribution of fixed costs shape the margins of exports and MP. We carefully estimate the structural parameters of the model in order to answer the following questions. Can the geographical pattern of MP (at the extensive and intensive margin) be explained by the geographical distribution of fixed costs alone? If not, how important is the role played by intra-firm trade? What is the geographical distribution of export and MP fixed costs, and how big are MP costs relative to export costs? How important is the firm-specific component of MP and export fixed costs? And finally, if firms switch from export to MP sales, is home manufacturing employment negatively affected?

We estimate the structural parameters of the model described in Section 3. We proceed in two steps. In the first stage, we estimate the country-specific parameters and the variance of the sales and fixed cost shocks. In this stage the structural parameters from the model can be estimated with maximum likelihood techniques using firm-level data on export and MP entry and on export and affiliate sales. The econometric model can be thought of as micro-gravity equations, i.e. we estimate theory consistent gravity-like equations at the firm level. An important aspect of the estimation methodology is that it is conditional on firms' home sales. Because of that, (i) the econometric model does not rely on any functional form assumptions about the productivity distribution, and (ii) we avoid complications related to having to re-compute the general equilibrium for each set of parameter candidates. We emphasize that the estimation procedure will identify an index of fixed costs of exporting and MP. The intuition is that while the entry choice of an individual firm will depend on both fixed and variable costs, firm's sales conditional on entry will only depend on variable costs. Hence, we can subtract the latter from the former to obtain an estimate of fixed costs alone.

In the second stage, under some assumptions about trade costs and assuming that the productivity distribution is Pareto, we estimate the shape parameter of the sales distribution and the parameter of the labor share of affiliate expenditure α that is consistent with the general equilibrium of the model. Identification of α relies on the fact that our model implies that (the absolute value of) the elasticity of MP sales with respect to variable trade costs (within the same firm) is lower than the elasticity of exports with respect to variable trade costs. Hence, identification resembles a difference-in-difference approach: we analyze the change in exports (and MP) between market A and B, and then take the difference in this change in order to back out α.

4.1 First Stage

In the first stage of the estimation we use data on export and MP entry, as well as home, export, and affiliate sales for all J Norwegian manufacturing firms in 2004. Let $y_{nE}(j)$ be a dummy variable equal to one if firm j exports to country n and $y_{nI}(j)$ be equal to one if firm j invests into country n. Let $\{s_H(j), s_{nE}(j), s_{nI}(j)\}$ denote home sales, export and affiliate sales respectively of firm j to country n.[57] We follow other authors (e.g. Anderson and van Wincoop (2003)) in hypothesizing that iceberg trade costs τ_{in} are a loglinear function of observables. Specifically, we use $\tau_n = d_n^{\rho_1}$ where d_n denotes distance (in kilometers) between country i and country n. Moreover, we assume that the wage in country n is a loglinear function, with coefficient ρ_2, of a wage index published by the Bureau of Labor Statistics.[58] As in the theory section, we consider two types of firm- and destination-specific shocks: one for entry $\varepsilon_n(j)$ and one for sales $\eta_n(j)$. We assume that they are *iid* lognormally distributed over firms j and destinations n, but we allow for correlation between $\varepsilon_n(j)$ and $\eta_n(j)$ within the same firm-destination pair.[59] These distributional assumptions allow us to write the likelihood function in closed form. [60]

4.1.1 Re-Expressing Entry and Sales Equations

Since our estimation is conditional on the sales of firms at home and productivity is not readily observable, it is useful to rewrite the equation for entry and sales in terms of home sales.

MP and Export entry. First we derive an expression for MP entry in terms of home sales. We know that firm j invests in country n if its productivity is higher than the MP cutoff $\bar{z}_{nI}(j)$. Recalling that home sales are

$$s_H(j) = \mu \eta_H(j) Y_H \left(\frac{\sigma}{\sigma - 1}\right)^{1-\sigma} w_H^{1-\sigma} z(j)^{\sigma-1} P_H^{\sigma-1}, \tag{13}$$

and using the MP cutoff (4), we can re-express the entry condition in terms of home sales

$$\ln s_H(j) + \upsilon_n(j) > \ln \sigma - \kappa_n + \ln \Omega_n \equiv M_{nI},$$

where $\eta_n^* = \eta_n(j)/\eta_H(j)$, $\upsilon_n(j)$ is the sum of the entry and sales shocks and κ_n is a country fixed effect. [61] [62]

[57] We drop the subscript i for all these variables since the source country is always Norway.

[58] BLS's index of hourly compensation costs for production workers, United States=100.

[59] We report standard errors that are robust to serially correlated errors, see Section A.5.

[60] Estimating the data set with an acceptable number of destination countries is relatively CPU-intensive, even with a closed-form likelihood. With the OECD set of destination countries, the MLE converges after approx. 20 minutes on an Intel server with 8 Xeon cores. More flexible distributional assumptions would require simulating the likelihood, which would increase the computational burden, probably to a point where estimation would become infeasible.

[61] Specifically $\upsilon_n(j) \equiv \ln \varepsilon_n(j) + \ln \eta_n^*(j)$ and $\kappa_n = \ln(Y_n/Y_H) + (\sigma - 1)\ln(P_n/P_H) - \rho_1(\sigma - 1)\ln d_n$.

[62] We have also explored the case when export and MP entry shocks are different, $\varepsilon_{nE} \neq \varepsilon_{nI}$. In

As we show further below, κ_n can be interpreted as export sales' potential in market n. Hence, firm j establishes an affiliate in country n if home sales, adjusted for the sum of the entry and sales shocks, are higher than the entry hurdle M_{nI}. The entry hurdle is increasing in the MP cost variable Ω_n and decreasing in sales potential κ_n.

The shocks have homoskedastic variance $\sigma^2_{\eta^*}$ and σ^2_{ε} and the covariance is $\sigma_{\varepsilon\eta^*}$. Then, the probability that firm j invests in country n, conditional on home sales, can be written as $1 - \Phi\left\{\left[M_{nI} - \ln s_H(j)\right]/\sigma_{\upsilon}\right\}$ where $\Phi(.)$ denotes the standard normal CDF and $\sigma^2_{\upsilon} = \sigma^2_{\varepsilon} + \sigma^2_{\eta^*} + 2\sigma_{\varepsilon\eta^*}$.

The probability of exporting can be derived in a similar fashion. Using the cutoff condition for exports (3), the export entry condition in terms of home sales can be expressed as

$$M_{nE} < \ln s_H(j) + \upsilon_n(j) < M_{nI},$$

where the export entry hurdle (in terms of home sales) is $M_{nE} \equiv \ln\sigma - \kappa_n + \ln f_{nE}$.[63] The probability of exporting is then $\Phi\left\{\left[M_{nI} - \ln s_H(j)\right]/\sigma_{\upsilon}\right\} - \Phi\left\{\left[M_{nE} - \ln s_H(j)\right]/\sigma_{\upsilon}\right\}$. Finally, the probability of not exporting or selling through an affiliate is likewise $\Phi\left\{\left[M_{nE} - \ln s_H(j)\right]/\sigma_{\upsilon}\right\}$. This is essentially an ordered probit, where the problem is well-behaved only if $M_{nE} < M_{nI}$.

Affiliate and Export Sales. Next we derive estimating equations for export and MP sales. We express affiliate sales in terms of home sales. Recalling that affiliate sales for firm j in market n are

$$s_{nI}(j) = \mu\eta_n(j)Y_n\left(\frac{\sigma}{\sigma-1}\right)^{1-\sigma}\left(w_H d_n^{\rho_1}\right)^{(1-\alpha)(1-\sigma)} w_n^{\alpha(1-\sigma)} z(j)^{\sigma-1} P_n^{\sigma-1},$$

and using (13) we have

$$\ln s_{nI}(j) = \kappa_n + \rho_1\alpha\left(\sigma-1\right)\ln d_n + \rho_2\alpha\left(\sigma-1\right)\ln\omega_n + \ln s_H(j) + \ln\eta^*_n(j).$$

Notice that in the absence of intra-firm trade ($\alpha = 1$) firm-level affiliate sales are independent of distance d_n.[64] This expression states that multinational production in market n equals the export sales potential κ_n adjusted for the fact that trade costs are less for multinational production than for exports (the $\rho_1\alpha\left(\sigma-1\right)\ln d_n$ term). Less intra-firm trade (high α) will tend to cancel out the negative effect of trade barriers embedded in κ_n. Also, lower unit costs abroad (high ω_n) translates into higher sales because firm j can charge a lower price. Note that it is the relative

that case, the entry condition becomes $\ln s_H - \ln\left(a\varepsilon^{-1}_{nI} - \varepsilon^{-1}_{nE}\right) + \ln\left(a-1\right) + \ln\eta^*_n > \ln\sigma - \kappa_n + \ln\Omega_n$ where $a = f_{inI}/f_{inE}$. The distribution of $a\varepsilon^{-1}_{nI} - \varepsilon^{-1}_{nE}$, a sum of two log-normals, has no closed-form expression. The right tail of the distribution can, however, be reasonably approximated by another log-normal distribution (see e.g. Fenton (1960)). In that sense, our restriction $\varepsilon_E = \varepsilon_I$ is a reasonable approximation of the more general case.

[63] Note that wages are not embedded in M_{nE} (except for wages' effect on income Y_n through κ_n). The reason is that higher labor costs affect both home sales and foreign sales. Since we are already controlling for home sales, wages cancel out in the equation.

[64] $\rho_1\left(\sigma-1\right)$ also appears in the κ_n, so α cancels out.

wage that matters: a proportional reduction in both home and foreign wage would boost both home sales and MP, so that the change in $s_H(j)$ would fully explain the change in $s_{nI}(j)$. Expected affiliate sales conditional on home sales and entry $\nu_{nI}(j) \equiv E\left[\ln s_{nI}(j)|s_H(j),\, y_{nI}(j)=1\right]$ are similar to the above equation but with $\ln \eta_n^*(j)$ replaced by $E\left[\ln \eta_n^*(j)|y_{inI}(j)=1\right]$. The expectation of this error term is

$$\begin{aligned} E\left[\ln \eta_n^*(j)|y_{nI}(j)=1\right] &= E\left[\ln \eta_n^*(j)|\ln s_H(j)+\upsilon_n(j)>M_{nI}\right] \\ &= \frac{\sigma_{\eta^*}^2+\sigma_{\varepsilon\eta^*}}{\sigma_\upsilon^2} E\left[\upsilon_n(j)|\ln s_H(j)+\upsilon_n(j)>M_{nI}\right] \\ &= \frac{\sigma_{\eta^*}^2+\sigma_{\varepsilon\eta^*}}{\sigma_\upsilon^2}\sigma_\upsilon \lambda\left[\frac{\ln s_H(j)-M_{nI}}{\sigma_\upsilon}\right] \end{aligned}$$

where $\lambda(.)$ is the inverse Mills ratio. The variance of the truncated error $\widetilde{\sigma}_{\eta^* I}^2$ along with further derivations are shown in Section A.3.

Following similar steps we can derive an expression for export sales as a function of home sales and find the conditional expectation. Knowing that export sales of firm j in market n are

$$s_{nE}(j)=\mu\eta_n(j)Y_n\left(\frac{\sigma}{\sigma-1}\right)^{1-\sigma} w_H^{1-\sigma} d_n^{\rho_1(1-\sigma)} z(j)^{\sigma-1} P_n^{\sigma-1},$$

and using (13) we have,

$$\ln s_{nE}(j)=\kappa_n+\ln s_H(j)+\ln \eta_n^*(j).$$

Export sales are equal to potential export sales κ_n adjusted for home sales and sales shocks. Expected sales, conditional on home sales and entry $\nu_{nE}(j) \equiv E\left[\ln s_{nE}(j)|s_H(j),\, y_{nE}(j)=1\right]$ are similar to the above equation, but with $\ln \eta_n^*(j)$ replaced by $E\left[\ln \eta_n^*(j)|y_{nE}(j)=1\right]$. The mean of the truncated error term is

$$\begin{aligned} E\left[\ln \eta_n^*(j)|y_{nE}(j)=1\right] &= E\left[\ln \eta_n^*(j)|M_{nE}<\upsilon_n(j)+\ln s_H(j)<M_{nI}\right] \\ &= \frac{\sigma_{\eta^*}^2+\sigma_{\varepsilon\eta^*}}{\sigma_\upsilon^2}\sigma_\upsilon \frac{\phi\left[\frac{M_{nE}-\ln s_H(j)}{\sigma_\upsilon}\right]-\phi\left[\frac{M_{nI}-\ln s_H(j)}{\sigma_\upsilon}\right]}{\Phi\left[\frac{M_{nI}-\ln s_H(j)}{\sigma_\upsilon}\right]-\Phi\left[\frac{M_{nE}-\ln s_H(j)}{\sigma_\upsilon}\right]} \end{aligned}$$

where $\phi(.)$ is the standard normal density. The variance of the truncated error $\widetilde{\sigma}_{\eta^* E}^2$ along with derivations are shown in Section A.3.

4.1.2 The Likelihood Function

We estimate the closed-form likelihood function with respect to the parameter vector $\vartheta=\left\{\kappa_n, M_{nE}, M_{nI}, \alpha\rho_1(\sigma-1), \alpha\rho_2(\sigma-1), \sigma_{\eta^*}^2, \sigma_\upsilon^2, \sigma_{\varepsilon\eta^*}\right\}$. The likelihood function can be decomposed into two parts: one representing entry and the other representing sales conditional on entry. The entry component can be written as

$$l_{entry}(\vartheta_1) = \sum_{n=1}^{N}\sum_{j=1}^{J}\left[1 - y_{nE}(j)\right]\left[1 - y_{nI}(j)\right]\ln\Phi\left[\frac{M_{nE} - \ln s_H(j)}{\sigma_\upsilon}\right]$$

$$+\, y_{nE}(j)\left[1 - y_{nI}(j)\right]\ln\left\{\Phi\left[\frac{M_{nI} - \ln s_H(j)}{\sigma_\upsilon}\right] - \Phi\left[\frac{M_{nE} - \ln s_H(j)}{\sigma_\upsilon}\right]\right\}$$

$$+\, y_{nI}(j)\left\{\ln\left[1 - \Phi\left(\frac{M_{nI} - \ln s_H(j)}{\sigma_\upsilon}\right)\right]\right\}$$

where $\vartheta_1 = \{M_{nE}, M_{nI}, \sigma_\upsilon^2\}$. The first term represents the likelihood of observing firms neither exporting nor conducting MP, the second term the likelihood of observing exporters and the last term the likelihood of observing firms conducting MP. We maximize the likelihood subject to $M_{nI} > M_{nE}$ (N constraints).

The sales component of the likelihood function is

$$l_{sales}(\vartheta_2) = \sum_{n=1}^{N}\sum_{j\in J_n^2} y_{nE}(j)\left(1 - y_{nI}(j)\right)\ln\phi\left[\left(s_{nE}(j) - \nu_{nE}(j)\right)/\widetilde{\sigma}_{\eta^*E}\right]$$

$$+\, y_{nI}(j)\ln\phi\left[\left(s_{nI}(j) - \nu_{nI}(j)\right)/\widetilde{\sigma}_{\eta^*I}\right]$$

where $\vartheta_2 = \{\kappa_n, \alpha\rho_1(\sigma-1), \alpha\rho_2(\sigma-1), \sigma_{\eta^*}^2, \sigma_{\varepsilon\eta^*}\}$ and J_n^e is the set of firms that exports or conducts MP in market n. The first term represents the likelihood of sales for exporters and the second the likelihood of sales for affiliates.

In Section A.5, we describe how we estimate standard errors that are robust to serial correlation. Serial correlation in the errors might occur e.g. if home sales are measured with an error, so that $cov\left[\eta_n(j), \eta_H(j)\right] \neq 0$. Even though MLE is consistent in this case, the standard formula for standard errors is no longer correct, since we no longer can apply the conditional information matrix equality.

The export flows of a firm conducting MP to the same destination do not enter the likelihood. In other words, $(y_{nE}(j), y_{nI}(j)) = (1,1)$ is interpreted as $(0,1)$.[65] There are two reasons for this. First, our theory is incompatible with firms selling final goods both through exports and MP. Second, our data do not identify to what extent these export flows are intra-firm or final goods exports (which would enter the likelihood differently).

[65] Below, we evaluate the implications of this procedure. If a firm owns more than one affiliate in the same destination (a rare event in the data) we add up sales across all affiliated plants.

4.1.3 Identification

To facilitate the exposition of our identification strategy we summarize the equations for entry and sales,

$$
\begin{aligned}
y_{nI}(j) &= 1\left[\ln s_H(j) + \upsilon_n(j) > M_{nI}\right], &(14)\\
y_{nE}(j) &= 1\left[M_{nE} < \ln s_H(j) + \upsilon_n(j) < M_{nI}\right], &(15)\\
\ln s_{nI}(j) &= \kappa_n + \alpha\rho_1(\sigma-1)\ln d_n + \alpha\rho_2(\sigma-1)\ln\omega_n + \ln s_H(j) + \ln\eta_n^*(j), &(16)\\
\ln s_{nE}(j) &= \kappa_n + \ln s_H(j) + \ln\eta_n^*(j), &(17)
\end{aligned}
$$

where 1[.] is an indicator function.

The κ_n term is identified as a fixed effect in the sales equation (17). The entry hurdles M_{nI} and M_{nE} are identified directly as fixed effects in the ordered probit equations (14) and (15). The structural interpretation of the fixed effects are

$$
\begin{aligned}
\kappa_n &= \ln(Y_n/Y_H) + (\sigma-1)\ln(P_n/P_H) - \rho_1(\sigma-1)\ln d_n, &(18)\\
M_{nE} &= \ln\sigma - \kappa_n + \ln f_{nE}, &(19)\\
M_{nI} &= \ln\sigma - \kappa_n + \ln\Omega_n. &(20)
\end{aligned}
$$

The fixed effects capture the effect of market size, prices and (fixed and variable) trade costs on entry and sales.[66] Given an estimate of κ_n, it is clear that the clusters of parameters $\alpha\rho_1(\sigma-1)$ and $\alpha\rho_2(\sigma-1)$ are identified from (16).

In the next subsection we discuss our procedure to estimate α. However, equations (14) to (17) already show that identification of the degree of intra-firm trade occurs through comparisons of sales patterns. Specifically, intra-firm trade is identified by the difference between the dampening effect of distance on exports and MP (within the same firm), captured by the $\alpha\rho_1(\sigma-1)$ term. We can then back out α by dividing $\alpha\rho_1(\sigma-1)$ by the standard distance coefficient from gravity regressions, $\rho_1(\sigma-1)$.

As is usual in classical regression models, the variance of the sales shocks $\sigma^2_{\eta^*}$ is identified. In standard (ordered) probit models the variance of the composite shock σ^2_υ is not usually identified. In this paper, however, σ^2_υ is identified by imposing the theoretical structure of the model. Specifically, the restriction that there is no coefficient in front of $\ln s_H$ in (14) and (15) facilitates the identification of σ^2_υ. Given estimates of σ^2_υ, $\sigma^2_{\eta^*}$ and $\sigma_{\varepsilon\eta^*}$, $\sigma^2_\varepsilon = \sigma^2_\upsilon - \sigma^2_{\eta^*} - 2\sigma_{\varepsilon\eta^*}$ is also identified.

It is important to note that the equations for entry and sales are not mutually dependent.[67] Hence, we can estimate the model using a two-step procedure, where the first step estimates the entry equations (14) and (15), while the second step estimates the sales equations (16) and (17). The econometric setup incorporates therefore an ordered probit for the entry decision, while the sales decision resembles a Heckman

[66] All traditional gravity variables such as distance, common language, bilateral FTA, etc., are subsumed into the fixed effects.

[67] The entry equations do not depend on the sales equations. Given the estimates from the ordered probit, we have sufficient information to calculate the expected sales shocks (the Mills ratios) in the sales equations.

(1979) selection model. This approach takes into account that entrants in general have unobserved positive shocks that also influence the amount of sales. The implicit exclusion restriction is that fixed costs affect firm-level entry but not sales. Fixed costs appear in the fixed effects M_{nE} and M_{nI} in the entry equations, but are excluded in the fixed effect κ_n in the sales equations.

Our structural estimation is related to the work of Helpman, Melitz, and Rubinstein (2008). They consider a model similar to ours that is able to explain bilateral export flows at the aggregate level. They control for firm heterogeneity and for the presence of zeros in the bilateral trade data. In contrast, we do not need to control for heterogeneity since we estimate at the firm level. We also deal with selection, but at the firm level instead of at the aggregate level.

Another related paper is that of Eaton, Kortum, and Kramarz (2010), who structurally estimate a general equilibrium model with exports. Their model is similar to ours, but it considers only export decisions. It is more general in the sense that they estimate the full general equilibrium through simulated method of moments. In contrast, we condition our estimation on home sales. Our structural shocks are similar to those considered by Eaton, Kortum, and Kramarz (2010). However, our maximum likelihood estimation strategy uses all of the information at the firm level, whereas Eaton, Kortum, and Kramarz (2010) use aggregate moments to identify their parameters.

4.2 Second Stage

In the second stage, we solve the full general equilibrium (the price indices) and obtain an estimate of the affiliate cost share α. Solving for the general equilibrium is necessary when we later on consider some counterfactuals (see Section 6). We emphasize that the estimate of α, which is of special interest to us, can also be obtained without solving the full general equilibrium (see Section 4.2.3).

In the following sections, we first estimate the Pareto shape parameter $\widetilde{\gamma} = \gamma / (\sigma - 1)$. Next, we introduce some additional assumptions, and finally we show how to calculate the general equilibrium and α.

4.2.1 Finding $\widetilde{\gamma}$

According to our model, the sales distribution captures the joint effect of the dispersion of productivity, the sales shocks and the elasticity of substitution, which tends to magnify productivity differences across firms. Since the first stage is entirely conditional on firm-level home sales, the dispersion of productivity is not identified in the first stage. Here we use the simulated method of moments in order to quantify $\widetilde{\gamma} = \gamma / (\sigma - 1)$.

The estimating procedure, similar to Eaton, Kortum, and Kramarz (2010), is as follows:

1. We guess an initial value for the vector of parameters to be estimated $(a, \widetilde{\gamma})$. The role of a is explained below.

2. We draw shocks $\varepsilon_n(j)$, $\eta_n(j)$ for every firm-destination pair given the 1^{st} stage estimates of $\sigma^2_{\eta^*}$, σ^2_ε and $\sigma_{\eta^*\varepsilon}$.[68] The simulated number of firms is $100,000$.

3. We determine latent home sales. From equation (13) we know that home sales can be expressed as $\ln s_H(j) = a + \ln z(j)^{\sigma-1} + \ln \eta_H(j)$, where a is a home demand shifter. We first draw $z(j)^{\sigma-1}$, which is distributed Pareto with shape $\widetilde{\gamma}$, and then add the domestic sales shock as well the value of a, from step 1.

4. We calculate entry and sales patterns in all export markets, by invoking equations (15) and (17), and by using the 1^{st} stage estimates of κ_n and M_{nE}.[69]

5. Next, we construct a set of simulated and actual moments that relate to the sales distributions. For actual firms selling in destination n we compute the q^{th} percentile sales s_n^q in that market, for $q = 5, 10, .., 95$. Using these 19 thresholds, we determine which percentile range $(0-5, 5-10, ..)$ the simulated firms selling in n belong to. We then compute the proportion $\widehat{m}_n^q(a, \widetilde{\gamma})$ of simulated firms belonging to each group in every market. The actual proportions m_n^q are by construction all equal to 0.05.

6. We stack these 19 moments for each of the 28 destination markets (giving in total 532 moments) in vectors $\widehat{\mathbf{m}}$ and $\mathbf{m}$ and minimize the objective function[70]

$$(\widehat{\mathbf{m}}(a, \widetilde{\gamma}) - \mathbf{m})' (\widehat{\mathbf{m}}(a, \widetilde{\gamma}) - \mathbf{m})$$

7. As the covariance matrix of the vector of empirical moments is unknown, the standard error of the estimator is not available using standard formulas. Instead, we employ a nonparametric bootstrap (empirical distribution function bootstrap). Specifically, we sample with replacement within each destination, obtaining the same number of observations as in the original sample. After performing 500 bootstrap replications, we form the standard errors by calculating the standard deviation for a and $\widetilde{\gamma}$.

Identification. The intuition behind the method is as follows. The sales distribution in a market n is a mixture of the distribution of efficiencies (adjusted for σ) and the distribution of sales and entry shocks. We have already identified the covariance matrix of entry and sales shocks from the 1^{st} stage. Therefore, we can back out the efficiency distribution by comparing actual and simulated sales distributions.

[68]Note that $cov(\eta_n^*, \varepsilon_n) = cov(\eta_n, \varepsilon_n) - cov(\eta_H, \varepsilon_n) = cov(\eta_n, \varepsilon_n)$ for $n \neq H$, given that there is no correlation between destinations. Draws from the multivariate normal are performed using Cholesky decomposition. We also assume that $\sigma^2_{\eta_H} = \sigma^2_{\eta_n}$, so that $\sigma^2_{\eta_n} = \sigma^2_{\eta^*}/2$.

[69]Moments for affiliate sales are not included because of the low number of MP entrants in some destinations, contributing to increased volatility in the empirical moments.

[70]Theory suggests that for overidentified models it is best to use optimal GMM. In implementation, however, the optimal GMM estimator may suffer from finite-sample bias (Altonji and Segal 1996).

Results. The point estimate of $\widetilde{\gamma}$ is 0.71, with standard error 0.50. In the following numerical experiments, we set $\widetilde{\gamma} = 1.01$, which is required in order to ensure that the general equilibrium is well-defined.[71]

4.2.2 Additional assumptions

In this section, we describe some additional assumptions that are needed in order to solve the general equilibrium. The price index is a function of all multilateral variables and fixed costs, as well as σ and α, which are unknowns. Therefore, we condition the equilibrium on a guess of σ, and we make further assumptions about the matrix of fixed costs (see below). We also use additional OECD data on absorption to compute Y_n for each country n and we set μ, the expenditure share on the monopolistic good, equal to 0.52, which is the consumption share of goods relative to total consumption in Norway in 2004.[72]

Fixed costs of exporting and MP from Norway (NO) to other destinations are identified from (19) and (20), given a choice of σIt remains to populate the full matrix of fixed costs, i.e. f_{inI} and f_{inE} when $i \neq NO$. Here we assume (a) symmetry, so that $f_{iNOv} = f_{NOiv}$ for all $i \neq NO$ and $v = \{E, I\}$ and (b) $f_{inv} = f_{NOnv}$ for all $i \neq n$, $n \neq NO,\ v = \{E, I\}$. The second assumption means that fixed costs to country n are equal to the fixed costs from Norway to country n, for all possible source countries. We also need an estimate of fixed costs at home, $f_{iiE.}$ Here we simply posit that home fixed costs are half of the lowest exporting fixed costs, $f_{ii} = \min(f_{NOn})/2$ for all i.

4.2.3 Finding α

We are particularly interested in the volume of intra-firm trade that is consistent with the observed geography of multinational production. The share produced by the affiliate α is not directly identified in the first stage. Here we propose a method that will tease out the value of α.

The general idea is to compare the elasticity of affiliate sales to distance with the elasticity of exports to distance (within the same firm). We find the elasticity of export sales with respect to distance $\rho_1(\sigma - 1)$ using the 1^{st} stage estimates of the κ_n fixed effect (see eq. (18)). Given this information, α is simply $\widehat{\alpha\rho_1(\sigma-1)}/\rho_1(\sigma - 1)$ where $\widehat{\alpha\rho_1(\sigma-1)}$ is also obtained in the 1^{st} stage of the estimation.

There are three ways of finding α, all of which yield roughly similar results. The *first* alternative (method I) is simply to use external estimates of $\rho_1(\sigma - 1)$. We know from many gravity studies, e.g. Helman, Melitz and Rubinstein (2008), that $\rho_1(\sigma - 1)$ is in the neighborhood of 1. The *second* alternative (method II) is to make the simplifying assumption that price indices are identical in all markets, $P_i = P_n$. In that case, solving (18) with respect to $[\rho_1(\sigma - 1)]^{-1}$ and multiplying with $\alpha\rho_1(\sigma - 1)$

[71]With the reported standard error, we cannot reject the hypothesis that $\widetilde{\gamma} > 1$ at conventional significance levels.

[72]Computed from Table 23 "Household final consumption expenditure by function. Current prices. Million kroner" of the "Annual National Accounts 1970-2007" published by Statistics Norway.

yields $\alpha_n = \alpha\rho_1(\sigma-1)\ln d_n\left[\ln(Y_n/Y_H)-\kappa_n\right]^{-1}$. Hence, α is only a function of the estimates from the first stage in addition to data on relative absorption.

The *third* alternative (method III) allows for different price indices, but also requires the additional assumptions needed in order to calculate price indices (see previous section). Again, solving (18) with respect to $[\rho_1(\sigma-1)]^{-1}$ and multiplying with $\alpha\rho_1(\sigma-1)$ yields

$$\alpha_n = f(P_n;\sigma,\vartheta) = \alpha\rho_1(\sigma-1)\ln d_n\left[\ln(Y_n/Y_H)+(\sigma-1)\ln(P_n/P_H)-\kappa_n\right]^{-1}$$

The price index, however, is a function of α, $P_n = g(\alpha;\sigma,\vartheta)$, so we cannot find an analytical solution for α. We can, however, solve for α with numerical methods. Specifically, we iterate over $\alpha_n^{i+1} = f\left[g\left(\overline{\alpha}^i;\sigma\right)\right]$ for i iterations until convergence is reached.[73] We must also deal with the fact that α_n^{i+1} is an $(Nx1)$ vector whereas our model only allows for a scalar α in the construction of the price index. Here, we simply take the mean of the α_n's for each iteration (indicated by $\overline{\alpha}^i$ above). Given the estimate of α, the price index P_n can be recovered using equation (8). The above solution method is conditional on a guess of σ. However, in practice it turns out that the estimate of α is invariant to the choice of σ. In the results section below, we report estimates using the third alternative.

5 Results

In this section, we present the results of the two-stage estimation. We first show that the estimates are in line with the theory outlined in Section 3. Then, we show how the model is able to predict export and MP entry and sales patterns. Finally, we test the relative importance of the information we did not use in the estimation by evaluating how the model is able to predict out-of-sample intra-firm trade.

5.1 Parameters Estimates

5.1.1 First Stage

Our sample comprises 7,949 firms (J) and 28 destinations (N). The number of active firm-destination pairs is 14,246, 2.3 percent of which are affiliate sales, 97.7 percent of which are exports. Table 2 reports all the parameters estimated in the first and second stage. The first stage delivers estimates of $\alpha\rho_1(\sigma-1)$, $\alpha\rho_2(\sigma-1)$, the variance of the shocks to sales $\sigma^2_{\eta^*}$, the ratio of shocks σ^2_{υ}, the covariance $\sigma_{\varepsilon\eta^*}$, the sales potential κ_n and the entry hurdles M_{nE} and M_{nI} by destination.[74] Table 2 shows that $\alpha\rho_1(\sigma-1)$, the cluster of parameters that captures the difference in the distance

[73] We find the fixed point α where $f(\alpha)=\alpha$. Tests show that the same fixed point is reached regardless of the initial value α^0.

[74] It is worthwhile reminding the reader that none of the first stage results depend on the specific functional form of the productivity distribution $G(z)$.

elasticity of export and affiliate sales, is positive and significant. Furthermore, the wage coefficient $\alpha\rho_2(\sigma-1)$ is not significantly different from zero.

Entry and sales shocks. The variance of the shocks to sales $\sigma^2_{\eta^*}$, the variance of the ratio of shocks σ^2_{υ} and the covariance $\sigma_{\eta\upsilon}$ are all significant. The standard deviation for the sales shock is 3.01 which represents approximately 33 percent of the mean of log of home sales. Similarly, with the value for σ_{υ} and $\sigma_{\eta\upsilon}$ we can compute a value for $\sigma_{\varepsilon}=2.37$, which is about 26 percent of the mean of log of home sales. The correlation between the shocks is -0.40. [75]

Entry hurdles. Figure 5 (as well as Table 3) shows the estimated cutoffs M_{nE} and M_{nI} (normalized by absorption). The graph indicates that firms in the data must in general be larger and more efficient at home in order to expand into more remote markets. Note that this result is entirely data-driven, because the reduced form equations put no particular structure on the fixed effects M_{nE} and M_{nI}. This result is consistent with the patterns described in Eaton, Kortum, and Kramarz (2010) for French exporters.

Furthermore, the threshold for conducting MP is much higher than for exports, indicating that MP firms are substantially more productive than exporters and non-exporters. The MP threshold is 140 times higher than the export cutoff, in terms of domestic sales (the median across destinations, not logs)[76]. The entry hurdles M_{nv}, however, confound the variable and fixed costs of trade.

Export and MP fixed costs. To clarify the importance of fixed cost we use equations (19) and (20) to recover f_{nI} and f_{nE}, measured relative to the fixed cost of exporting to Sweden.[77] Figure 6 (and Table 3) shows a number of interesting patterns. First, fixed costs of exporting are broadly increasing in distance, while MP costs are fairly constant across destinations.[78] This suggests that fixed costs of MP are indeed less related to distance than fixed costs of export. Hence, other explanations for gravity for MP are needed. Second, median MP fixed costs are about 700 times higher than export costs to Sweden. Third, by comparing Figure 6 with Figure

[75] Our results are consistent with the prediction of Arkolakis (2008) model, i.e. firms that sustain higher fixed costs are able to reach a larger fraction of consumers (recall that, in our framework, a *lower* entry shock ε_n is associated with a higher entry fixed cost).

[76] Tomiura (2007) shows that firm productivity varies with the choice of globalization modes and concludes that FDI firms are distinctly more productive than foreign outsourcers and exporters, which in turn are more productive than domestic firms.

[77] Note that this measure is independent of the elasticity of substitution σ. If, instead, we set a value for σ we obtain an estimate of the absolute level of the fixed costs. For example, if $\sigma=8$ then the fixed cost of exporting to Sweden is \$2136. To find f_{inI} recall that $f_{inI}=\Omega_n\left(d_n^{\psi_1}-1\right)+f_{inE}$. Here and below, ψ_2 (and hence ρ_2), the coefficient for relative wages w_{in}, is dropped because it is not significantly different from zero.

[78] A careful examination of Figure 6, reveals that the relationship between fixed costs of MP and distance varies along the distance range. Regressing the export fixed cost index on distance, GDP/capita, GDP, and the World Bank's Doing Business ranking (all in logs) shows that distance and GDP increases fixed export costs with an elasticity of 0.28 and 0.08 respectively, whereas GDP/capita decreases fixed costs with an elasticity of -0.49 (all significant at the 0.1 level). The Doing Business indicator is insignificant, but turns significant if we drop the GDP variables. Regressing the MP fixed costs index on the same variables yields insignificant estimates for all covariates.

5 we can now better understand why is it difficult to enter a foreign market. From Figure 6 we observe, for example, that even though Mexico has the highest M_E, fixed costs there are fairly average. This suggests that entry is difficult in Mexico because it is a remote and small market (as proxied by export sales potential κ_n) , not because fixed costs are particularly high. Conversely, Sweden has the lowest M_E, which we find is due to both low fixed costs as well as a high export sales potential κ_n (because of the proximity to the market). However, the fixed costs of MP to Sweden are not particularly low.[79]

Are fixed costs increasing with trade barriers? We also conduct a formal test of the null hypothesis that fixed costs are increasing with trade barriers. Specifically, we estimate a restricted model where $f_{nI} = Ad_n^{\rho_{3I}}$ and $f_{nE} = d_n^{\rho_{3E}}$ and perform a likelihood ratio test between the restricted and unrestricted models. Since fixed costs only affect the extensive margin of trade, the equations for the intensive margin (firm-level sales) remain unchanged. On the extensive margin, M_{nE} and M_{nI} become

$$\begin{aligned} M_{nE} &= \ln\sigma - \kappa_n + \rho_{3E}\ln d_n \\ M_{nI} &= \ln\sigma - \kappa_n + \ln\left(Ad_n^{\rho_{3I}} - d_n^{\rho_{3E}}\right) - \ln\left(d_n^{\rho_1\alpha(\sigma-1)} - 1\right) \end{aligned}$$

Hence, we have $2N$ restrictions on the entry hurdles M_{nE} and M_{nI}. Clearly, they cannot be estimated as fixed effects anymore. Also, since the hurdles are functions of κ_n, which are identified in the sales stage of the maximum likelihood, the entry and sales stage system of equations must be estimated simultaneously.

The resulting restricted log likelihood is $75,345$.[80] The likelihood ratio test statistic is $LR = -2\left[l_{restricted}(\widetilde{\vartheta}) - l_{entry}(\vartheta_1^*) - l_{sales}(\vartheta_2^*)\right] = 279.8$, which is asymptotically chi-square distributed with $2N$ degrees of freedom under the null hypothesis (the restricted model). The null is rejected at any conventional significance levels.

Potential export and MP sales. Figure 7 (and Table 3) shows the estimates of export sales potential κ_n and MP sales potential $\kappa_n + \alpha\rho_1(\sigma-1)\ln d_n$, normalized by destination absorption. As explained, these are measures of expected firm export/MP sales, for a given efficiency level (we simply set home sales to zero for convenience). The left graph shows a clear downward sloping relationship for exports. Interestingly, the graph for MP (right) is very similar, implying that the estimated parameter $\alpha\rho_1(\sigma-1)$ is not large enough to counteract the gravity relationship. This indicates that intra-firm trade is very high and that trade costs are incurred on a large share of affiliate output, or in other words, that the unit cost of MP is increasing in trade barriers.

[79] Das, Roberts, and Tybout (2007) is the only other paper (to the best of our knowledge) that estimates sunk costs of entry into foreign markets. They propose a dynamic structural model of export supply to study the decision to enter export markets and the decision of how much to sell there. They focus only on exports and not on FDI and estimate sunk cost of entry for three sectors of the Colombian economy (leather products, knitted fabrics, and basic chemicals). Their finding is that sunk costs of export for Colombian firms are substantial.

[80] The estimates for the slope coefficients are $\rho_{3I} = -0.07$ (0.05) $\rho_{3E} = 0.43$ (0.03) (standard errors in parentheses).

5.1.2 Second Stage

The second stage delivers an estimate of α. Table 2 shows that α is estimated to 0.11. This is the estimate when controlling for general equilibrium effects (method III in Section 4.2.3. [81] Methods I and II also yield similar estimates of α.[82] Taken at face value, it means that an affiliate adds only 11 percent of value to the goods it sells. The result is robust to any geographical differences in fixed costs.[83] One interpretation for the low α is that variable trade costs are large between parent and affiliate. In fact, variable costs are so high that the model has problems distinguishing between the geography of exports and affiliate sales. A complimentary interpretation is that affiliate unit costs are increasing in distance, almost with the same rate as for exports. Clearly, there might be additional explanations for the relatively low α. Hence, our estimate can be interpreted as a lower bound on the true α. To offer other explanations is outside the scope of this paper, but our exercise shows that assumptions about fixed costs, for example increasing fixed costs in distance, is insufficient for explaining the data points in this study.

We saw above that gravity for MP emerged if $(\omega_{in}\tau_{in})^{\alpha(\sigma-1)}(1-\alpha) > 1$. The estimate of α together with the results from the MLE indicate that gravity for MP is present for all countries in our sample.

5.1.3 Estimating on different sub-samples

In this section, we investigate whether the results are robust to excluding firms and/or destinations from the sample population. First, we divide the set of destinations into two groups: European OECD countries and non-European ones. One reason for doing so is that European trading partners may be different than other destinations, e.g. due to participation in the European Single Market or cultural proximity. Second, we hypothesize that the magnitude of intra-firm trade may be different across industries. Therefore, we estimate separately on firms from four different 2-digit industries: NACE sectors 21, 24, 29 and 31.[84] These are the four sectors with the maximum number of firm-destination pairs with positive MP.[85]

The results are summarized in Table 4. The point estimates of α are similar in the EU and non-EU estimates, underscoring the robustness of the results. As expected, we observe significant heterogeneity in α across industries. The point estimates are in the lower end of the $[0, 1]$ interval. However, the number of observations per sector

[81] We report the average α over $\sigma \in [2, 15]$. The value of α was more or less unchanged for any choice of σ.

[82] E.g. the estimate of $\alpha\rho_1(\sigma-1) = 0.12$ divided by a distance coefficient from a gravity regression of 1.00 yields $\alpha = 0.12$ (method I).

[83] Below, we evaluate a scenario where entry patterns are unchanged, but $\alpha = 1$.

[84] NACE 21=Manufacture of pulp, paper and paper products, 24=Manufacture of chemicals and chemical products, 29=Manufacture of machinery and equipment, and 31=Manufacture of electrical machinery and apparatus.

[85] We limit the set of destinations so that each market has at least one MP observation (per industry). The set of destinations then becomes: Canada, Denmark, Finland, France, Germany, Ireland, Netherlands, Poland, Spain, Sweden and the United Kingdom.

is relatively low, giving large standard errors. As a consequence, we cannot reject the hypothesis that the estimated α's are equal across industries.

5.1.4 How Important is the Selection Bias?

We evaluate the importance of the selection bias through the following procedure. First we choose a set of structural parameters ϑ. Then, we generate a set of errors $\ln \varepsilon_n(j)$ and $\ln \eta_n^*(j)$ for all firm-destination pairs in our data set and create entry and sales patterns based on i) ϑ, ii) the random draws and iii) the data for domestic sales s_H as well as absorption Y_n and distance d_n. Finally, we estimate the model based on the artificial data set and compare the estimated parameters with and without the selection equation.

Table 5 shows an example of our guess of ϑ along with the recovered parameters $\widehat{\vartheta}$. The recovered parameters are estimated under (a) our main model and (b) a model that does not control for unobserved selection. The coefficients under (a) are in general very close to the true values, showing that identification is successful and that the parameter values are recovered with high accuracy. Under model (b) however, the sales potential κ_n, $\alpha\rho_1(\sigma-1)$ and the extent of intra-firm trade α are severely biased[86]. The κ_n's are too high, meaning that we would overpredict trade flows and erroneously conclude that trade barriers are low. The bias of $\alpha\rho_1(\sigma-1)$ shows that intra-firm trade would be underestimated (the share of local inputs in affiliate total costs would be overestimated).

5.2 Model Evaluation

We compute traditional ML measures to evaluate goodness of fit. We calculate the likelihood ratio index $1 - l_{entry}(\vartheta_1^*)/l_{entry}(\widetilde{\vartheta}_1)$, where $l_{entry}(\vartheta_1^*)$ is the log likelihood at the estimated parameters and $l_{entry}(\widetilde{\vartheta}_1)$ is its value if domestic sales $s_H(j)$ had no explanatory power. We perform the same calculation for $l_{sales}()$. The likelihood ratio index turns out to be 0.77 and 0.41 in the entry and sales models, respectively, indicating that home sales are in fact affecting both intensive and extensive margins. We also calculate $1 - l_{entry}(\vartheta_1^*)/l_{entry}(0)$, where $l_{entry}(0)$ means that all parameters, including the fixed effects, are set to zero as well. Then the index becomes 0.93 and 0.84. All in all, these tests show that our econometric model is able to capture a substantial share of the variation in the data.

We also evaluate how well the model can predict important moments in the data. We compare predicted with actual entry and sales patterns for both exports and MP. We use equations (14) and (15) to compute the number of firms that, according to our model, belong to nonexporters, exporters or multinationals categories, by destination. Entry is determined based on the actual value of home sales $s_H(j)$ and 200 random draws of the shocks $\varepsilon_n(j)$ and $\eta_n^*(j)$ per firm and destination. Then, conditional on entry, we compute firm-level sales in each market using equations (16) and (17).

[86]Note that selection bias will occur as long as shocks in the entry and sales equations (υ and η^*) are correlated. Our structural model implies that $cov(\upsilon_n, \eta_n^*) = cov(\eta_n^* + \varepsilon_n, \eta_n^*) = \sigma_{\eta^*}^2 + \sigma_{\varepsilon\eta^*}$.

Predicting entry and sales. Figure 8 plots the actual number of firms entering in different markets versus the values predicted by the model. The model captures very well entry for both exports and MP. Likewise, Figure 9 depicts simulated and actual total sales for exporters and MP firms across markets. The fit is less tight compared to the entry graph. In particular, total MP is overpredicted for many destinations. Overall, the model picks up quite well the decline of total affiliate sales with distance that we showed in Section 2 and the positive relationship between aggregate affiliate sales and the size of the destination country.

Out-of-sample prediction of intra-firm trade. Recall that in our estimation we disregard export data of companies that undertake both export and MP to the same destination. If the exports of an MP firm are truly intra-firm trade, we discard important information in the ML estimation. However, we believe that there are large measurement errors associated with intra-firm trade, due to i) uncertainty related to transfer pricing and ii) the fact that service exports are omitted in our export data.[87] In many cases the export flows are probably not intra-firm trade, but different products.[88] Our model is silent on the possibility that a firm exports and establishes a plant in the same country. To test how important this potential omission is, we compare predicted intra-firm sales with reported export sales for those firms that both export and undertake MP in the same country. First, we select the subset of firms that exports and conducts MP to the same destination. Then we simulate export and MP entry for the selected firms and count as a success the event that a firm enters to the destination that is actually reported in the data. Then we compute affiliate sales and intra-firm sales for these firms using equation (7).

Figure 10 shows actual exports versus predicted intra-firm sales. For most observations the model predicts intra-firm sales that are greater than actual exports, suggesting the presence of "invisible" intra-firm exports, such as services, which are not included in the manufacturing trade data. For a smaller number of firms the model predicts intra-firm sales that are lower than reported exports (below ther 45 degree line). This suggests that a minority of firms service a market through both exports and MP, requiring a more complex model.

6 Implications of the Model

We have shown that our estimated model is consistent with entry patterns and captures fairly well the relationships between export and affiliate sales, distance and destination market size. In this section we perform some numerical experiments. First, we study the importance of vertical integration for explaining aggregate patterns of MP. Then we study how welfare, export flows and domestic labor demand respond when the costs of MP become prohibitively high. We are particularly interested in understanding how those firms that switch from MP to export adjust employment in their domestic plants.

[87] See Bernard, Jensen, and Schott (2006).

[88] See recent evidence on multiproduct firms such as Bernard, Jensen, and Redding (2007).

6.1 The Importance of Intra-firm Trade

In our first experiment we study the behavior of firms' exports and MP in the case of no vertical integration ($\alpha = 1$). Specifically, we examine how aggregate MP responds to trade barriers when we simulate MP (under $\alpha = 1$) *conditional on* actual entry.[89] We condition on actual entry in order to focus on one mechanism exclusively: the effect of eliminating intra-firm trade on intensive margin MP sales.

Firm-level latent affiliate sales then become, using equation (16)

$$\ln s_{nI}(j) = \kappa_n + \left(\alpha \widehat{\rho_1 (\sigma - 1)} / \widehat{\alpha}\right) \ln d_n + \ln s_H(j) + \ln \eta_n^*(j)$$

where $\widehat{\alpha}$ is the estimate of α found in the previous section. Firm-level sales are now invariant with distance because $\rho_1 (\sigma - 1) \ln d_n$ embedded in κ_n cancels out. In other words, we take the observed entry patterns for MP and check what our model would predict for total affiliate sales if variable trade costs did not affect firms' affiliate sales. Figure 11 shows actual and predicted affiliate sales given $\alpha = 1$. Predicted affiliate sales are much higher than actual ones and they are not negatively related with distance. This clearly shows that even if there is gravity on the extensive margin (entry), this is *insufficient* to generate gravity for total affiliate sales. Hence, we need variable trade costs in MP in order to explain this feature of the data.

6.2 Prohibitive Barriers to MP

Next, we use our model to explore the implications of severe restrictions on MP activity, modeled as a complete shutdown of MP. We explore the effects on welfare, trade and labor demand.

Welfare. The change in the price index P_n, and therefore the change in welfare, can be found by imposing an MP entry hurdle so high that no firm will enter, $M_{nI} \to \infty$ for all n. Results are presented in Table 6. The decline in welfare, averaged across destination markets, is between zero and 3.6 percent, and the effect is stronger for low values of $\sigma \in [2, 15]$. The relatively small adverse impact is related to the large amounts of intra-firm trade associated with MP: firms switching from MP to exports will not increase their prices by much because trade costs were already incurred on a large share of their output. The correlation between welfare loss and market size is negative - larger markets are generally less affected by limiting MP.

Trade. We simulate the model by i) using estimated parameter values and actual data for domestic sales, ii) drawing 200 random shocks per firm per destination, iii) determining export and MP entry and sales for two cases: the baseline case and the MP shutdown case. Entry hurdles and firm sales change according to $dM_{nI} = \infty$, $dM_{nE} = -d\kappa_n$ and $d \ln s_{nE}(j) = (\sigma - 1) dP_n$, and $d \ln s_H = (\sigma - 1) P_H$ where $d\kappa_n = (\sigma - 1) d \ln (P_n / P_H)$. Note that we account for endogenous changes in home sales. Restricting MP has large effects on final goods trade flows. Letting firms switch from MP to exports yields a 95 percent increase in final goods exports, averaged across

[89] I.e. we calculate predicted MP for the firms that are MP entrants in the data set.

markets.[90] Although the number of MP firms is small, they are located in the right tail of the productivity distribution, which translates into large export volumes. Due to higher price indices in every market, incumbent exporters also increase their sales. But this effect is significantly smaller, contributing to approximately 3 percent more exports, averaged across markets.

Labor demand. What is the impact of prohibitive MP barriers on multinationals' domestic labor demand? Prohibitive costs of multinational production force firms to reallocate labor to the home country. On the other hand, costs will increase, depressing sales. A priori, therefore, net labor demand from multinationals could go both ways.[91][92] Knowing that variable domestic exporting and MP costs are $s_{nE}(j)(\sigma-1)/\sigma$ and $s_{nI}(j)(1-\alpha)(\sigma-1)/\sigma$ per firm per destination, we can compare aggregate labor costs for MP firms forced to relocate at home. The resulting change in domestic labor expenditure for this subset of firms is then

$$\frac{\sum_n \sum_j s_{nE}(j)}{(1-\alpha)\sum_n \sum_j s_{nI}(j)}$$

where the summation is performed over the firm-destination pairs that conducted MP in the baseline case. Our simulation shows that domestic labor expenditure for the firms that switch from MP to export falls by as much as 54 percent. Why do the switching firms reduce their domestic labor demand? First, domestic labor use will *decrease* because switching to exports entails higher marginal costs and prices, and therefore reduced sales. Second, home labor demand will *increase* because some labor is reallocated from subsidiaries to the headquarter. However, the large amount of intra-firm trade means that the second effect is not strong enough to counteract the first effect. Hence, we conclude that there are indeed negative labor market effects of impeding MP because the largest firms in the economy significantly scale back their operations.

7 Conclusions

Despite numerous studies on the location of multinational production and its economic significance, there is little evidence on the interaction between exporting and MP at the firm level. We study this issue by structurally estimating a new trade model where heterogenous firms enter foreign markets either by exporting or by foreign direct investment, headquarters and affiliates are vertically integrated, and entry and

[90] The increase in total exports, i.e. including the reduction in intrafirm trade, is between 30 and 36 percent, depending on the choice of $\sigma \in [2, 15]$.

[91] Since there is no unemployment in the model, changes in multinationals' labor demand is simply absorbed by the homogeneous sector. Nevertheless, we believe that this particular set of firms is of particular interest, since multinationals are different than other firms along a wide range of dimensions, see e.g. Bernard, Jensen, and Schott (2005).

[92] This issue is at the center of a recent debate in the U.S. on the reform of the U.S. International Tax System. See for ex. the article "How to Destroy American Jobs" by Matthew J. Slaughter on the Wall Street Journal online of February 3^{rd}, 2010.

sales in a foreign market are dependent on firms' characteristics, as well as on firm- and destination-specific shocks.

We make three main contributions to the literature. First, using a unique data set on manufacturing firms, we describe key regularities about the entry and sales patterns of multinationals across markets. Second, motivated by these stylized facts, we construct a parsimonious model of exports and multinational production, building on Helpman, Melitz, and Yeaple (2004), but modified to allow for vertical integration between headquarters and affiliate. Third, we structurally estimate the model using maximum likelihood.

Strong results emerge from the analysis. Intra-firm trade appears to play a crucial role in shaping the geography of MP. We reject the standard proximity-concentration model where intra-firm trade is zero. This conclusion is robust to any geographical distribution of fixed costs of export and MP. The point estimate of the affiliate cost share related to purchases from the headquarters is about 9/10. We interpret this as an upper bound, and hypothesize that there must be additional mechanisms that dampen MP on the intensive margin. This is the subject of ongoing research. One natural candidate is imperfect transmission of technology between parents and affiliates, either due to imperfect codifiability (see Keller and Yeaple (2009)) or due to higher frictions in the match between firms and workers.

Our counterfactual experiments indicate that impeding MP has strong effects on trade flows but the decline is welfare is not particularly large: shutting down MP completely leads to welfare losses in the range of zero to 3.6 percent, depending on country characteristics. However, we do find that the multinationals affected by these barriers cut their home employment by as much as 50 percent. Hence, reducing barriers to MP may have positive effects on the domestic labor market because outward MP entails a substantial amount of economic activity at home.

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A Appendix

A.1 The Gravity Condition

We saw that gravity for MP prevails if

$$h(\tau_{in}, \alpha) = (\omega_{in}\tau_{in})^{\alpha(\sigma-1)}(1-\alpha) > 1.$$

The function $h(\tau_{in}, \alpha)$ is always increasing in τ_{in}. We find the τ_{in} where the cutoff is neither increasing nor decreasing,

$$\ln \tau^*_{in} = -\ln \omega_{in} - \frac{1}{\alpha(\sigma-1)} \ln(1-\alpha)$$

Differentiating this expression with respect to α,

$$\frac{d \ln \tau^*_{in}}{d\alpha} = \frac{\frac{\alpha}{1-\alpha} + \ln(1-\alpha)}{\alpha^2(\sigma-1)} \equiv q(\alpha)$$

$q(\alpha) \geq 0$ for $\alpha \in [0,1]$ because i) $q(0) = 0$ and ii) $q'(\alpha)$ is positive. Hence, increasing α (decreasing intra-firm trade) yields a higher cutoff value τ^*_{in}. This means that more impediments to trade are needed to ensure gravity if intra-firm trade goes down, or in other words, that gravity is more likely if intra-firm trade is high.

A.2 General Equilibrium

Derivation of the Price Index. The price index is

$$P_n^{1-\sigma} = E_{\varepsilon_n,\eta_n} \sum_i w_i L_i \left[\int_{\bar{z}_{inE}(\varepsilon_n,\eta_n)}^{\bar{z}_{inI}(\varepsilon_n,\eta_n)} \eta_n p_{inE}(z)^{1-\sigma} dG_i(z) + \int_{\bar{z}_{inI}(\varepsilon_n,\eta_n)}^{\infty} \eta_n p_{inI}(z)^{1-\sigma} dG_i(z) \right]$$

where $dG_i(z) = \gamma w_i^\gamma z^{-\gamma-1} dz$ along $[w_i, +\infty)$ with $\gamma > \sigma - 1$. Inserting the equilibrium prices and solving the integrals we get,

$$P_n^{1-\sigma} = \frac{\gamma\left(\frac{\sigma}{\sigma-1}\right)^{1-\sigma}}{\gamma-(\sigma-1)} \sum_i w_i L_i E_{\varepsilon_n,\eta_n} \left\{ \eta_n (w_i \tau_{in})^{1-\sigma} w_i^\gamma \left[\begin{array}{c} \bar{z}_{inI}(\varepsilon_n,\eta_n)^{\sigma-\gamma-1} \left[(\omega_{in}\tau_{in})^{\alpha(\sigma-1)} - 1 \right] \\ +\bar{z}_{inE}(\varepsilon_n,\eta_n)^{\sigma-\gamma-1} \end{array} \right] \right\}.$$

Inserting the equilibrium cutoffs (3) and (4), which are functions of P_n, yields

$$\begin{aligned} P_n^{1-\sigma} &= \delta_1^{\sigma-\gamma-1} \frac{\gamma\left(\frac{\sigma}{\sigma-1}\right)^{1-\sigma}}{\gamma-(\sigma-1)} E\left[(\eta_n\varepsilon_n)^{\gamma/(\sigma-1)-1} \eta_n \right] P_n^{1-\sigma+\gamma} Y_n^{-1+\gamma/(\sigma-1)} \\ &\quad \sum_i w_i L_i \tau_{in}^{-\gamma} \left[\Omega_{in}^{1-\gamma/(\sigma-1)} \left((\omega_{in}\tau_{in})^{\alpha(\sigma-1)} - 1 \right) + f_{inE}^{1-\gamma/(\sigma-1)} \right], \end{aligned}$$

which can be solved for P_n,

$$P_n^{-\gamma} = \delta_2^{-\gamma} Y_n^{-1+\gamma/(\sigma-1)} \frac{Y}{1+\pi} \sum_i \frac{Y_i}{Y} \tau_{in}^{-\gamma} \left[\Omega_{in}^{1-\gamma/(\sigma-1)} \left((\omega_{in}\tau_{in})^{\alpha(\sigma-1)} - 1 \right) + f_{inE}^{1-\gamma/(\sigma-1)} \right]$$

where $\delta_2^{-\gamma} = \delta_1^{\sigma-\gamma-1}\left(\frac{\sigma}{\sigma-1}\right)^{1-\sigma}\frac{\gamma}{\gamma-(\sigma-1)}E\left[(\eta_n\varepsilon_n)^{\gamma/(\sigma-1)-1}\eta_n\right]$ and $Y_i = w_iL_i(1+\pi)$. Hence, using the multilateral resistance variable θ_n defined in the text we obtain

$$P_n = \delta_2 Y_n^{1/\gamma-1/(\sigma-1)}\theta_n\left(\frac{1+\pi}{Y}\right)^{1/\gamma}$$

which is equivalent to expression (8). ■

Proof of Proposition 1 and 2. Aggregate exports (affiliate sales) from i to n is defined as the sum of exports (affiliate sales) of each individual firm with productivity $\bar{z}_{inE}(\varepsilon_n,\eta_n) \leq z \leq \bar{z}_{inI}(\varepsilon_n,\eta_n)$ $(z \geq \bar{z}_{inI}(\varepsilon_n,\eta_n))$,

$$S_{inE} = w_iL_iE_{\varepsilon_n,\eta_n}\int_{\bar{z}_{inE}(\varepsilon_n,\eta_n)}^{\bar{z}_{inI}(\varepsilon_n,\eta_n)} s_{inE}(z,\eta_n)\,dG_i(z), \quad (21)$$

$$S_{inI} = w_iL_iE_{\varepsilon_n,\eta_n}\int_{\bar{z}_{inI}(\varepsilon_n,\eta_n)}^{\infty} s_{inI}(z,\eta_n)\,dG_i(z). \quad (22)$$

From Eqs. (9) and (10) we know the reduced form size of firm level exports and affiliate sales. Using the reduced form expression for the price index we can derive the general equilibrium cutoffs,

$$\bar{z}_{inE}(\varepsilon_n,\eta_n) = \delta_4(1+\pi)^{-1/\gamma}\left(\frac{Y}{Y_n}\right)^{1/\gamma}\frac{w_i\tau_{in}}{\theta_n}f_{inE}^{1/(\sigma-1)}(\eta_n\varepsilon_n)^{-1/(\sigma-1)} \text{ and} \quad (23)$$

$$\bar{z}_{inI}(\varepsilon_n,\eta_n) = \delta_4(1+\pi)^{-1/\gamma}\left(\frac{Y}{Y_n}\right)^{1/\gamma}\frac{w_i\tau_{in}}{\theta_n}\Omega_{in}^{1/(\sigma-1)}(\eta_n\varepsilon_n)^{-1/(\sigma-1)} \quad (24)$$

where $\delta_4 = \delta_1/\delta_2$. Using our assumption about the distribution $G(z)$ of productivity shocks, we can rewrite aggregate exports as[93]

$$\begin{aligned} S_{inE} &= \frac{\gamma}{\gamma-(\sigma-1)}\delta_3\delta_4^{\sigma-\gamma-1}(1+\pi)w_iL_i\frac{Y_n}{Y}\left(\frac{\theta_n}{\tau_{in}}\right)^{\gamma} \\ &\quad \left(f_{inE}^{1-\gamma/(\sigma-1)} - \Omega^{1-\gamma/(\sigma-1)}\right)E\left[(\eta_n\varepsilon_n)^{\gamma/(\sigma-1)-1}\eta_n\right] \\ &= \mu\frac{Y_iY_n}{Y}\left(\frac{\theta_n}{\tau_{in}}\right)^{\gamma}\left(f_{inE}^{1-\gamma/(\sigma-1)} - \Omega_{in}^{1-\gamma/(\sigma-1)}\right). \end{aligned}$$

Similarly, total affiliate sales are

$$S_{inI} = \mu\frac{Y_iY_n}{Y}\left(\frac{\theta_n}{\tau_{in}}\right)^{\gamma}(\omega_{in}\tau_{in})^{\alpha(\sigma-1)}\Omega_{in}^{1-\gamma/(\sigma-1)}.$$

The number of exporters (FDI firms) from i to n is defined as the measure of firms with productivity $\bar{z}_{inE}(\varepsilon_n,\eta_n) \leq z \leq \bar{z}_{inI}(\varepsilon_n,\eta_n)$ $(z \geq \bar{z}_{inI}(\varepsilon_n,\eta_n))$,

$$n_{inE} = w_iL_iE_{\varepsilon_n,\eta_n}\int_{\bar{z}_{inE}(\varepsilon_n,\eta_n)}^{\bar{z}_{inI}(\varepsilon_n,\eta_n)} dG_i(z),$$

$$n_{inI} = w_iL_iE_{\varepsilon_n,\eta_n}\int_{\bar{z}_{inI}(\varepsilon_n,\eta_n)}^{\infty} dG_i(z).$$

[93]Recall that $\delta_3 = \sigma(\delta_2/\delta_1)^{\sigma-1}$.

Using the reduced form expressions for the cutoffs and the Pareto distribution for $G_i(z)$, the number of exporters and the number of FDI firms are

$$\begin{aligned} n_{inE} &= -w_i L_i w_i^{\gamma} E_{\varepsilon_n,\eta_n} \left[\bar{z}_{inI}(\varepsilon_n,\eta_n)^{-\gamma} - \bar{z}_{inE}(\varepsilon_n,\eta_n)^{-\gamma} \right] \\ &= \delta_4^{-\gamma} \frac{Y_i Y_n}{Y} \left(\frac{\theta_n}{\tau_{in}} \right)^{\gamma} \left(f_{inE}^{-\gamma/(\sigma-1)} - \Omega_{in}^{-\gamma/(\sigma-1)} \right) E\left[(\eta_n \varepsilon_n)^{\gamma/(\sigma-1)} \right] \end{aligned}$$

and

$$\begin{aligned} n_{inI} &= w_i L_i w_i^{\gamma} E_{\varepsilon_n,\eta_n} \bar{z}_{inI}(\varepsilon_n,\eta_n)^{-\gamma} \\ &= \delta_4^{-\gamma} \frac{Y_i Y_n}{Y} \left(\frac{\theta_n}{\tau_{in}} \right)^{\gamma} \Omega_{in}^{-\gamma/(\sigma-1)} E\left[(\eta_n \varepsilon_n)^{\gamma/(\sigma-1)} \right]. \end{aligned}$$

■

Derivation of the Dividend per Share . Dividend per share in the economy is defined as $\pi = \Pi / \sum w_i L_i$. Total profits Π include profits from exporting and from affiliate sales,

$$\Pi = \sum_i \sum_n (\pi_{inE} + \pi_{inI}).$$

Profits for country i firms exporting to n are

$$\begin{aligned} \pi_{inE} &= w_i L_i E_{\eta_n,\varepsilon_n} \int_{\bar{z}_{inE}(\varepsilon_n,\eta_n)}^{\bar{z}_{inI}(\varepsilon_n,\eta_n)} \left[\frac{s_{inE}(z,\eta_n)}{\sigma} - \frac{f_{inE}}{\varepsilon_n} \right] dG_i(z) \\ &= \frac{S_{inE}}{\sigma} - n_{inE} f_{inE} \frac{E\varepsilon_n^{\gamma/(\sigma-1)-1}}{E\varepsilon_n^{\gamma/(\sigma-1)}} \end{aligned}$$

and, similarly, profits for country i firms conducting FDI in country n are

$$\pi_{inI} = \frac{S_{inI}}{\sigma} - n_{inI} f_{inI} \frac{E\varepsilon_n^{\gamma/(\sigma-1)-1}}{E\varepsilon_n^{\gamma/(\sigma-1)}}.$$

Total profits are then,

$$\Pi = \sum_i \sum_n \left[\frac{S_{inE} + S_{inI}}{\sigma} - \frac{E\varepsilon_n^{\gamma/(\sigma-1)-1}}{E\varepsilon_n^{\gamma/(\sigma-1)}} (n_{inE} f_{inE} + n_{ini} f_{inI}) \right].$$

Note that the first term $\sum_i (S_{inE} + S_{inI})$ is simply μY_n. The second term, using the expressions found for the number of entrants and summing over i, is

$$\frac{E\varepsilon_n^{\gamma/(\sigma-1)-1}}{E\varepsilon_n^{\gamma/(\sigma-1)}} \sum_i (n_{inE} f_{inE} + n_{inI} f_{inI}) =$$

$$= \frac{\mu}{\sigma} \frac{\gamma - (\sigma-1)}{\gamma} Y_n \theta_n^{\gamma} \sum_i \frac{Y_i}{Y} (w_i \tau_{in})^{-\gamma} \left[\Omega_{in}^{1-\gamma/(\sigma-1)} \left((\omega_{in} \tau_{in})^{\alpha(\sigma-1)} - 1 \right) + f_{inE}^{1-\gamma/(\sigma-1)} \right]$$

$$= \frac{\mu}{\sigma} \frac{\gamma - (\sigma-1)}{\gamma} Y_n$$

where we used the definition of θ_n in the second line. So worldwide profits are

$$\Pi = \sum_n \left[\frac{\mu Y_n}{\sigma} - \frac{\mu}{\sigma} \frac{\gamma - (\sigma - 1)}{\gamma} Y_n \right] = \frac{\mu}{\sigma} \frac{\sigma - 1}{\gamma} Y.$$

Hence, dividends per share are

$$\pi = \Pi / \sum w_i L_i = \frac{\mu}{\sigma} \frac{\sigma - 1}{\gamma} (1 + \pi)$$

where we used $Y = \sum w_i L_i (1 + \pi)$. Finally,

$$\pi = \frac{\frac{\mu}{\sigma} \frac{\sigma - 1}{\gamma}}{1 + \frac{\mu}{\sigma} \frac{\sigma - 1}{\gamma}}.$$

■

A.3 Truncated Normal Distributions

We briefly review results for truncated normals. It can be shown that

$$E\left[\upsilon | M_{nE} - s_H < \upsilon_n < M_{nI} - s_H\right] = \sigma_\upsilon \frac{\phi(\zeta_n^L) - \phi(\zeta_n^U)}{\Phi(\zeta_n^U) - \Phi(\zeta_n^L)}$$

where $\zeta_n^U(j) \equiv \left[M_{nI} - \ln s_H(j)\right] / \sigma_\upsilon$ and $\zeta_n^L(j) \equiv \left[M_{nE} - \ln s_H(j)\right] / \sigma_\upsilon$. Similarly, it can be shown that

$$var\left(\upsilon | M_{nE} - s_H < \upsilon < M_{nI} - s_H\right) = \sigma_\upsilon^2 \left\{ \begin{array}{c} 1 + \frac{\zeta_n^L \phi(\zeta_n^L) - \zeta_n^U \phi(\zeta_n^U)}{\Phi(\zeta_n^U) - \Phi(\zeta_n^L)} \\ - \left[\frac{\phi(\zeta_n^L) - \phi(\zeta_n^U)}{\Phi(\zeta_n^U) - \Phi(\zeta_n^L)} \right]^2 \end{array} \right\}.$$

Note that one-sided truncation is just a special case with $M_{nI} = Inf$,

$$\begin{aligned} E(\omega | M_{nE} - s_H < \upsilon < Inf) &= \sigma_\upsilon \lambda(-\zeta_n^L) \\ var\left(\omega | M_{nE} - s_H < \upsilon < Inf\right) &= \sigma_\upsilon^2 \left[1 + \zeta_n^L \lambda(-\zeta_n^L) - \lambda(-\zeta_n^L)^2\right] \end{aligned}$$

where $\lambda()$ is the inverse Mills ratio, $\lambda(z) \equiv \phi(z)/\Phi(z)$.

We are interested in $E(\ln \eta_n^* | y_{nE} = 1) = E(\ln \eta_n^* | M_{nE} - s_H < \upsilon_n < M_{nI} - s_H)$. υ_n is the sum of two normal random variables and is therefore also normal. The conditional normal distribution is

$$\ln \eta^* | \upsilon \backsim N(\Sigma_{\eta^* \upsilon} \Sigma_{\upsilon\upsilon}^{-1} \upsilon, \Sigma_{\eta^* \eta^*} - \Sigma_{\eta^* \upsilon} \Sigma_{\upsilon\upsilon}^{-1} \Sigma_{\upsilon \eta^*})$$

where Σ_{in} is an element of the covariance matrix. Hence, $\ln \eta^* = \Sigma_{\eta^* \upsilon} \Sigma_{\upsilon\upsilon}^{-1} \upsilon + \xi$, were $\xi \backsim N(0, \Sigma_{\eta^* \eta^*} - \Sigma_{\eta^* \upsilon} \Sigma_{\upsilon\upsilon}^{-1} \Sigma_{\upsilon \eta^*})$. Then we can write

$$\begin{aligned} & E\left[\ln \eta^* | M_{nE} - s_H < \upsilon < M_{nI} - s_H\right] \\ = \; & E\left[\Sigma_{\eta^* \upsilon} \Sigma_{\upsilon\upsilon}^{-1} \upsilon + \xi | M_{nE} - s_H < \upsilon < M_{nI} - s_H\right] \\ = \; & \frac{\sigma_{\eta^*}^2 + \sigma_{\varepsilon \eta^*}}{\sigma_\upsilon^2} E\left[\upsilon | M_{nE} - s_H < \upsilon < M_{nI} - s_H\right] \end{aligned}$$

and

$$
\begin{aligned}
& var\left[\ln \eta^*|M_{nE}-s_H<\upsilon<M_{nI}-s_H\right] \\
= \; & \Sigma_{\eta^*\upsilon}^2\Sigma_{\upsilon\upsilon}^{-2} var\left[\upsilon|M_{nE}-s_H<\upsilon<M_{nI}-s_H\right]+\Sigma_{\eta^*\eta^*}-\Sigma_{\eta^*\upsilon}\Sigma_{\upsilon\upsilon}^{-1}\Sigma_{\upsilon\eta^*} \\
= \; & \left(\frac{\sigma_{\eta^*}^2+\sigma_{\varepsilon\eta^*}}{\sigma_\upsilon^2}\right)^2 var\left[\upsilon|M_{nE}-s_H<\upsilon<M_{nI}-s_H\right]+\sigma_{\eta^*}^2-\frac{\left(\sigma_{\eta^*}^2+\sigma_{\varepsilon\eta^*}\right)^2}{\sigma_\upsilon^2}
\end{aligned}
$$

where we have used that $\Sigma_{\upsilon\eta^*}=cov(\upsilon,\ln\eta^*)=cov(\ln\varepsilon+\ln\eta^*,\ln\eta^*)=\sigma_{\eta^*}^2+\sigma_{\varepsilon\eta^*}$, $\Sigma_{\upsilon\upsilon}=\sigma_\upsilon^2$ and $\Sigma_{\eta^*\eta^*}=\sigma_{\eta^*}^2$. This expression equals $\widetilde{\sigma}_{\eta^*E}^2$ in the main text, while $\widetilde{\sigma}_{\eta^*I}^2$ is similar, but with $var\left[\upsilon|M_{nE}-s_H<\upsilon<M_{nI}-s_H\right]$ replaced with $var\left(\upsilon|M_{nI}-s_H<\upsilon<Inf\right)$.

A.4 Re-Expressing Entry and Sales Equations

Firm j chooses to do FDI in country n if its productivity $z(j)$ is higher than the corresponding firm- and destination-specific FDI cutoff, i.e.

$$
z(j)\geq\bar{z}_{nI}(j)=\delta_1\left[P_n^{\sigma-1}Y_n\varepsilon_n(j)\eta_n(j)\right]^{-1/(\sigma-1)}w_H d_n^{\rho_1}\Omega_n^{1/(\sigma-1)}. \tag{25}
$$

This condition can be re-expressed in terms of home sales. From (13) if firm j sells $s_H(j)$ at home, then its productivity level is

$$
z(j)=s_H(j)^{1/(\sigma-1)}w_H P_H^{-1}\frac{\sigma}{\sigma-1}\left(Y_H\mu\eta_H(j)\right)^{-1/(\sigma-1)}. \tag{26}
$$

Inserting (26) in (25) yields

$$
\begin{aligned}
\left[s_H(j)\varepsilon_n(j)\frac{\eta_n(j)}{\eta_H(j)}\right]^{1/(\sigma-1)} &> \mu^{1/(\sigma-1)}\frac{\sigma-1}{\sigma}\delta_1\frac{P_H}{P_n}d_n^{\rho_1}\Omega_n^{1/(\sigma-1)} \\
s_H(j)\varepsilon_n(j)\eta_n^*(j) &> \sigma\left(\frac{P_H}{P_n}\right)^{\sigma-1}\frac{Y_H}{Y_n}d_n^{\rho_1(\sigma-1)}\Omega_n \\
\ln s_H(j)+\ln\varepsilon_n(j)+\ln\eta_n^*(j) &> \ln\sigma-\kappa_n+\ln\Omega_n\equiv M_{nI}
\end{aligned}
$$

where we have used $\delta_1=(\sigma/\mu)^{1/(\sigma-1)}\sigma/(\sigma-1)$ and $\eta_n^*(j)=\eta_n(j)/\eta_H(j)$ from the second to the third line. Note that the domestic wage w_H cancels out. κ_n is a country fixed effect,

$$
\kappa_n=\ln\frac{Y_n}{Y_H}+(\sigma-1)\ln\frac{P_n}{P_H}-\rho_1(\sigma-1)\ln d_n.
$$

The export entry condition in terms of home sales is derived in a similar way.

A.5 Standard Errors

Standard errors in the main text are robust to serial correlation in the errors. In this section, we describe how we calculate them, following Wooldridge (2001). In general, the likelihood problem can be written as

$$
\min_\vartheta\frac{1}{J}\sum_j q\left(\Delta_j,\vartheta\right)
$$

where $q\left(\Delta_j,\vartheta\right)$ is the (negative) likelihood for firm j, Δ_j is the data for firm j and ϑ is the coefficient vector we would like to estimate. Denote $H\left(\Delta_j,\vartheta\right)$ the Hessian associated with

$q(\Delta_j, \vartheta)$, and $s(\Delta_j, \vartheta)$ the score vector associated with $q(\Delta_j, \vartheta)$. The asymptotic variance of an ML estimator is then $Avar\widehat{\vartheta} = A_0^{-1} B_0 A_0^{-1}/J$, where

$$\begin{aligned} A_0 &= E\left[H(\Delta_j, \vartheta)\right] \\ B_0 &= E\left[s(\Delta_j, \vartheta)\, s(\Delta_j, \vartheta)'\right] \end{aligned}$$

In our context, there may be repeated observations for firm j, depending on whether the firm exports or conducts MP. Hence, A_0 and B_0 becomes

$$\begin{aligned} A_0 &= E\left[\sum_{n \in N_j^e} H(\Delta_{jn}, \vartheta)\right] \\ B_0 &= E\left[\sum_{n \in N_j^e} s(\Delta_{jn}, \vartheta) \sum_{n \in N_j^e} s(\Delta_{jn}, \vartheta)'\right] \end{aligned}$$

where N_j^e denotes the set of destinations summed over for firm j (in $l_{entry}(\vartheta_1)$, $N_j^e = N\ \forall\ j$ whereas for $l_{sales}(\vartheta_2)$, N_j^e will vary). For notational simplicity, define $\widehat{H}_{jn} \equiv H\left(\Delta_{jn}, \widehat{\vartheta}\right)$ and $\widehat{s}_{jn} \equiv s\left(\Delta_{jn}, \widehat{\vartheta}\right)$. We estimate A_0 and B_0 with

$$\begin{aligned} \widehat{A}_0 &= \frac{1}{J}\sum_j \sum_{n \in N_j^e} \widehat{H}_{jn} \\ \widehat{B}_0 &= \frac{1}{J}\sum_j \left[\sum_{n \in N_j^e} \widehat{s}_{jn} \sum_{n \in N_j^e} \widehat{s}'_{jn}\right] \\ &= \frac{1}{J}\sum_j \sum_{n \in N_j^e} \widehat{s}_{jn}\widehat{s}'_{jn} + \frac{1}{J}\sum_j \sum_{n \in N_j^e} \sum_{r \neq n} \widehat{s}_{jr}\widehat{s}'_{jn} \end{aligned}$$

where the second term on the right-hand side accounts for possible serial correlation in the score.

A.6 Analytical Derivatives

A.6.1 Price Index and Distance

Here we show the relationship between the price index (P_n) and variable trade barriers (τ_{in}). As a preliminary step note that Ω_{in}, which measures the cost of FDI relative to exports, is decreasing in τ_{in}:

$$\frac{\partial \ln \Omega_{in}}{\partial \ln \tau_{in}} = -\frac{\alpha(\sigma-1)(\omega_{in}\tau_{in})^{\alpha(\sigma-1)}}{(\omega_{in}\tau_{in})^{\alpha(\sigma-1)} - 1} < 0\ . \tag{27}$$

When a bilateral barrier τ_{in} changes, the price index in the destination country n changes through changes in θ_n. The elasticity of θ_n with respect to τ_{in},

$$\frac{\partial \ln \theta_n}{\partial \ln \tau_{in}} = \theta_n^{\gamma} \frac{Y_i}{Y} \tau_{in}^{-\gamma} \left\{ \Omega_{in}^{-\gamma/(\sigma-1)} (f_{inI} - f_{inE}) \frac{(\omega_{in}\tau_{in})^{\alpha(\sigma-1)}(1-\alpha) - 1}{(\omega_{in}\tau_{in})^{\alpha(\sigma-1)} - 1} + f_{inE}^{1-\frac{\gamma}{\sigma-1}} \right\}$$

is positive if

$$\Omega_{in}^{1-\gamma/(\sigma-1)} (\omega_{in}\tau_{in})^{\alpha(\sigma-1)} (1-\alpha) + f_{inE}^{1-\frac{\gamma}{\sigma-1}} - \Omega_{in}^{1-\gamma/(\sigma-1)} > 0\ .$$

Note that: i) $\Omega_{in}^{1-\gamma/(\sigma-1)} (\omega_{in}\tau_{in})^{\alpha(\sigma-1)} (1-\alpha) > 0$ since we assume $(\omega_{in}\tau_{in})^{\alpha(\sigma-1)} - 1 > 0$ and ii) $f_{inE}^{1-\gamma/(\sigma-1)} - \Omega_{in}^{1-\gamma/(\sigma-1)} > 0$ requires $f_{inI} > (\omega_{in}\tau_{in})^{\alpha(\sigma-1)} f_{inE}$, which is also assumed and necessary for the export cutoff to be lower than the FDI cutoff. Therefore, the price index P_n is always increasing in τ_{in}.

A.6.2 Entry into Export and MP

Here we show how the number of exporters (n_{inE}) and the number of multinational firms (n_{inI}) depend on variable trade barriers (τ_{in}).

Number of multinational firms. Using (12) and our earlier derivation of $\partial \ln \Omega_{in}/\partial \ln \tau_{in}$ we have,

$$\frac{\partial \ln n_{inI}}{\partial \ln \tau_{in}} = \gamma \left[-\frac{(\omega_{in}\tau_{in})^{\alpha(\sigma-1)} (1-\alpha) - 1}{(\omega_{in}\tau_{in})^{\alpha(\sigma-1)} - 1} + \frac{\partial \ln \theta_n}{\partial \ln \tau_{in}} \right] \tag{28}$$

$$= \gamma \left[-\chi_I + \frac{\partial \ln \theta_n}{\partial \ln \tau_{in}} \right]. \tag{29}$$

where χ_I, as defined above, is the elasticity of the MP cutoff to variable trade barriers. It is now easy to see that, if the gravity condition (6) holds, with no changes via the price index (and θ_n), the number of firms declines with trade barriers. Accounting for the price index as well,

$$\frac{\partial \ln n_{inI}}{\partial \ln \tau_{in}} < 0 \Longleftrightarrow \theta_n^{-\gamma} > (Y_i/Y)\, \tau_{in}^{-\gamma} \left[\Omega_{in}^{-\gamma/(\sigma-1)} (f_{inI} - f_{inE}) + \chi_I^{-1} f_{inE}^{1-\frac{\gamma}{\sigma-1}} \right] \tag{30}$$

where χ_I^{-1}, as shown above, is the inverse of the elasticity of the FDI cutoff with respect to variable trade barriers. Note that $\chi_I^{-1} > 1$ when condition (6) holds. Comparing (30) with the definition of $\theta_n^{-\gamma}$, we see that the number of entrants declines as long as the other (than i) partners of destination n are sizeable with respect to i, meaning that source i must not be important enough to affect P_n. If J is small and χ_I small, the condition may not hold. Numerical simulations show that this is unlikely, however. Intuitively, the number of entrants declines with trade barriers as long as the increase in the price index (which is favorable from the firm's point of view) is not larger than the increase in barriers (which is unfavorable from the firm's point of view). When there is no parent-affiliate trade ($\alpha = 1$), both terms of condition (28) are positive, so that the number of multinational firms is clearly increasing in variable trade barriers.

Number of exporters. Using (11), the relationship between the number of exporters and variable trade barriers is

$$\frac{\partial \ln n_{inE}}{\partial \ln \tau_{in}} = \gamma \left(\frac{\partial \ln \theta_n}{\partial \ln \tau_{in}} - 1 \right) - \frac{1}{f_{inE}^{-\gamma/(\sigma-1)} - \Omega_{in}^{-\gamma/(\sigma-1)}} \frac{\partial \Omega_{in}^{-\gamma/(\sigma-1)}}{\partial \ln \tau_{in}} .$$

Note that i) the last element of the product term is positive since we showed that $\partial \ln \Omega_{in}/\partial \ln \tau_{in} < 0$ and since $\sigma > 1$, ii) $f_{inE}^{-\gamma/(\sigma-1)} - \Omega_{in}^{-\gamma/(\sigma-1)} > 0$ because we assume $f_{inI} > (\omega_{in}\tau_{in})^{(\sigma-1)} f_{inE}$ (necessary for the export cutoff to be lower than the MP cutoff.). Therefore, in partial equilibrium, the number of exporters is decreasing in variable trade barriers. The expression for the elasticity of the number of exporters to variable trade barriers shown in the main text can be easily derived using (5) and (27)

$$\frac{\partial \ln n_{inE}}{\partial \ln \tau_{in}} = -\gamma - \frac{1}{f_{inE}^{-\gamma/(\sigma-1)} - \Omega_{in}^{-\gamma/(\sigma-1)}} \left(\frac{f_{inI} - f_{inE}}{(\omega_{in}\tau_{in})^{\alpha(\sigma-1)} - 1} \right)^{-\frac{\gamma}{\sigma-1}} \frac{\gamma\alpha\,(\omega_{in}\tau_{in})^{\alpha(\sigma-1)}}{(\omega_{in}\tau_{in})^{\alpha(\sigma-1)} - 1}$$

$$= -\gamma \left[1 + \frac{1-\chi_I}{\left(\frac{\bar{z}_{inI}}{\bar{z}_{inE}}\right)^{\gamma} - 1} \right].$$

A.6.3 Decomposition of Total Exports and Affiliate Sales

Here we show how to decompose total exports into an intensive and an extensive margins. The equivalent decomposition for total affiliate sales is easier, follows Chaney (2008), and is available upon request. Consider the derivative of log total exports as in (21) with respect to variable trade barriers,

$$\frac{d \ln S_{inE}}{d \ln \tau_{in}} = \underbrace{\frac{\tau_{in}}{S_{inE}} w_i L_i E_{\varepsilon_n,\eta_n} \left[\int_{\bar{z}_{inE}(\varepsilon_n,\eta_n)}^{\bar{z}_{inI}(\varepsilon_n,\eta_n)} \frac{\partial s_{inE}(z,\eta_n)}{\partial \tau_{in}} dG_i(z) \right]}_{\text{Intensive-margin}}$$

$$+ \underbrace{\frac{\tau_{in}}{S_{inE}} w_i L_i E_{\varepsilon_n,\eta_n} \left[s_{inE}\left(\bar{z}_{inI}(\varepsilon_n,\eta_n), \eta_n\right) g_i\left(\bar{z}_{inI}(\varepsilon_n,\eta_n)\right) \frac{d\bar{z}_{inI}(\varepsilon_n,\eta_n)}{d\tau_{in}} \right]}_{\text{Extensive-margin}}$$

$$- \underbrace{\frac{\tau_{in}}{S_{inE}} w_i L_i E_{\varepsilon_n,\eta_n} \left[s_{inE}\left(\bar{z}_{inE}(\varepsilon_n,\eta_n), \eta_n\right) g_i\left(\bar{z}_{inE}(\varepsilon_n,\eta_n)\right) \frac{d\bar{z}_{inE}(\varepsilon_n,\eta_n)}{d\tau_{in}} \right]}_{\text{Extensive-margin}}.$$

Intensive margin. The derivative of firm-level latent exports as in (9) with respect to variable trade barriers (assuming that $\partial\theta_n/\partial\tau_{in} = 0$) is,

$$\frac{\partial s_{inE}(z,\eta_n)}{\partial \tau_{in}} = -(\sigma-1)\frac{s_{inE}(z,\eta_n)}{\tau_{in}}.$$

Then the elasticity of the intensive margin with respect to variable trade cost is

$$-\frac{\tau_{in}}{S_{inE}} w_i L_i E_{\varepsilon_n,\eta_n} \int_{\bar{z}_{inE}(\varepsilon_n,\eta_n)}^{\bar{z}_{inI}(\varepsilon_n,\eta_n)} (\sigma-1) \frac{s_{inE}(z,\eta_n)}{\tau_{in}} dG_i(z)$$

$$= -(\sigma-1)\frac{\tau_{in}}{S_{inE}}\frac{S_{inE}}{\tau_{in}} = -(\sigma-1).$$

Extensive margin. Using the definitions of the equilibrium productivity thresholds as in (24) and (23), the derivative of the cutoffs with respect to variable trade barriers are,

$$\frac{d\bar{z}_{inI}(\varepsilon_n,\eta_n)}{d\tau_{in}} = \frac{\bar{z}_{inI}(\varepsilon_n,\eta_n)}{\tau_{in}} \left[1 + \frac{1}{(\sigma-1)} \frac{d\ln\Omega_{in}}{d\ln\tau_{in}} \right] \text{ and}$$

$$\frac{d\bar{z}_{inE}(\varepsilon_n,\eta_n)}{d\tau_{in}} = = \frac{\bar{z}_{inE}(\varepsilon_n,\eta_n)}{\tau_{in}}.$$

Using the definition of firm level exports as in (9) and the definition of the distribution of productivity shocks, aggregate exports can be written as

$$S_{inE} = \frac{w_i L_i}{\gamma - \sigma + 1} E_{\varepsilon_n,\eta_n} \begin{bmatrix} s_{inE}\left(\bar{z}_{inE}\left(\varepsilon_n,\eta_n\right),\eta_n\right) g_i(\bar{z}_{inE}\left(\varepsilon_n,\eta_n\right))\bar{z}_{inE}\left(\varepsilon_n,\eta_n\right) \\ -s_{inE}\left(\bar{z}_{inI}\left(\varepsilon_n,\eta_n\right),\eta_n\right) g_i\left(\bar{z}_{inI}\left(\varepsilon_n,\eta_n\right)\right)\bar{z}_{inI}\left(\varepsilon_n,\eta_n\right) \end{bmatrix}.$$

Using the latter expression and then simplifying, the elasticity of the first term of the extensive margin with respect to variable trade costs can be written as,

$$\begin{aligned} & \frac{\tau_{in}}{S_{inE}} \frac{w_i L_i E_{\varepsilon_n,\eta_n}\left\{s_{inE}\left(\bar{z}_{inI}\left(\varepsilon_n,\eta_n\right),\eta_n\right) g_i\left(\bar{z}_{inI}\left(\varepsilon_n,\eta_n\right)\right)\bar{z}_{inI}\left(\varepsilon_n,\eta_n\right)\left[1+\frac{1}{(\sigma-1)}\frac{d\ln\Omega_{in}}{d\ln\tau_{in}}\right]\right\}}{\tau_{in}} \\ = & \left(\gamma-\sigma+1\right)\left[1+\frac{1}{(\sigma-1)}\frac{d\ln\Omega_{in}}{d\ln\tau_{in}}\right] \frac{E_{\varepsilon_n,\eta_n}\left[s_{inE}\left(\bar{z}_{inI}\left(\varepsilon_n,\eta_n\right),\eta_n\right) g_i\left(\bar{z}_{inI}\left(\varepsilon_n,\eta_n\right)\right)\bar{z}_{inI}\left(\varepsilon_n,\eta_n\right)\right]}{E_{\varepsilon_n,\eta_n}\begin{bmatrix} s_{inE}\left(\bar{z}_{inE}\left(\varepsilon_n,\eta_n\right),\eta_n\right) g_i(\bar{z}_{inE}\left(\varepsilon_n,\eta_n\right))\bar{z}_{inE}\left(\varepsilon_n,\eta_n\right) \\ -s_{inE}\left(\bar{z}_{inI}\left(\varepsilon_n,\eta_n\right),\eta_n\right) g_i\left(\bar{z}_{inI}\left(\varepsilon_n,\eta_n\right)\right)\bar{z}_{inI}\left(\varepsilon_n,\eta_n\right) \end{bmatrix}} \\ = & \left(\gamma-\sigma+1\right)\left[1+\frac{1}{(\sigma-1)}\frac{d\ln\Omega_{in}}{d\ln\tau_{in}}\right] \frac{\Omega_{in}^{\sigma-\gamma-1/(\sigma-1)}}{\left[f_{inE}^{\sigma-\gamma-1/(\sigma-1)} - \Omega_{in}^{\sigma-\gamma-1/(\sigma-1)}\right]}. \end{aligned}$$

Similarly, the elasticity of the second term of the extensive margin with respect to variable trade costs can be written as,

$$\begin{aligned} & -\frac{\tau_{in}}{S_{inE}} w_i L_i \frac{E_{\varepsilon_n,\eta_n}\left[s_{inE}\left(\bar{z}_{inE}\left(\varepsilon_n,\eta_n\right),\eta_n\right) g_i\left(\bar{z}_{inE}\left(\varepsilon_n,\eta_n\right)\right)\bar{z}_{inE}\left(\varepsilon_n,\eta_n\right)\right]}{\tau_{in}} \\ = & -\left(\gamma-\sigma+1\right) \frac{E_{\varepsilon_n,\eta_n}\left[s_{inE}\left(\bar{z}_{inE}\left(\varepsilon_n,\eta_n\right),\eta_n\right) g_i\left(\bar{z}_{inE}\left(\varepsilon_n,\eta_n\right)\right)\bar{z}_{inE}\left(\varepsilon_n,\eta_n\right)\right]}{E_{\varepsilon_n,\eta_n}\begin{bmatrix} s_{inE}\left(\bar{z}_{inE}\left(\varepsilon_n,\eta_n\right),\eta_n\right) g_i(\bar{z}_{inE}\left(\varepsilon_n,\eta_n\right))\bar{z}_{inE}\left(\varepsilon_n,\eta_n\right) \\ -s_{inE}\left(\bar{z}_{inI}\left(\varepsilon_n,\eta_n\right),\eta_n\right) g_i\left(\bar{z}_{inI}\left(\varepsilon_n,\eta_n\right)\right)\bar{z}_{inI}\left(\varepsilon_n,\eta_n\right) \end{bmatrix}} \\ = & -\left(\gamma-\sigma+1\right) \frac{f_{inE}^{\sigma-\gamma-1/(\sigma-1)}}{\left[f_{inE}^{\sigma-\gamma-1/(\sigma-1)} - \Omega_{in}^{\sigma-\gamma-1/(\sigma-1)}\right]}. \end{aligned}$$

Therefore, the elasticity of the extensive margin with respect to variable trade cost is,

$$-\left(\gamma-\sigma+1\right)\left[\frac{1-\chi_I}{\left(\frac{\bar{z}_{inI}}{\bar{z}_{inE}}\right)^{\gamma-\sigma+1} - 1}\right].$$

The expression in the main text can be easily derived using,

$$\left(\frac{\bar{z}_{inI}}{\bar{z}_{inE}}\right)^{\gamma-\sigma+1} = \left(\frac{n_{inI}}{n_{inE}}+1\right)^{\frac{\gamma-\sigma+1}{\gamma}}.$$

A.7 Additional Data Sources

U.S. Total Exports. (Table 1, column 2) U.S. Census Bureau, Foreign Trade Division, Historical Series, Exports by NAICS3 and country to non-related parties, Millions of Dollars;

U.S. Affiliate Sales. (Table 1, in column 3) Bureau of Economic Analysis, U.S. Direct Investment Abroad, All Foreign Affiliates, Total Sales by Industry of Affiliate and Country

(NAICS3), Millions of Dollars, 2002-07;

U.S. Number of Exporters. (Table 1, in column 4) U.S. Department of Commerce, International Trade Administration, Office of Trade and Industry Information, Exporter Database, Number of Exporters by NAICS3 and destination, All exporters, 2007;

U.S. Number of MP Parents. (Table 1, in column 5) Bureau of Economic Analysis, USDIA 2004 Final Benchmark Data, Table I.M 2, Number of U.S. Parents That Had Affiliates in a Given Country and Industry, Country by Industry of Affiliate, 2004;

Distance from the U.S. (Table 1, in column 2-5) distance in miles between capital cities from Bruce Blonigen's data set on Inbound and Outbound US FDI Activity,
`http://www.uoregon.edu/ bruceb/workpap.html`;

Country GDP. (Table 1, in column 2-5) CHELEM database, current GDP in mil. USD, 2002-2007;

Wage index. (Main Econometric Analysis) Bureau of Labor Statistics' International Comparisons of Hourly Compensation Costs in Manufacturing database; the wage index measures nominal compensation costs for production workers in 2004;
`http://www.bls.gov/news.release/ichcc.toc.htm`;

Distance from Norway. (Main Econometric Analysis) CEPII's Trade, Production and Bilateral Protection database (see Mayer, Paillacar, and Zignago (2008)), simple distance between most populated cities, measured in kilometers;

Absorption. (Main Econometric Analysis) OECD's Economic Outlook: Annual and quarterly data Vol. 2008 release 01, total production minus exports plus imports in 2004;
`http://oberon.sourceoecd.org/vl=5146063/cl=12/nw=1/rpsv/ij/oecdstats/16081153/v115n1/s1/p1..`

Table 1: Extensive and Intensive Margins

	Total Exports (2)	Total Affiliate Sales (3)	Number of Exporters (4)	Number of Parents (5)	Firm Exports (6)	Affiliate Sales (7)
GDP (log)	0.42^a	0.29^c	0.43^a	0.50^a	0.31^a	0.15
	(0.000)	(0.062)	(0.000)	(0.000)	(0.000)	(0.124)
Distance (log)	-0.86^a	-0.66^a	-0.24^a	-0.23^b	-0.58^a	-0.25^c
	(0.000)	(0.000)	(0.000)	(0.011)	(0.000)	(0.076)
Industry FE	X	X	X	X		
Firm FE					X	X
Year FE	X	X				
Obs.	918	513	378	328	17,213	369
# Countries	9	9	54	54	29	29
# Industries	17	17	7	7	n.a.	n.a.
# Firms	n.a.	n.a.	n.a.	n.a.	3061	91
R^2	0.76	0.69	0.67	0.51	0.09	0.02

Notes: This table reports the results from different econometric models, estimated using different data sets, discussed in Sections 2.2 and 2.3. The dependent variable (in logs) is listed on top of each column. The data used in columns 2-5 as well as some of the data used in columns 6 and 7 are described in Section A.7. The remaining data used in columns 6 and 7 come from the firm-level database described in Section 2.1. Countries included in the analysis of columns 2 and 3 are: Canada, France, Germany, The Netherlands, United Kingdom, Mexico, Brasil, Australia and Japan. NAICS3 Industries included in the analysis of columns 2 and 3 are: 311-316, 321-327, 331, 333-337, 339. Industries 313-316 have been aggregated due to data availability reasons. NAICS3 Industries included in the analysis of columns 3 and 4 are: 311, 325, and 331-6. Industries 331-332 have been aggregated due to data availability reasons. Standard errors (in parentheses) are clustered at the NAICS3-level in columns 2, 3, 4, and 5, and at the firm-level in columns 6 and 7. R^2 in columns 6 and 7 is the within-R^2. ^{a} $p < 0.01$, ^{b} $p < 0.05$, ^{c} $p < 0.10$

Table 2: Estimates

Parameter	Stage	Estimate	Std. Error
$\alpha\rho_1 (\sigma - 1)$	1^{st}	0.12	(0.03)
$\alpha\rho_2 (\sigma - 1)$	1^{st}	0.01	(0.23)
κ_n	1^{st}	See Table 3	
M_{nE} & M_{nI}	1^{st}	See Table 3	
σ_{η^*}	1^{st}	3.01	(0.02)
σ_{υ}	1^{st}	2.99	(0.04)
$\sigma_{\varepsilon\eta^*}$	1^{st}	-2.86	(0.10)
α	2^{nd}	0.10	(0.03)
$\tilde{\gamma}$	2^{nd}	0.71	(0.50)
$l_{entry}(\vartheta_1)$	1^{st}	$-42,830$	
$l_{sales}(\vartheta_2)$	1^{st}	$-32,375$	
N		28	
J		$7,949$	

Notes: The top panel of this table reports the estimates of all the parameters. The second column indicates whether the estimates are obtained in the 1^{st} or in the 2^{nd} stage of the empirical implementation described in Section 4.1 and 4.2, respectively. Standard errors robust to serial correlation. The reported estimate of α is an average of the estimates over a range of values for σ. The standard error of α is computed using nonparametric boostrapping with sampling with replacement and 200 bootstrap replications. The bottom panel of the table reports the values of the estimated entry and sales log-likelihood functions, described in Section 4.1.2. N is the number of destinations considered and J the number of firms.

Table 3: First-Stage Country-Specific Estimates

	κ_n		M_{nE}		M_{nI}		$ln\,(\sigma f_{nE})$	$ln\,(\sigma f_{nI})$
AT	−9.39	(0.25)	15.21	(0.24)	20.14	(0.64)	5.83	11.12
AU	−9.40	(0.25)	15.31	(0.24)	19.30	(0.44)	5.91	10.74
BE	−8.83	(0.23)	14.49	(0.21)	20.18	(0.59)	5.67	11.67
CA	−9.04	(0.22)	14.91	(0.23)	19.20	(0.49)	5.86	10.81
CH	−9.22	(0.24)	14.77	(0.22)	20.12	(0.56)	5.55	11.28
CZ	−9.77	(0.25)	15.73	(0.26)	19.89	(0.52)	5.96	10.45
DE	−7.54	(0.18)	12.80	(0.15)	18.74	(0.37)	5.26	11.49
DK	−7.35	(0.14)	11.94	(0.11)	18.73	(0.35)	4.60	11.52
ES	−8.53	(0.22)	14.19	(0.20)	19.88	(0.58)	5.66	11.83
FI	−8.07	(0.18)	13.45	(0.18)	19.21	(0.43)	5.37	11.38
FR	−8.18	(0.20)	14.00	(0.19)	19.00	(0.42)	5.82	11.19
GB	−7.39	(0.18)	12.93	(0.14)	18.29	(0.37)	5.54	11.22
GR	−9.63	(0.25)	15.58	(0.26)	21.86	(1.13)	5.95	12.73
HU	−10.41	(0.29)	16.37	(0.30)	21.14	(1.35)	5.96	11.12
IE	−9.62	(0.25)	15.46	(0.24)	19.78	(0.49)	5.84	10.52
IS	−9.38	(0.20)	14.39	(0.22)	21.07	(1.34)	5.01	12.10
IT	−8.35	(0.21)	14.27	(0.20)	19.49	(0.52)	5.91	11.58
JP	−8.63	(0.25)	15.03	(0.21)	19.53	(0.51)	6.40	11.62
KR	−8.85	(0.26)	15.52	(0.25)	20.20	(0.58)	6.67	12.05
MX	−10.82	(0.34)	17.08	(0.38)	20.75	(0.70)	6.26	10.67
NL	−7.98	(0.18)	13.39	(0.18)	19.39	(0.45)	5.41	11.69
NZ	−10.69	(0.30)	16.51	(0.30)	20.68	(0.71)	5.82	10.85
PL	−8.42	(0.21)	14.34	(0.20)	19.04	(0.44)	5.92	10.94
PT	−9.67	(0.27)	15.68	(0.27)	20.61	(0.76)	6.01	11.45
SE	−6.56	(0.14)	11.30	(0.09)	17.86	(0.35)	4.75	11.40
SK	−10.64	(0.32)	16.83	(0.31)	21.25	(0.49)	6.20	10.98
TR	−9.15	(0.27)	15.95	(0.27)	21.85	(1.07)	6.81	13.19
US	−7.77	(0.21)	13.82	(0.20)	18.35	(0.39)	6.05	11.24

Notes: This table reports estimates of the export (κ_n) sales potential, export (M_{ne}) and MP (M_{nI}) cutoffs, and (the log of) the export and MP fixed costs (multiplied by the elasticity of substitution). All estimates are obtained in the first stage of the empirical implementation, as described in Section 4.1. The discussion of the results shown in this table is in Section 5.1.1. Standard errors robust to serial correlation in parentheses.

Table 4: Different subsamples

	EU	non-EU	NACE21	NACE24	NACE29	NACE31
$\alpha\rho_1 (\sigma - 1)$	0.11	0.10	0.15	0.02	0.16	0.37
	(0.03)	(0.04)	(0.15)	(0.09)	(0.11)	(0.12)
$\alpha\rho_2 (\sigma - 1)$	0.01	0.10	0.15	-0.04	-0.04	-0.18
	(0.08)	(0.11)	(0.42)	(0.21)	(0.32)	(0.33)
α	0.09	0.09	0.20	0.02	0.16	0.41
	(0.03)	(0.06)	(0.40)	(0.22)	(0.23)	(0.22)
N	20	8	11	11	11	11
J	7949	7949	68	116	872	230

Notes: Standard errors robust to serial correlation in parentheses. The reported estimate of α is an average of the estimates over a range of values of σ. Full set of estimates available upon request. NACE 21=Manufacture of pulp, paper and paper products, 24=Manufacture of chemicals and chemical products, 29=Manufacture of machinery and equipment, and 31=Manufacture of electrical machinery and apparatus.

Table 5: Selection Bias

Parameter	True Value	Main Model (a)	No Selection (b)
κ_n	-5.43	-5.40	-2.89
M_{nE}	11.61	11.60	11.60
M_{nI}	15.85	15.89	15.89
$\alpha\rho_1 (\sigma - 1)$	0.35	0.36	0.61
α	0.50	0.51	1.48
σ_{η^*}	3.00	3.00	2.44
σ_{ε}	2.00	2.03	4.13
$\sigma_{\varepsilon\eta^*}$	-3.00	-3.00	–

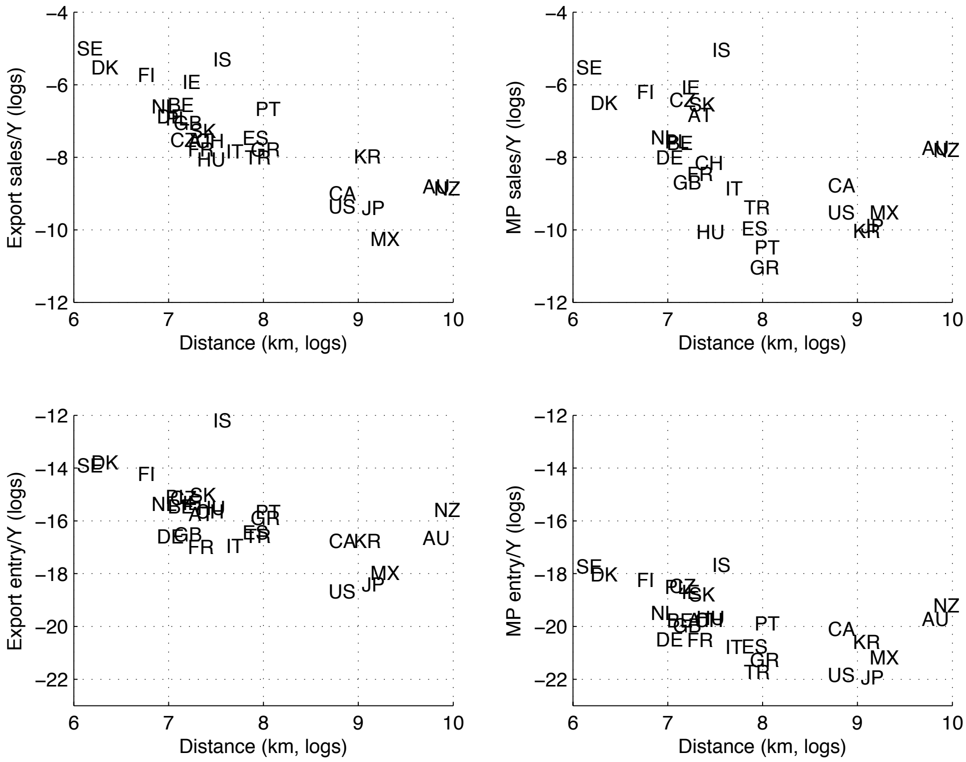
Notes: This table reports parameters estimated under (a) our main model and (b) a model that does not control for unobserved selection using an artificial sample constructed as described in Section 5.1.4. Reported estimates for sales potential κ_n, and entry hurdles M_{nE} and M_{nI} are averages across destinations. The initial parameters for this exercise are $N = 6, \rho_1 = .1$, $\rho_2 = 0$, $\sigma = 8$, $\gamma (\sigma - 1) = 1.1$, $f_{nE} = 0.01$ million and $f_{nI} = 10$ million.

Table 6: Counterfactuals: Prohibitive barriers to MP

	Δ Welfare	Δ Exports due to: *Entrants*	*Incumbents*
AT	−0.40	138.26	2.41
AU	−0.03	157.36	0.16
BE	−0.66	102.16	4.04
CA	−0.17	85.10	1.01
CH	−0.42	154.35	2.57
CZ	−1.07	99.17	6.67
DE	−0.05	103.53	0.33
DK	−0.48	86.95	2.91
ES	−0.07	61.67	0.45
FI	−0.41	114.16	2.52
FR	−0.07	75.30	0.43
GB	−0.06	112.02	0.37
GR	−0.26	11.45	1.56
HU	−0.91	60.60	5.66
IE	−0.71	74.32	4.39
IS	−3.56	49.48	24.27
IT	−0.05	256.18	0.28
JP	−0.01	80.83	0.03
KR	−0.07	63.36	0.42
MX	−0.06	159.61	0.35
NL	−0.38	121.51	2.29
NZ	−0.18	43.66	1.07
PL	−0.35	102.81	2.14
PT	−0.40	19.74	2.46
SE	−0.26	149.61	1.56
SK	−2.38	18.25	15.57
TR	−0.16	40.50	0.94
US	0.00	109.23	0.02
NO	−0.41		
avg	−0.48	94.68	3.10

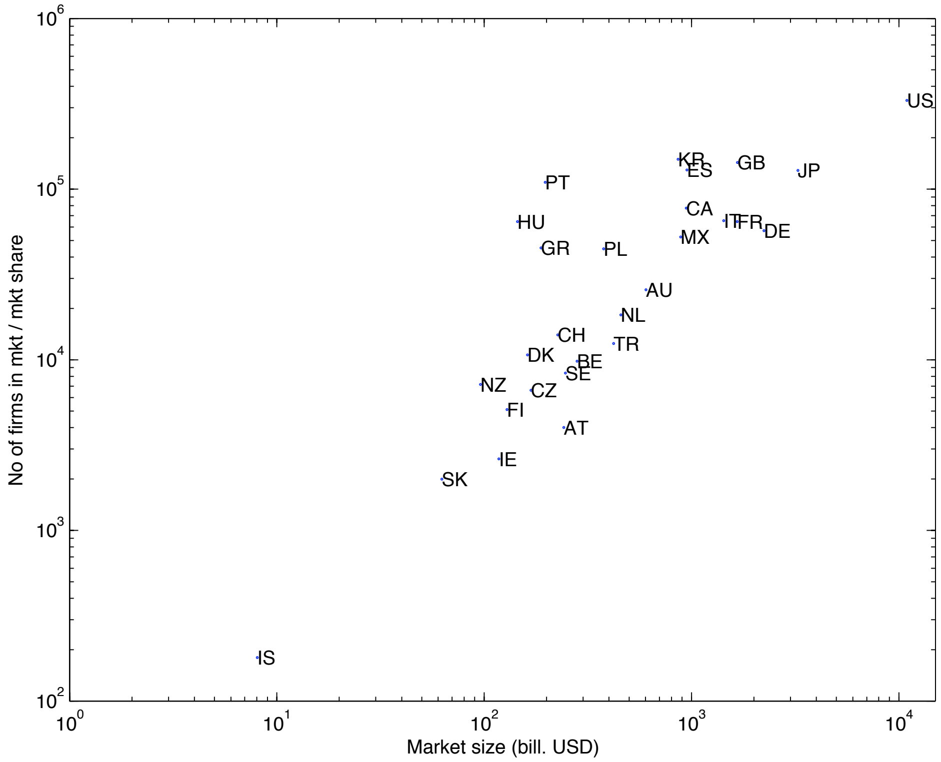
Notes: This table reports the predicted percentage change in welfare and Norwegian exports (due to entrants and incumbents) deriving from a complete shutdown of MP. The counterfactual exercise is describe in Section 6.2. Welfare is calculated under $\sigma = 8$. while the other results are independent of σ.

Figure 1: Gravity for Export and FDI, Overall and Extensive Margin



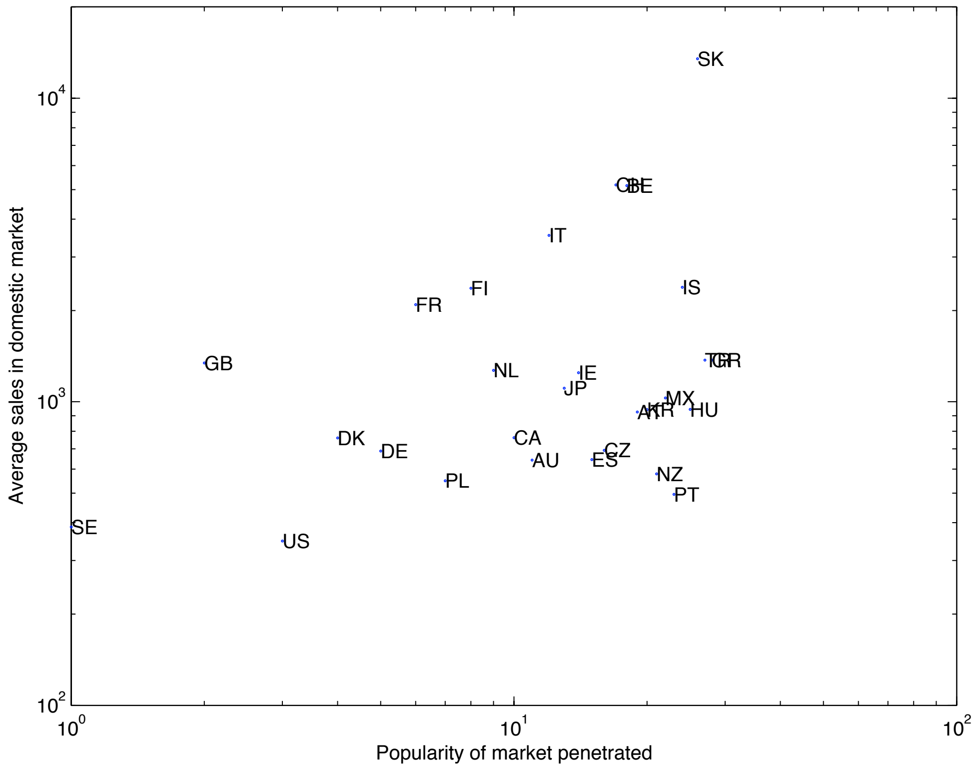
Notes: The top-left panel reports total exports from Norway to different countries, normalized by destination absorption, (on the vertical axis) vs. distance, measured in kilometers, between Norway and the destination (on the horizontal axis). The top-right panel reports a similar relationship but with total affiliate sales (of subsidiaries of Norwegian parents) instead of total exports. The bottom-left panel reports the number of Norwegian exporters to different destinations, normalized by destination absorption, (on the vertical axis) vs. distance, measured in kilometers, between Norway and the destination (on the horizontal axis). The bottom-right panel reports a similar relationship but with the number of Norwegian parents instead of exporters. All quantities are expressed in logs and plotted on a log scale.

Figure 2: Entry and Market Size



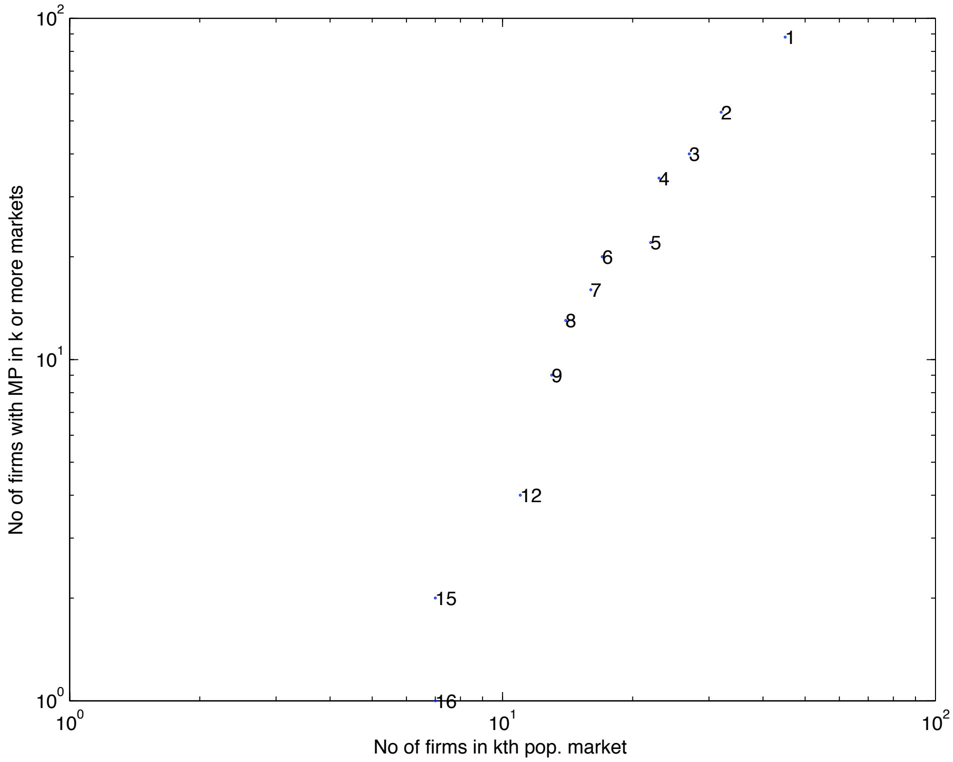
Notes: The graph reports the number of Norwegian affiliates, divided by Norwegian market share, selling in a particular destination (on the vertical axis) vs. the size of the destination market (on the horizontal axis). Norwegian market share is measured as total exports to a destination relative to the destination absorption while market size is absorption measured in billions of U.S. dollars. All quantities are expressed in logs and plotted on a log scale.

Figure 3: Average Sales in Norway and Destination Market Popularity



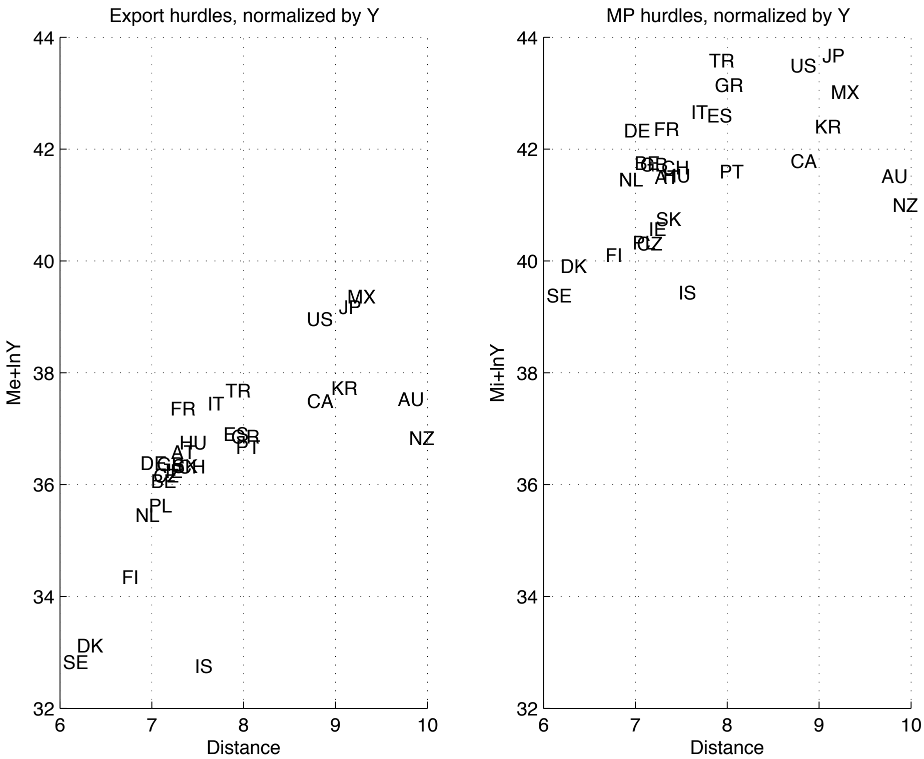
Notes: The graph reports average sales in Norway (on the vertical axis) vs. destination market popularity (on the horizontal axis). Market popularity is measured as the rank in terms of the number of Norwegian-based firms conducting MP to the destination. All quantities are expressed in logs and plotted on a log scale.

Figure 4: Entry market hierarchy for MP



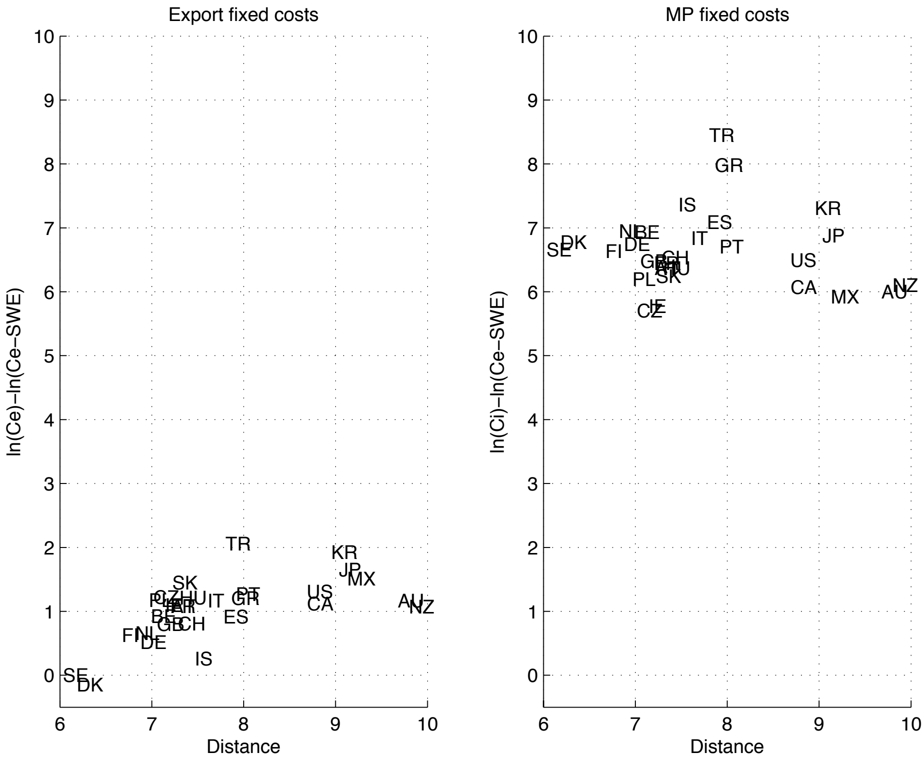
Notes: The graph reports the number of firms engaging in MP in the k^{th} most popular destination (on the horizontal axis) vs. the number of firms engaging in MP in k or more countries (on the vertical axis). All quantities are expressed in logs and plotted on a log scale.

Figure 5: Entry Hurdles



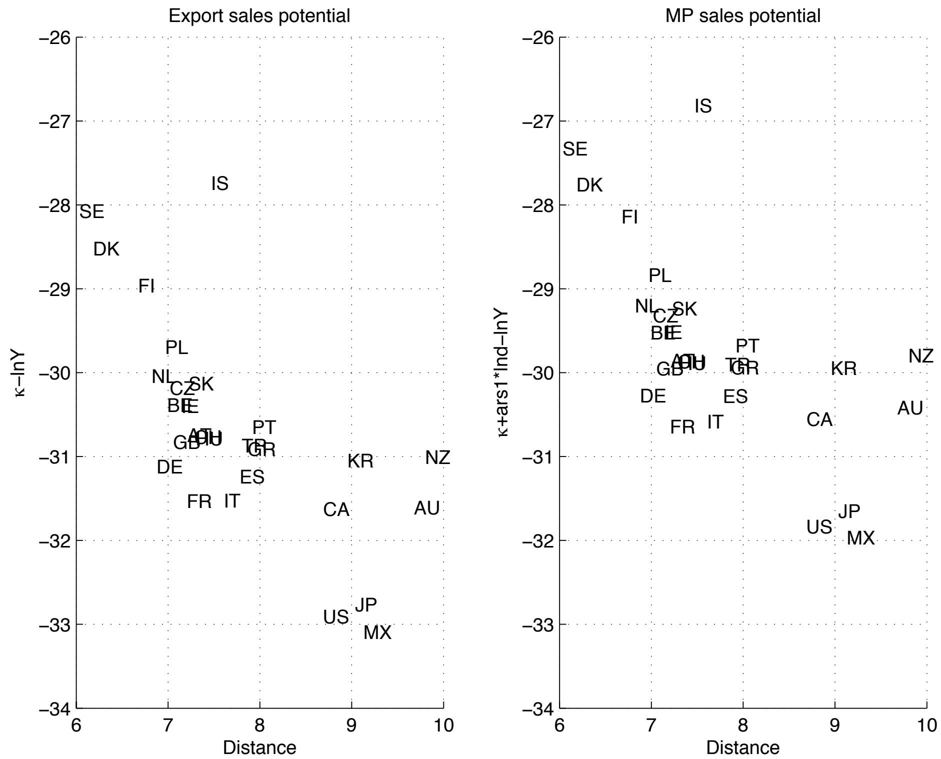
Notes: The graph reports the estimated export (M_{nE}) and MP (M_{nI}) cutoffs, normalized by absorption (on the vertical axis) vs. distance, measured in kilometers, between Norway and the destination (on the horizontal axis). The cutoffs are estimated in the first stage of the empirical implementation, as described in Section 4.1. The discussion of the results shown in this Figure is in Section 5.1.1. All quantities are expressed in logs and plotted on a log scale.

Figure 6: Entry Fixed Costs



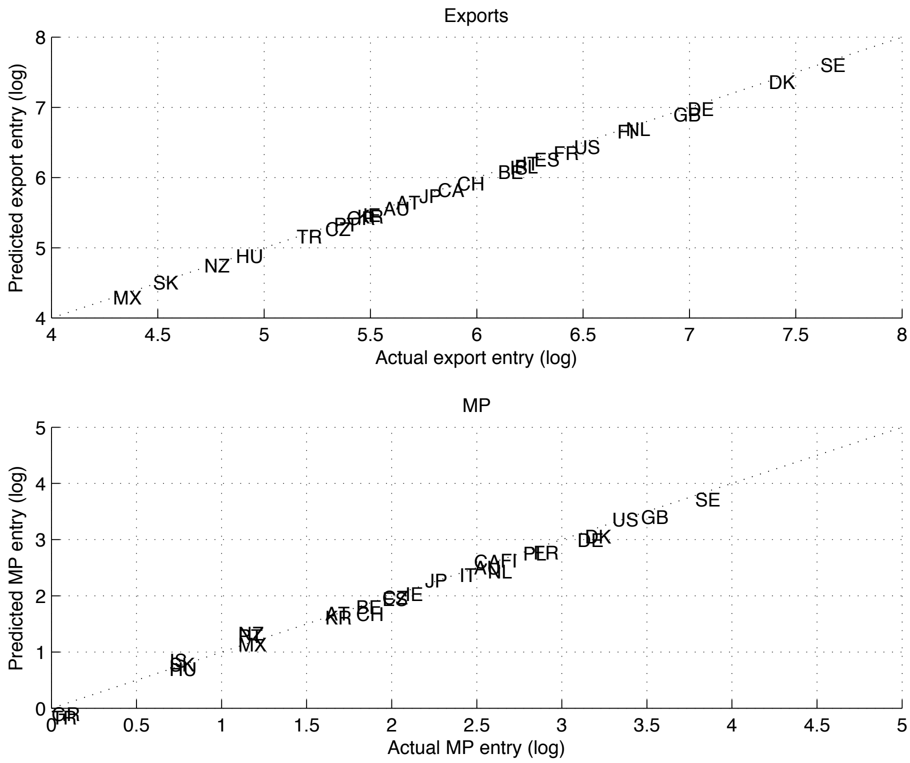
Notes: The graph reports the estimated export (f_{nE}) and MP (f_{nI}) fixed costs, normalized by the fixed cost of exporting to Sweden (on the vertical axis) vs. distance, measured in kilometers, between Norway and the destination (on the horizontal axis). Normalizing by the fixed cost of exporting to Sweden implies that the reported fixed costs are independent of the elasticity of substitution σ. The fixed costs are estimated in the first stage of the empirical implementation, as described in Section 4.1. The discussion of the results shown in this Figure is in Section 5.1.1. All quantities are expressed in logs and plotted on a log scale.

Figure 7: Sales Potential



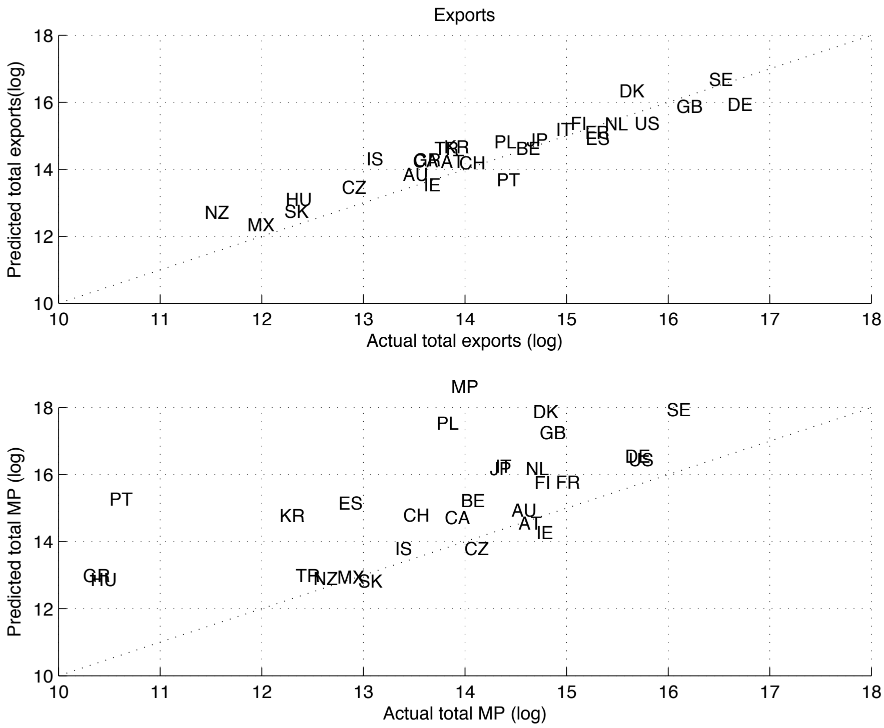
Notes: The graph reports the estimates of export sales potential (κ_n) and MP sales potential ($\kappa_n + \alpha\rho_1(\sigma - 1)\ln d_n$), normalized by destination absorption (on the vertical axis) vs. distance, measured in kilometers, between Norway and the destination (on the horizontal axis). Sales potential for export and MP are estimated in the first stage of the empirical implementation, as described in Section 4.1. The discussion of the results shown in this Figure is in Section 5.1.1. All quantities are expressed in logs and plotted on a log scale.

Figure 8: Actual vs Predicted Entry



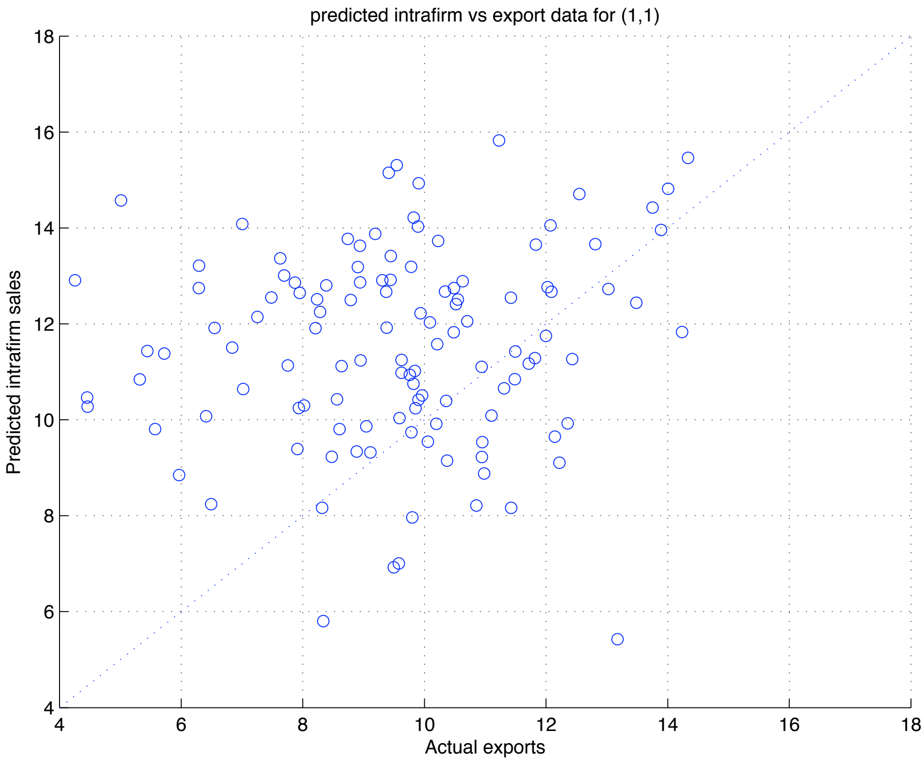
Notes: The graph reports the predicted number of firms entering in different markets (on the vertical axis) vs. the actual number of firms (on the horizontal axis). The top panel reports figures and predictions about the number of exporters while the bottom panel reports figures and predictions about the number of MP parents. Predictions are based on the estimates of the first stage of the empirical implementation described in Section 4.1. The discussion of the results shown in this Figure is in Section 5.2. All quantities are expressed in logs and plotted on a log scale.

Figure 9: Actual vs Predicted Sales



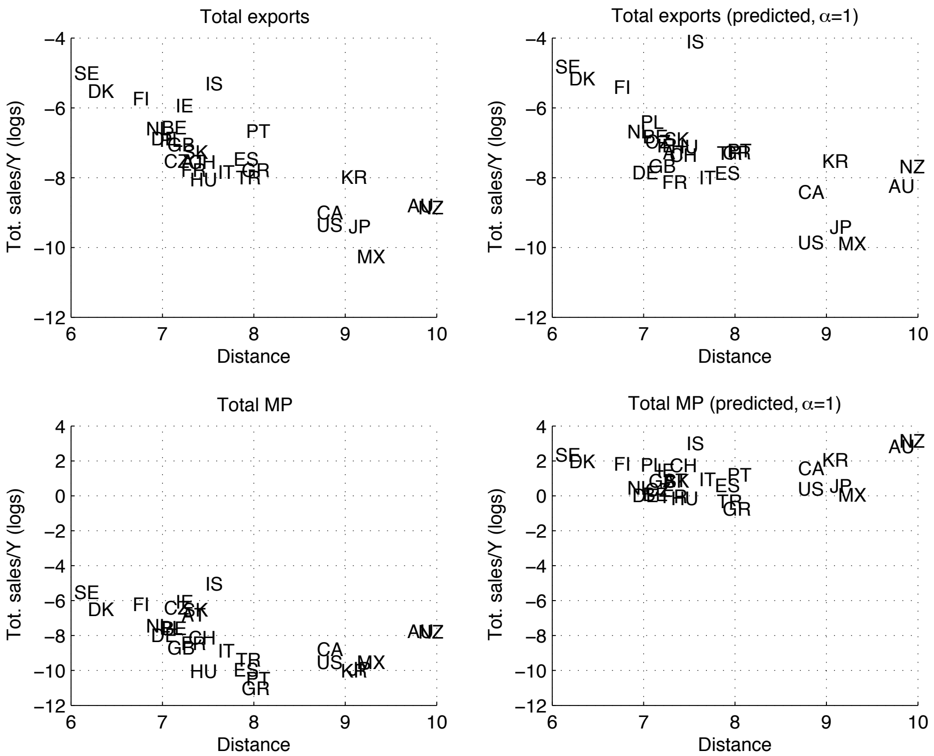
Notes: The graph reports predicted sales by destination (on the vertical axis) vs. actual sales by destination (on the horizontal axis). The top panel reports figures and predictions about exports while the bottom panel reports figures and predictions about affiliate sales. Predictions are based on the estimates of the first stage of the empirical implementation described in Section 4.1. The discussion of the results shown in this Figure is in Section 5.2. All quantities are expressed in logs and plotted on a log scale.

Figure 10: Out-of-Sample Prediction of Intra-Firm Trade



Notes: The graph reports predicted intra-firm sales (on the vertical axis) with reported export sales (on the horizontal axis) for those firms that both export and undertake MP in the same country. Predictions are based on the estimates of the first stage of the empirical implementation (described in Section 4.1) and on the estimate of α obtained in the second stage of the empirical implementation (described in Section 4.2). The discussion of the results shown in this Figure is in Section 5.2. All quantities are expressed in logs and plotted on a log scale.

Figure 11: Actual vs Predicted Sales without Intra-firm Trade



Notes: The graph reports actual (top- and bottom-left panels) and predicted (top- and bottom-right panels) total exports and total affiliate sales (on the vertical axis) vs. distance, measured in kilometers, between Norway and the destination (on the horizontal axis). The top- and bottom-left panels coincide with the top-left and top-right panels, respectively, of Figure 1. Total predicted affiliate sales are computed under the assumption that $\alpha = 1$, i.e. no intra-firm trade. Predictions are based on the estimates of the first stage of the empirical implementation described in Section 4.1. The discussion of the results shown in this Figure is in Section 6.1. All quantities are expressed in logs and plotted on a log scale.