The Margins of Multinational Production and the Role of Intra-firm Trade*

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Abstract

Multinational production (MP) can lead to large gains through international technology sharing. However, empirical evidence suggests that geography matters for MP: Affiliate sales fall in distance from the headquarters. We introduce intra-firm trade into a standard model of exports and MP, and show that the model is consistent with firm-level and aggregate evidence. Using a maximum likelihood estimator, we find that intra-firm trade plays a crucial role in shaping the geography of MP. An implication of our work is that MP and exports are very similar activities. Consequently, shutting down MP leads to relatively small welfare losses.

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 9.5 percent from 1990 to 2006, and by 2010 the value added from multinational corporations amounted to a quarter of global GDP.[2]

This remarkable growth has led researchers to analyze the welfare impact of MP. The gains from opening up to MP are potentially large, since multinationals can use their technology simultaneously in multiple domestic and foreign locations (McGrattan and Prescott (2009)). Yet, even though technology—e.g. the firm's unique know-how, R&D stock and brand name—can be transferred with small marginal cost across locations, empirical evidence suggests that geography matters for MP activity: at the firm-level, affiliates sales strongly decline with distance from the headquarters; at the aggregate level, total MP sales fall with distance from the home country (see Section 2 and Yeaple (2009)).

In the first part of this paper, we propose a simple mechanism that can rationalize these facts, based on three premises. First, as in the previous literature, the firm's technology can be used in any potential location.[3] Investing in new production facilities only entails a fixed cost. For example, given a design for a new central processing unit (CPU), a firm can transform intermediate inputs and raw materials like silicon to the final output at the same rate in any location. Second, the headquarters produce a firm-specific tangible or intangible input, which is required for production in any location, thus giving rise to intra-firm trade between headquarters and affiliates. The importance of tangible intra-firm trade is documented in Bernard et al. (2010), who show that half of U.S. imports occur within the same multinational firm.[4] In their work on U.S. production chains, Syverson,

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

[2]Nominal figures, World Investment Report 2011, UNCTAD, Table I.5.

[3]See e.g. the Markusen and Maskus (2001) survey on the early MP literature.

[4]Hanson, Mataloni, and Slaughter (2005) find that 11 percent of U.S. affiliates' costs are

Atalay, and Hortaçsu (2012) argue that vertical integration is often about transfers of intangible inputs. Managerial oversight, marketing know-how and R&D capital are examples of such headquarters services.[5,6] Third, intra-firm trade is subject to trade costs: transportation costs or tariffs in the case of physical inputs; cultural and geographical remoteness from the headquarters in the case of headquarters services like marketing campaigns and managerial oversight.[7] Together, these three assumptions are sufficient to introduce geography as a determinant of world MP flows.

The model presented in Section 3 is motivated by two additional stylized facts. First, the great majority of affiliate sales are intended for the destination market (i.e. not the home market or third markets), suggesting that market access is an important motive for conducting MP (Chor, Foley, and Manova (2008), and Section 2).[8] Second, only a small share of firms are multinationals, and their sales in the home market rise with conducting MP in less popular destinations, suggesting that heterogeneity in firm efficiency can explain variation in MP entry and sales (Section 2). This leads us to adopt the framework of Helpman, Melitz, and Yeaple (2004), who build a model of horizontal MP and exports with firm heterogeneity. In their model, exporting entails high variable trade costs and low fixed costs, while the opposite holds for MP (the proximity concentration trade-off). Only the largest and most productive firms choose MP, since the variable cost savings are increasing in firm size. We extend Helpman, Melitz, and Yeaple

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related to inputs imported from their headquarters.

[5]For example, Intel's Santa Clara headquarters is home to sales and marketing, legal, supply network and human resources, see `http://www.intel.com/jobs/usa/sites/santaclara`.

[6]Keller and Yeaple (2012) present a theory with both tangible and intangible inputs transferred from the headquarters to affiliate. Helpman (1984) introduces headquarter services in an early model of MP, while Head and Ries (2008) analyze the impact of monitoring costs on bilateral FDI.

[7]In a recent Reuters article, the chief executive of Boeing, Jim McNerney, admitted that their supply chains extended a little too far globally, and that "we lost control in some cases over quality and service when we did that", see `reuters.com/article/2012/02/13/us-usa-manufacturing-onshoring-idUSTRE81C1B720120213`

[8]See also Markusen and Maskus (2001), Markusen and Maskus (2002), Blonigen, Davies, and Head (2003), and Brainard (1997).

(2004)'s framework in two ways. First, we introduce intra-firm trade; without it, total MP sales would increase with distance from the home country, which is inconsistent with the stylized facts. Second, in the spirit of Eaton, Kortum, and Kramarz (2011), we add a stochastic layer to the model, in the form of firm- and destination-specific taste and entry shocks. This becomes useful in the subsequent empirical analysis. Without doubts our model misses some relevant features of MP, like more complex sourcing strategies and export-platform MP (Ramondo and Rodríguez-Clare (2012) and Arkolakis et al. 2011). Nevertheless, our simple extension of the existing theory captures key aspects of export and MP.

In the second part of the paper, we confront the model with data on exports and MP to every OECD destination for the universe of manufacturing firms in Norway. The main objective is to quantify the magnitude of intra-firm trade, which is unobserved in our data. Using the stochastic structure of the model, we derive firm-level gravity equations for export and MP and estimate the model by maximum likelihood (henceforth, ML). We pay extra attention to biases arising due to unobserved selection.[9] Identification of intra-firm trade is reminiscent of a difference-in-differences approach: we calculate the within-firm elasticities of exports and MP with respect to distance; their difference informs us about the magnitude of intra-firm trade. For example, if a firm's final goods exports (MP sales) to the U.S. drop by 20 (10) percent, compared to exports (MP sales) by the same firm to similar markets close to Norway then, *ceteris paribus*, half of the U.S. affiliate's costs are related to inputs from the Norwegian headquarters. The use of within-firm variation for identification—coupled with novel data on exports and MP for the same firm—shows that a firm-level approach to both theory and empirics is essential in our paper. Moreover, it enables us to estimate the model without distributional assumptions about firm heterogeneity.

We make three main contributions to the literature. First, we uncover new firm-level facts about MP. Second, we propose a parsimonious general equilibrium model of exports and MP that extends, in a simple but nontrivial way, existing

[9]MP entrants have unobserved characteristics that influence both entry and sales. Our ML estimator deals with this bias by using a Heckman (1979) selection framework.

models. Third, we develop a new ML estimator that allows us to identify key parameters of the model. We use the estimates to explore and discuss the model's plausibility and implications. For example, using the general equilibrium structure of the model, we examine the welfare impact of MP.

Several strong conclusions emerge from the analysis. First, intra-firm trade plays a crucial role in shaping the geography of MP. The point estimate of the affiliate's cost share related to purchases from the headquarters is about 9/10. This leads us to reject the standard 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 may also capture other mechanisms that are dampening firms' 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 not on welfare: since MP and exports are very similar activities, shutting down MP leads to welfare losses that, across countries, are not higher than 3.6 percent.[10] Moreover, as headquarters inputs are so important, reducing barriers to MP raises home labor demand among the firms that switch from exports to MP.

Our analysis connects to three branches of the literature. First, the literature on welfare gains from trade and MP. Ramondo and Rodríguez-Clare (2012) extend the Ricardian framework of Eaton and Kortum (2002) to include MP, export-platform MP, and intra-firm trade. Consistent with our findings, MP and exports are substitutes and the welfare gains from MP are smaller than in a model without exports. Arkolakis et al. (2011) develop a stochastic monopolistic competition model of trade and (potentially export-platform) MP where firm entry is endogenous and openness affects the location of innovation and real wages. Garetto (2012) studies a model of vertical MP where affiliates ship intermediates back to the parent. While these studies largely rely on aggregate evidence, we use firm-level data on MP and exports to propose a specific mechanism for why the curse of distance

[10]We estimate the model based on exports and MP to OECD countries, and the welfare effects could potentially be different for non-OECD countries. However, OECD is by far the largest destination market for Norwegian firms (96.8 percent for exports and 80.7 percent for MP).

holds for MP and to quantify its importance. McGrattan and Prescott (2009) also focus on the welfare gains from MP, but do not model the interaction between MP and exports, which we emphasize in this paper.

Second, our work relates to the literature on firm-level heterogeneity, exports, and MP. Besides Helpman, Melitz, and Yeaple (2004) and Eaton, Kortum, and Kramarz (2011), our work relates to Yeaple (2009), who describes U.S. multinational enterprises sales across destinations. Keller and Yeaple (2012) show that affiliate's sales— especially of knowledge-intensive goods—decline with distance from their headquarters. In their model, headquarters can either ship tangible inputs or communicate knowledge to the affiliate; both are subject to a cost. Kleinert and Toubal (2010) document a set of firm-level MP facts and show that a model of horizontal MP with intra-firm trade fits the data well. Compared to our work, they cannot identify intra-firm trade, since they lack data on final goods exports. Another important contribution is Feinberg and Keane (2006), who build a dynamic structural model of U.S multinationals and their Canadian affiliates to study the growth of multinational-based trade. 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 (Blonigen (2001), Clausing (2000), Svensson (1996), Head and Ries (2001), and Desai, Foley, and Hines (2009)). Most of these studies find that FDI and home activity are complements, which is consistent with our finding that higher MP barriers reduce headquarters employment.

The rest of the paper is organized as follows. In Section 2 we document firm-level facts about exports and MP. In Section 3 we lay out the partial equilibrium of our model. Since the subsequent empirical framework is formulated conditional on a set of general equilibrium variables, we only present the features of the model that are relevant for the empirical work. Section 4 describes the estimation strategy and the first set of results. In Section 5 we describe the general equilibrium, while Section 6 presents the remaining empirical methodology and results. Section 7 presents counterfactuals, while Section 8 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 aggregate evidence from U.S. data. 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 is an important determinant of aggregate trade/MP patterns. Third, we show that the facts documented by Eaton, Kortum, and Kramarz (2011) for exports are also valid for MP. These facts provide evidence of the importance of fixed costs of entry and of heterogeneity of firms' productivity. Overall, this section supports 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 $7,949$ 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 arm's-length trade transactions. About 40 per cent of the total number of firms are exporters and, among 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

[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).

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. Among firms conducting MP, the average number of MP destinations was 4.4.[14] 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 countries belonging to the Organisation for Economic Co-operation and Development (OECD), since our theory of horizontal MP is more relevant in the OECD area.[15] Exports (MP) to OECD countries constitute 96.8 (80.7) percent of total Norwegian exports (MP).

2.2 The Extensive Margin of Affiliate Sales

As it 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 MP as well. These patterns are, in part, driven by the extensive margin (bottom panels): both the number of exporters and the number of firms conducting MP are clearly decreasing in distance (after controlling for destination market size).

This pattern is not specific to Norway. Aggregate U.S. data (Table 1, columns

[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] 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.

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

2 and 3) 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 one of total affiliate sales.[16] The extensive margin, again, partly drives these results: both the number of U.S. exporters and MP parents are decreasing with distance (columns 4 and 5).[17]

The strong dampening effect of distance on MP (both overall and at the extensive margin) presents a puzzle: horizontal models of MP (henceforth "HMP models") imply a *positive* relationship both between total affiliate sales and distance and between the number of MP parents and distance; *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 Figure 1 and Table 1 with HMP models would be to conjecture that fixed costs of MP were increasing in distance. The next section shows that, even within the same multinational, affiliates' sales fall as distance from the headquarters rise, suggesting that variation in fixed costs (and hence entry) is not enough to explain the observed micro and macro patterns.

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 46 percent of U.S. imports were intra-firm in 2000. 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 intra-firm. 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.[18]

[16]The Poisson estimator (Silva and Tenreyro (2006))—which accounts for heteroskedasticity in a log-log specification—delivers qualitatively similar results (available upon request).

[17]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.

[18]Evidence on intra-firm trade exists for countries other than the U.S. and Norway as well, see e.g. Corcos et al. (forthcoming) and Ito and Matsuura (2009).

Firm-level data. Our database lacks direct information about intra-firm trade, but it shows clear circumstantial evidence. First, 80 percent of firm-destinations with positive MP also show positive exports.[19] Among those firm-destination pairs, the median ratio of exports to affiliate sales is 0.23.[20] 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 sell less, on average, the further away (from Norway) they are located. In Table 1, column 7 we regress (log) affiliate sales by destination vs. (log) distance and GDP, using firm fixed effects. The estimated distance elasticity is -0.25. A similar regression with firm-level exports as dependent variable (column 6) delivers a distance elasticity of -0.58; a formal test rejects the hypothesis that the coefficients are identical.

The dampening effect of distance on aggregate MP is not just about selection: Even *within* multinationals, MP sales fall as distance from the parent rise.[21] Moreover, the difference in within-firm elasticities (between export and MP) is consistent with the hypothesis that multinationals are vertically integrated and that affiliates are sourcing inputs from their headquarters. In Section 4, we exploit the differential impact of variable trade costs on exports and MP to identify the degree of intra-firm trade implicit in the data.

[19]Preliminary data show that at least 20 percent of Norwegian multinationals transfer goods to their foreign affiliates—recall that our definition of intra-firm trade is broader than trade in goods). These data are incomplete and we exclude them from the estimation of the model.

[20]Using this ratio as an upper bound for the share of intra-firm trade in affiliate output is misleading. 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 data. Moreover, most of the firm-destination pairs in our data are "export-only". This contributes to explaining why aggregate exports are higher than aggregate affiliate sales.

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

2.4 Pure Vertical or Export-Platform MP

Before proceeding, we discuss why we are not considering more complex sourcing strategies such as export-platform MP. Both our data (which lack information on the final destination of affiliate output) and other sources suggest 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 that over 70 percent of U.S. affiliate sales are intended for the destination market. Our update for 2004 suggests that 62 percent of total affiliate output is sold in the destination market.[22]

Firm-level data. Several statistics suggest that pure vertical MP and export-platform MP are not widespread. First, we look at imports by Norwegian multinationals from markets where they also conduct MP and find that the median import/MP sales ratio is just 0.06; 70 percent of these firm-destination pairs have a ratio lower than 0.3. This suggests that foreign plants are not primarily supplying inputs to their headquarters. Second, most MP occurs in countries similar to Norway in terms of wages and relative factor endowments. Production offshoring aimed at exploiting cross-country factor price differences is not the main motive underlying Norwegian MP. Third, the number of MP entrants are increasing in the size of the destination market (see next subsection), 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 headquarters provide inputs to their foreign affiliates and where market access is the main motive behind MP.

[22]We use BEA data but, unlike Chor, Foley, and Manova (2008), we only have access 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 produce a downward bias in the share of affiliate sales that is destined to the host market, since services are in general less tradable than goods.

2.5 Regularities for MP at the Firm Level

Before laying out our model, we show that the facts documented by Eaton, Kortum, and Kramarz (2011) for exports are also valid for MP. In Figures 2, 3, and 4 discussed below, country codes represent MP entrants, whereas crosses represent export entrants.

Number of MP firms and market size. 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 (Figure 2).[23] We divide by market share to condition on other factors determining the number of entrants, such as proximity to the market.[24]

Market popularity and firm size. Average sales in Norway rise with MP in markets with few Norwegian MP entrants. Figure 3 depicts average sales in Norway (on the y-axis) of those firms entering a market with n entrants, where n is reported on the x-axis. The relationship suggests that selling to less popular markets requires higher firm efficiency or quality, which translates into higher domestic sales.[25]

Destinations hierarchy. Firms engaging in MP in the $k+1$st most popular market tend to do so for the kth most popular market as well. Figure 4 plots the number of firms entering the kth most popular destination on the horizontal axis against the number of firms entering 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. As in Eaton, Kortum, and Kramarz (2011), 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. Our model will include firm- and destination-specific shocks to the fixed cost of entry into a market. Moreover, we will also introduce firm- and destination-specific sales shocks (as in Eaton,

[23]Norwegian market share is measured as total exports to destination n relative to country n absorption.

[24]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.

[25]Yeaple (2009) also finds that more efficient firms are more likely to own an affiliate in any given host country.

Kortum, and Kramarz (2011)) to account for the widely documented heterogeneity in export intensity across firms for a given destination.

3 Model

In this section we present a simple model consistent with the stylized facts outlined above. The model, based on Helpman, Melitz, and Yeaple (2004), features firms that face a proximity-concentration trade-off between exporting and MP. The main departure from Helpman, Melitz, and Yeaple (2004) is that affiliates combine locally available inputs with inputs imported from the headquarters. Multinational production therefore requires intra-firm trade. A partial equilibrium version of the model is sufficient to implement the maximum likelihood estimation that represents the first part of our empirical analysis. Later, we present the full model, estimate the remaining parameters, solve for the general equilibrium and perform counterfactuals.

3.1 Consumer Demand

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, used as *numéraire*, 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 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

A firm owns a technology, associated with productivity z. 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 an iceberg trade cost and w_i is wage in country i.[26]

A firm that instead decides to serve country n through foreign direct investment must pay a fixed cost f_{inI}/ε_n.[27] We assume that a firm's technology z is non-rival within the firm, and it can therefore be used in any location. This is a commonly adopted assumption in the literature.[28] One way to think about z is as a set of instructions and procedures to combine raw materials and intermediate inputs in order to produce a final good. However, even if z can be shared across locations, we hypothesize that the affiliate requires a headquarters-specific input to produce. This can be a tangible input embodying technology from the parent firm, or an intangible input such as marketing or human resources services.

The headquarters input is produced by a constant returns to scale production function where one unit of labor yields z units of output. Transferring the input from headquarters to affiliates is subject to trade costs τ_{in}. Hence, the marginal

[26]As common in the literature, we assume that 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 only consider equilibria where every country produces some of the homogeneous good. 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.

[27]Note that the entry shock is identical for export and MP entry. We explore the implications of this restriction in Section 4.1.1.

[28]Yeaple (2009) finds that foreign affiliate sales are increasing in the parent firm's productivity, controlling for country and industry fixed effects.

cost of an input from i in location n is $\tau_{in} w_i / z$. Assuming that the headquarters' input and local labor are combined by a Cobb-Douglas production function, total marginal costs for an affiliate are

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

where $0 \leq \alpha \leq 1$ is the fixed ratio of affiliate labor expenditure to total variable costs. Note that our model collapses to Helpman, Melitz, and Yeaple (2004)'s model when α is equal to one (and there are no sales and entry shocks).

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.

3.3 Entry

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 $s_{inv}(z, \eta_n) = \mu \eta_n Y_n P_n^{\sigma-1} p_{inv}^{1-\sigma}(z)$ are 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 the fixed cost of entering a new market. We define the productivity 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. Solving for $\bar{z}_{inE}$ yields

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

with δ_1 a constant.[29] 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 a firm is indifferent between MP and exports. Solving for $\bar{z}_{inI}$ yields

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

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

where $\omega_{in} = w_i/w_n$ is the wage of country i relative to country n. The term $(f_{inI} - f_{inE})/\left[(\omega_{in}\tau_{in})^{\alpha(\sigma-1)} - 1\right]$ 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 instead of exporting to n. In this sense, this term can be interpreted as the relative cost of MP.

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

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

Assuming $f_{inI}/f_{inE} > (\omega_{in}\tau_{in})^{\alpha(\sigma-1)} > 1$, the MP cutoff is larger than the export cutoff. The first inequality ensures that the fixed costs of MP are sufficiently high so that some firms would rather export than do MP. The second inequality ensures that variable trade costs (or Norwegian relative wages ω_{in}) are sufficiently high so that some firms would rather do MP than export. As a consequence, a firm chooses to export if $\bar{z}_{inE} < z < \bar{z}_{inI}$ and MP if $z > \bar{z}_{inI}$. 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.

3.4 The Extensive Margin and the Role of Intra-Firm Trade

In Section 2.2 we showed that, both in Norwegian and U.S. data, the number of MP entrants (as well as total MP sales) falls with distance. The model predicts this relationship if the MP cutoff rises with τ_{in}. Proposition 1 shows under which conditions the elasticity of the MP cutoff with respect to τ_{in} is positive. For future reference, we denote this elasticity χ_I.[30]

Proposition 1 (Gravity for MP) *The MP cutoff rises with τ_{in} (holding P_n constant)*[31] *if and only if*

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

[30] $\chi_I = \left[(\omega_{in}\tau_{in})^{\alpha(\sigma-1)}(1-\alpha) - 1\right] / \left[(\omega_{in}\tau_{in})^{\alpha(\sigma-1)} - 1\right]$.

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

The MP cutoff rises with trade barriers if intra-firm trade is high (low α): latent variable profits from MP are less elastic to τ_{in} than export profits; [32] however, MP profits are initially higher and, in absolute terms, decline more than export profits. Hence, the MP cutoff will increase with τ_{in} when α is low.

The effect of high trade barriers can be similarly explained (initial high difference between MP and export profits, and lower elasticity of MP profits to variable trade costs). Likewise for the effect of the elasticity of substitution (high σ magnifies the difference in profits between MP and exports).[33] Whenever equation (6) does not hold, MP is rising with variable trade barriers. For example, if α is relatively high and τ is sufficiently small, then substitution between MP and exports dominates, so that higher trade costs make MP more attractive.

It remains to compute the amount of intra-firm trade. We know that $(1-\alpha)$ is the expenditure share for the headquarters good, so intra-firm trade is a fraction $(1-\alpha)$ of total variable costs. Since gross profits are a fraction $1/\sigma$ of sales, intra-firm trade is

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

i.e. proportional to affiliate sales.

4 Empirical Implementation: First Stage ML

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. The main objective is to quantify the magnitude of intra-firm trade, which is unobserved in the data. Using the stochastic structure of the model, we derive firm-level gravity equations for export and MP and then estimate the model by maximum likelihood. Identification of intra-firm trade is reminiscent of a difference-in-differences approach: The difference between the within-firm elasticities of exports

[32] 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 $|1-\sigma+\alpha(\sigma-1)|$.

[33] In Section A.1 we prove that the MP cutoff increases with τ_{in} as long as $\ln\tau_{in} > -\ln\omega_{in} - 1/\alpha\,(\sigma-1)\ln(1-\alpha)$.

and MP with respect to distance informs us about the magnitude of intra-firm trade.

We emphasize two features of the estimation procedure: First, it identifies an index of fixed costs of exporting and MP. Firm entry depends on both fixed and variable costs, while firms sales (conditional on entry) only depend on variable costs. By comparing entry and sales patterns, we obtain an estimate of fixed costs. Second, our estimation is conditional on firms' home sales. This avoids (i) functional form assumptions about the productivity distribution, and (ii) complications related to re-computing the general equilibrium for each set of candidate parameters.

In Sections 5 and 7, we specify the full general equilibrium of the model and perform counterfactuals based on the estimated parameters from this section.

4.1 Data, Sales and Entry Shocks

We use data on export and MP entry, as well as home, export, and affiliate sales for all J Norwegian manufacturing firms in 2004. Following other authors (e.g. Anderson and van Wincoop (2003)), iceberg trade costs are a loglinear function of observables: $\tau_n = d_n^{\rho_1}$, where d_n denotes distance (in kilometers, see Section A.7) between Norway and country n.[34] Moreover, the wage in each country is a loglinear function, with coefficient ρ_2, of a wage index published by the Bureau of Labor Statistics.[35] Finally, both the entry, $\varepsilon_n(j)$, and sales, $\eta_n(j)$, shocks are *iid* lognormally distributed over firms j and destinations n, with, possibly, non-zero correlation within the same firm-destination pair.[36]

4.1.1 Re-Expressing Entry and Sales Equations

Because productivity is not readily observable, we rewrite the equation for export and MP entry and sales in terms of an observable variable, domestic sales.

[34] We drop the subscript i since the source country is always Norway.

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

[36] These distributional assumptions allow us to write the likelihood function in closed form. We report standard errors that are robust to serial correlation, see Section A.5.

Export and MP entry. First, we derive an expression for export entry in terms of home sales. Firm j exports to country n if its productivity is higher than the export cutoff $\bar{z}_{nE}(j)$ from equation (3) but lower than the MP cutoff $\bar{z}_{nI}(j)$ from equation (4). Recalling that home sales are $s_H(j) = \mu_2 \eta_H(j) Y_H w_H^{1-\sigma} z(j)^{\sigma-1} P_H^{\sigma-1}$,[37] we can re-express the entry condition as

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

where the export entry hurdle (in terms of home sales) is $M_{nE} \equiv \ln\sigma - \kappa_n + \ln f_{nE}$, and the MP entry hurdle is $M_{nI} \equiv \ln\sigma - \kappa_n + \ln(f_{nI} - f_{nE}) - \ln\left[(\omega_{in}\tau_{in})^{\alpha(\sigma-1)} - 1\right]$.[38] $\upsilon_n(j)$ is the sum of the entry and sales shocks,[39] while κ_n, which enters into the hurdles M_{nE} and M_{nI}, is a country fixed effect that can be interpreted as export sales potential in market n (see next paragraph),

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

The shocks have homoskedastic variances $\sigma^2_{\eta^*}$ and σ^2_{ε} and their covariance is $\sigma_{\varepsilon\eta^*}$; the composite shock has variance $\sigma^2_{\upsilon} = \sigma^2_{\varepsilon} + \sigma^2_{\eta^*} + 2\sigma_{\varepsilon\eta^*}$. The probability of exporting is $\Phi\left\{[M_{nI} - \ln s_H(j)]/\sigma_\upsilon\right\} - \Phi\left\{[M_{nE} - \ln s_H(j)]/\sigma_\upsilon\right\}$, while the probability of neither exporting nor selling through an affiliate is $\Phi\left\{[M_{nE} - \ln s_H(j)]/\sigma_\upsilon\right\}$, where $\Phi(.)$ denotes the standard normal CDF.

Second, we derive an expression for MP entry. Using the same logic as above, firm j invests in MP in country n if its productivity is higher than the MP cutoff $\bar{z}_{nI}(j)$ from equation (4), so that we can re-express the entry condition as

[37] $\mu_2 = \mu\sigma/(\sigma-1)$.

[38] 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.

[39] $\upsilon_n(j) \equiv \ln\varepsilon_n(j) + \ln\eta^*_n(j)$, where $\eta^*_n = \eta_n(j)/\eta_H(j)$. We have also explored the case when export and MP entry shocks are different, $\varepsilon_{nE} \neq \varepsilon_{nI}$. In that case, the entry condition becomes $\ln s_H - \ln\left(a\varepsilon_{nI}^{-1} - \varepsilon_{nE}^{-1}\right) + \ln(a-1) + \ln\eta^*_n > \ln\sigma - \kappa_n + \ln(f_{inI} - f_{inE}) - \ln((\omega_{in}\tau_{in})^{\alpha(\sigma-1)} - 1)$ where $a = f_{inI}/f_{inE}$. The distribution of $a\varepsilon_{nI}^{-1} - \varepsilon_{nE}^{-1}$, 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.

$$\ln s_H(j) + \upsilon_n(j) > M_{nI}.$$

The probability that firm j invests in country n, conditional on home sales, is then $1 - \Phi\left\{\left[M_{nI} - \ln s_H(j)\right]/\sigma_\upsilon\right\}$. The joint export/MP entry problem 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 conditional on home sales. Recalling that exports of firm j to market n are $s_{nE}(j) = \mu_2 \eta_n(j) Y_n \left(w_H d_n^{\rho_1}\right)^{(1-\sigma)} z(j)^{\sigma-1} P_n^{\sigma-1}$, and using the expression for home sales, we get

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

Export sales are equal to potential export sales κ_n adjusted for home sales and sales shocks. Following similar steps we can derive an expression for affiliate sales as a function of home sales,

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

Notice that in the absence of intra-firm trade ($\alpha = 1$), firm-level affiliate sales are independent of distance d_n.[40] Also notice that when intra-firm trade is 100 percent ($\alpha = 0$), MP sales are identical to exports. Intuitively, it is this difference in the trade elasticities that allows us to identify the magnitude of intra-firm trade (see also Section 4.1.3). The 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.[41]

Finally, we need to find expressions for expected exports and MP conditional on entry, which will enter the likelihood function. Let $y_{nE}(j)$ and $y_{nI}(j)$ be indicator

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

[41] It is the relative 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 $s_{nI}(j)$.

variables equal to one if firm j exports or performs MP to country n. Expected exports, 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 expression for $\ln s_{nE}(j)$, but with $\ln \eta_n^*(j)$ replaced by $E\left[\ln \eta_n^*(j)|y_{nE}(j) = 1\right]$. Similarly, 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 expression for $\ln s_{nI}(j)$ but with $\ln \eta_n^*(j)$ replaced by $E\left[\ln \eta_n^*(j)|y_{inI}(j) = 1\right]$. The expectations and variances of the truncated errors 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 $\vartheta = \left\{\kappa_n, M_{nE}, M_{nI}, \alpha\rho_1\left(\sigma-1\right), \alpha\rho_2\left(\sigma-1\right), \sigma_{\eta^*}^2, \sigma_\upsilon^2, \sigma_{\varepsilon\eta^*}\right\}$. 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

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

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

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

where $\vartheta_2 = \{\kappa_n, \alpha\rho_1\left(\sigma-1\right), \alpha\rho_2\left(\sigma-1\right), \sigma_{\eta^*}^2, \sigma_{\varepsilon\eta^*}\}$ and J_n^e is the set of firms that export or conduct MP in market n. The first term represents the likelihood of sales for exporters and the second the likelihood of sales for affiliates.[42]

Note that 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 $(0,1)$. The main reason for doing so is that our data do not identify to what extent these export flows are intra-firm or final goods exports, which would enter the likelihood differently. In addition, our theory is incompatible with firms selling final goods both through exports and MP. We evaluate the implications of this procedure in Section 6.3.

4.1.3 Identification

In sum, we estimate the following 4 equations for export and MP entry and sales:

$$
\begin{aligned}
y_{nI}(j) &= 1\left[\ln s_H(j) + \upsilon_n(j) > M_{nI}\right], && (8)\\
y_{nE}(j) &= 1\left[M_{nE} < \ln s_H(j) + \upsilon_n(j) < M_{nI}\right], && (9)\\
\ln s_{nI}(j) &= \kappa_n + \alpha\rho_1(\sigma-1)\ln d_n + \alpha\rho_2(\sigma-1)\ln\omega_n + \ln s_H(j) + \ln\eta_n^*(j), && (10)\\
\ln s_{nE}(j) &= \kappa_n + \ln s_H(j) + \ln\eta_n^*(j), && (11)
\end{aligned}
$$

where $1[.]$ is an indicator function. The κ_n term is identified as a fixed effect in the sales equation (11). The entry hurdles M_{nI} and M_{nE} are identified directly as fixed effects in the ordered probit equations (8) and (9). The structural interpretation of the fixed effects are

$$
\begin{aligned}
\kappa_n &= \ln(Y_n/Y_H) + (\sigma-1)\ln(P_n/P_H) - \rho_1(\sigma-1)\ln d_n, && (12)\\
M_{nE} &= \ln\sigma - \kappa_n + \ln f_{nE}, && (13)\\
M_{nI} &= \ln\sigma - \kappa_n + \ln(f_{inI} - f_{inE}) - \ln\left[(\omega_{in}\tau_{in})^{\alpha(\sigma-1)} - 1\right]. && (14)
\end{aligned}
$$

κ_n is the export potential in market n, after controlling for firm home sales s_H. Export potential is a function of relative market size, relative prices and variable

[42] 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.

trade costs.[43] M_{nE} is the export entry hurdle in terms of home sales, which depends on both the export sales potential and fixed entry costs. M_{nI} is the MP entry hurdle, which depends on the export entry hurdle in addition to factors related to the relative attractiveness of MP relative to exports.

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 (10). In the next subsection we discuss our procedure to estimate α. However, equations (8) to (11) 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.

As it 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, σ^2_{υ} is identified from the restriction that the slope coefficient in front of $\ln s_H$ in (8) and (9) is one. 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.[44] Hence, we can estimate the model using a two-step procedure, where the first step estimates the entry equations (8) and (9), while the second step estimates the sales equations (10) and (11). The second step resembles a Heckman (1979) selection model, where we account for the fact that entrants may have unobserved positive shocks that also influence their 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 Helpman, Melitz, and Rubinstein (2008). They propose a model that explains bilateral export flows at the aggregate level,

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

[44] 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.

controlling for firm heterogeneity and for the presence of zeros. The main difference relative to our approach is that we use micro data and estimate firm-level gravity equations for export and MP. As a consequence, (i) we do not need to control for firm heterogeneity, (ii) we deal with selection at the firm level instead of at the aggregate level, and (iii) we do not rely on assumptions about the distribution of firm productivity.

4.2 MLE Results

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, and 97.7 percent of which are exports. Rows 1 to 7 in Table 2 report all the parameters estimated in the first stage of our econometric framework. It 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 export sales potential κ_n and the entry hurdles M_{nE} and M_{nI} by destination.[45] Table 2 shows that $\alpha\rho_1(\sigma-1)$, the cluster of parameters that captures the difference in the distance 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. [46]

Entry hurdles. Figure 5 and Table 3 show the estimated hurdles M_{nE} and M_{nI}, normalized by absorption. The lower end of a vertical line represents export

[45] In the online appendix, we report results when estimating the model on different subsamples. Overall, the results are relatively similar to the baseline results reported here.

[46] Our results are consistent with the prediction of Arkolakis (2008) model, where 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).

hurdles, whereas the upper end represents MP hurdles. The graph shows that firms must 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 (2011) 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 median MP hurdle is 140 times higher than the export hurdle, in terms of domestic sales.

Export and MP fixed costs. Using equations (13) and (14), we recover f_{nI} and f_{nE} measured relative to the fixed cost of exporting to Sweden.[47] Figure 6 and Table 3 show a number of interesting patterns. In the figure, the lower end of a vertical line represents export fixed costs, whereas the upper end represents MP fixed costs. First, fixed costs of exporting are broadly increasing in distance, while MP costs are fairly constant across destinations.[48] [49] This suggests that the strong dampening effect of distance on aggregate MP cannot be explained by variation in fixed costs of MP.

Second, median MP fixed costs are about 700 times higher than export costs to Sweden. Third, by comparing Figure 6 with Figure 5 we can decompose the entry hurdles in various markets. For example, even though Mexico has the highest M_E in our sample, fixed costs there are fairly average. This suggests that entry in

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[47] 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 $f_{inI} = (f_{inI} - f_{inE})\left(d_n^{\psi_1} - 1\right) / \left[(\omega_{in}\tau_{in})^{\alpha(\sigma-1)} - 1\right] + f_{inE}$. 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.

[48] In the online appendix, we show a likelihood ratio test that confirms these patterns.

[49] 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.

Mexico is difficult 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).[50]

Finding α. We are particularly interested in the volume of intra-firm trade that is consistent with the observed geography of multinational production. The general idea is to compare the elasticity of affiliate sales to distance with the elasticity of exports to distance (within the same firm). According to our model, the difference between the two, which is $\alpha\rho_1(\sigma-1)$, is due to intra-firm trade.

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. Helpman, Melitz, and Rubinstein (2008), that $\rho_1(\sigma-1)$ is in the neighborhood of 1. We then simply divide our estimate of $\alpha\rho_1(\sigma-1)$ by 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 (12) with respect to $[\rho_1(\sigma-1)]^{-1}$ and multiplying with $\alpha\rho_1(\sigma-1)$ yields $\alpha_n = \alpha\rho_1(\sigma-1)\ln d_n [\ln(Y_n/Y_H) - \kappa_n]^{-1}$. Hence, we can calculate α by using data on relative absorption. The third alternative (method III) allows for different price indices, but also requires additional assumptions in order to calculate price indices [51].

Each of the three approaches delivers a value of α close to 0.12. Taken at face value, it means that an affiliate only adds 12 percent of value added to its output. The result is robust to any geographical differences in fixed costs.

Our results reflect the fact that, within the same multinational, affiliate unit costs seem to be strongly increasing in the distance from its headquarters. In fact, unit costs are increasing almost as fast as with exports, so that exports and MP look very similar through the lens of the model. Clearly, there might be additional

[50]The online appendix shows that both the export and MP sales potential, normalized by destination absorption, are decreasing in distance to the destination market with a similar slope. This suggests that the unit costs of MP are increasing with distance at roughly the same rate as for exports.

[51]We describe this method in the online appendix.

mechanisms behind the relatively low estimate of α. We therefore interpret our estimate as a lower bound on the true α. To offer other explanations is outside the scope of this paper, but our analysis shows that alternative hypotheses such as increasing fixed costs in distance, are insufficient for explaining the curse of distance for MP.

5 Back to Theory: General Equilibrium

This section completes the presentation of the model. Under the assumption of Pareto-distributed productivities we solve the general equilibrium, derive a set of gravity equations for aggregate exports and MP, and for the number of exporters and MP parents, and perform counterfactuals (in Section 7).

We assume that the total mass of potential entrants in country i is proportional to labor income $w_i L_i$, so that larger and wealthier countries have more entrants.[52] As in Chaney (2008), 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 $w_i L_i$ and of the dividends they get from their portfolio $w_i L_i \pi$, where π is the (constant) dividend per share of the global mutual fund.[53] Productivity is distributed Pareto along $[w_i, +\infty)$, that is $dG_i(z) = \gamma w_i^\gamma z^{-\gamma-1} dz$ where $\gamma > \sigma - 1$ is an inverse measure of heterogeneity.[54]

The equilibrium price index (see the appendix) is $P_n = \delta_2 Y_n^{1/\gamma - 1/(\sigma-1)} \theta_n \left(\frac{1+\pi}{Y}\right)^{1/\gamma}$, where δ_2 is a constant, Y is world income, and θ_n can be interpreted as a multi-

[52]This assumption greatly simplifies the analysis and it is similar to Eaton and Kortum (2002), where the set of goods is exogenously given.

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

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

lateral resistance variable as in Anderson and van Wincoop (2003).[55]

The following proposition describes the MP extensive margin.

Proposition 2 (Extensive Margin) *The equilibrium number of country i firms conducting MP in country n is*

$$n_{inI} = \delta_4^{-\gamma}\delta_5 \frac{Y_i Y_n}{Y}\left(\frac{\theta_n}{\tau_{in}}\right)^{\gamma}\left[\frac{f_{inI} - f_{inE}}{(\omega_{in}\tau_{in})^{\alpha(\sigma-1)} - 1}\right]^{-\gamma/(\sigma-1)}, \tag{15}$$

where δ_4 and δ_5 are constants.[56]

Proof. See Section A.2. ■

The number of MP firms is decreasing in variable trade barriers, as long as equation (6) holds.[57] Specifically,

$$\frac{\partial \ln n_{inI}}{\partial \ln \tau_{in}} = -\gamma\chi_I < 0,$$

where χ_I is the elasticity of the MP cutoff with respect to τ_{in}. Note that without intra-firm trade (i.e. when $\chi_I < 0$), the number of MP firms is increasing in variable trade barriers, in clear contrast with the pattern showed in Figure 1.

Using the price index we can write latent affiliate sales of a firm with productivity z and sales shock η_n (see Section A.2), and then aggregate over the set of firms which conducts MP to obtain aggregate affiliate sales. This expression is shown in the following proposition.

Proposition 3 (Aggregate Affiliate Sales) *Aggregate affiliate sales from country i to country n are*

$$S_{inI} = \mu \frac{Y_i Y_n}{Y}\left(\frac{\theta_n}{\tau_{in}}\right)^{\gamma}(\omega_{in}\tau_{in})^{\alpha(\sigma-1)}\left(\frac{f_{inI} - f_{inE}}{(\omega_{in}\tau_{in})^{\alpha(\sigma-1)} - 1}\right)^{1-\gamma/(\sigma-1)}. \tag{16}$$

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[55] $\delta_2^{-\gamma} = \delta_1^{\sigma-\gamma-1}\left(\frac{\sigma}{\sigma-1}\right)^{1-\sigma}\frac{\gamma}{\gamma-(\sigma-1)}E_{\eta_n,\varepsilon_n}\left[(\eta_n\varepsilon_n)^{\gamma/(\sigma-1)-1}\eta_n\right]$ θ_n 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: $\theta_n^{-\gamma} = \sum_i (Y_i/Y)\,\tau_{in}^{-\gamma}\left\{(f_{inI} - f_{inE})^{1-\gamma/(\sigma-1)}\left[(\omega_{in}\tau_{in})^{\alpha(\sigma-1)} - 1\right]^{\gamma/(\sigma-1)} + f_{inE}^{1-\gamma/(\sigma-1)}\right\}$.

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

[57] The elasticity of affiliate sales is derived in Section A.6.2.

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).

Proof. See Section A.2. ■

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).[58] 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. When condition (6) holds, the elasticity χ_I is positive, so that the number of firms engaged in MP decreases with τ_{in}. Recall that χ_I is increasing in the degree of intra-firm trade (Section 3.4), 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 zero, while the extensive margin effect is positive.[59] 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.

[58] 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.

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

Finally, the ratio of total exports relative to affiliate sales is decreasing in trade barriers,[60]

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

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.

6 Empirical Implementation: Second Stage

In the second stage of the empirical analysis, we estimate the remaining parameters of the model. This enables us to solve the general equilibrium and conduct counterfactuals in Section 7. This also enables us to estimate the intra-firm trade parameter α without the restrictions imposed earlier (method I and II in Section 4.2). The key remaining unknown parameter is the shape parameter of the sales distribution, given the assumption that productivity is distributed Pareto. Solving the general equilibrium also requires additional assumptions about the full matrix of fixed costs of exporting and MP.

In the following sections, we first estimate the Pareto shape parameter $\widetilde{\gamma} = \gamma/(\sigma - 1)$. Second, we introduce some additional assumptions and show how to calculate the general equilibrium as well as α. Third, we evaluate the fit of the model and perform robustness checks.

6.1 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 magnifies productivity differences across firms. Since we condition on firm-level

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

home sales, the dispersion of productivity is not identified in the first stage. Here we propose a simulated method of moments estimator in order to quantify $\widetilde{\gamma} = \gamma / (\sigma - 1)$. The estimating procedure is similar to the one in Eaton, Kortum, and Kramarz (2011), and can be found in the online appendix.

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 first stage. Therefore, we can back out the efficiency distribution by comparing actual and simulated sales distributions.

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.[61]

6.2 Additional assumptions

In this section, we describe the additional assumptions needed 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. 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.[62] Fixed costs of exporting and MP from Norway (NO) to other destinations are identified from (13) and (14), given a choice of σ. It remains to populate the full matrix of fixed costs, i.e. f_{inI} and f_{inE} when $i \neq NO$. 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

[61]With the reported standard error, we cannot reject the hypothesis that $\widetilde{\gamma} > 1$ at conventional significance levels. A potential explanation for the low estimate of $\tilde{\gamma}$ is that small firms deviate from the Pareto law. We therefore estimated the model considering only firms above the median export value. This, however, produced very similar results, with an estimated $\tilde{\gamma} = 0.79$.

[62]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.

estimate of fixed costs at home, $f_{iiE.}$, which we set to half of the lowest exporting fixed costs, $f_{ii} = \min(f_{NOn})/2$ for all i. Finally, as the elasticity of substitution σ is not identified, we condition the equilibrium on a guess of σ and calculate the general equilibrium for a range of possible values of σ.

6.3 Model Evaluation

6.3.1 Model Fit

We compute traditional maximum likelihood 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 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 (8) and (9) 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 (10) and (11).

Predicting entry and sales. Figure 7 plots the actual number of firms entering in different markets versus the values predicted by the model. Likewise, Figure 8 depicts simulated and actual total sales for exporters and MP firms across markets. The fit is somewhat less tight compared to the entry graph, and in particular total MP is overpredicted for many destinations.

6.3.2 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 maximum likelihood 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.[63] In some cases, the export flows are probably not intra-firm trade, but different products.[64] 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 trade 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 the destination that is actually reported in the data. Then we compute affiliate sales and intra-firm trade for these firms using equation (7). Figure 9 shows actual exports versus predicted intra-firm trade.[65] For most observations the model predicts intra-firm trade 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 trade that is 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.

6.3.3 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

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

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

[65] The level of intra-firm trade depends on the elasticity of substitution σ. In the calculations for the figure, we chose $\sigma = 8$. Choosing a different σ did not change the plot significantly.

$\ln \varepsilon_n(j)$ 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 4 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 export sales potential κ_n, $\alpha\rho_1(\sigma-1)$ and the extent of intra-firm trade α are severely biased.[66] 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).

7 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 two numerical experiments. First, we study the importance of vertical integration for explaining aggregate patterns of MP. Second, we investigate 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.

[66] 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 $cov(\upsilon_n, \eta^*_n) = cov(\eta^*_n + \varepsilon_n, \eta^*_n) = \sigma^2_{\eta^*} + \sigma_{\varepsilon\eta^*}$.

7.1 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 the geography of MP when we simulate MP (under $\alpha = 1$) *conditional on* actual entry.[67] 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 (10)

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

where $\widehat{\alpha}$ is the estimate of α found in the previous section. Firm-level sales are now invariant to 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 10 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 in order to generate gravity for total affiliate sales.

7.2 Prohibitive Barriers to MP

Next, we use our model to explore the implications of prohibitive barriers to 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 infinite MP entry hurdle, $M_{nI} \to \infty$ for all n. Results are presented in Table 5. 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

[67] We calculate predicted MP for the firms that are MP entrants in the data set.

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 markets.[68] 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? On the one hand, 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.[69,70] 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

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

[69] 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 (2009).

[70] 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.

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 headquarters. 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 negative labor market effects of impeding MP because the largest firms in the economy significantly scale back their operations.

8 Conclusions

Despite numerous studies on multinational production and its economic significance, there is little firm-level evidence on MP, exports, and the interaction between the two. In this paper, we show new stylized facts about the geography of MP and exports, we propose a quantitative framework for analyzing exports and MP, and we structurally estimate key parameters of the model by maximum likelihood.

The starting point of our analysis is the empirical fact that MP falls sharply with the distance from its headquarters. This presents a puzzle in standard models of MP, since in these models multinationals can replicate their technology in any domestic and foreign location. We propose a simple extension of existing theory to rationalize these facts. In our model, multinationals are vertically integrated and headquarters supply tangible or intangible inputs to the affiliate. This introduces a gravitational force to MP under certain parameterizations of the model. Our structural empirical framework exploits the variation across firms in export and MP entry and sales, and this allows us to quantify the magnitude of intra-firm trade that is consistent with the model. A key feature of our approach is that we use data on joint firm-level exports and MP flows. Without it, intra-firm trade would not be identified.

Strong results emerge from the analysis. Intra-firm trade plays a crucial role in shaping the geography of MP, and 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 9/10. We interpret this as an upper bound, and hypothesize that additional mechanisms might also 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 (2012)) or due to higher frictions in the match between firms and workers.

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 in the range of zero to 3.6 percent, depending on country characteristics. Losses are small since firms can switch from MP to exports without incurring large additional costs. 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 $\delta_2^{-\gamma} = \delta_1^{\sigma-\gamma-1} \left(\frac{\sigma}{\sigma-1}\right)^{1-\sigma} \frac{\gamma}{\gamma-(\sigma-1)} E\left[(\eta_n \varepsilon_n)^{\gamma/(\sigma-1)-1} \eta_n\right]$, $\Omega_{in} = (f_{inI} - f_{inE}) / \left[(\omega_{in}\tau_{in})^{\alpha(\sigma-1)} - 1\right]$ and $Y_i = w_i L_i (1+\pi)$. 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 (5). ■

Proof of Propositions 2 and 3. Aggregate affiliate sales from i to n are defined as the sum of affiliate sales of each individual firm with productivity $z \geq \bar{z}_{inI}(\varepsilon_n, \eta_n)$,

$$S_{inI} = w_i L_i E_{\varepsilon_n, \eta_n} \int_{\bar{z}_{inI}(\varepsilon_n, \eta_n)}^{\infty} s_{inI}(z, \eta_n) \, dG_i(z).$$

The reduced form size of firm level affiliate sales for a firm with productivity z and sales shock η_n is

$$s_{inI}(z, \eta_n) = \delta_3 (1+\pi)^{(\sigma-1)/\gamma} \left(\frac{Y_n}{Y}\right)^{(\sigma-1)/\gamma} \left[\frac{\theta_n}{(w_i \tau_{in})^{1-\alpha} w_n^{\alpha}}\right]^{\sigma-1} z^{\sigma-1} \eta_n, \qquad (17)$$

where δ_3 is a constant.[71] Note that affiliate sales in a market increase less than proportionally to the size of the market Y_n. As in Eaton, Kortum, and Kramarz (2011), the intuition is that a larger market attracts more entry, so that the price index is lower. Using the reduced form expression for the price index we can derive the MP general equilibrium cutoff,

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

where $\delta_4 = \delta_1/\delta_2$, and $\Omega_{in} = (f_{inI} - f_{inE}) / \left[(\omega_{in}\tau_{in})^{\alpha(\sigma-1)} - 1\right]$. Using our assumption about the distribution $G(z)$ of productivity shocks, we can rewrite aggregate affiliate sales as

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

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

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

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

---

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

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

■

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

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

where $\Omega_{in} = (f_{inI} - f_{inE})/\left[(\omega_{in}\tau_{in})^{\alpha(\sigma-1)} - 1\right]$ and 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

$$E\left[\upsilon | M_{nE} - s_H < \upsilon_n < M_{nI} - s_H\right] = \sigma_\upsilon \frac{\phi(\zeta_n^L) - \phi(\zeta_n^U)}{\Phi(\zeta_n^U) - \Phi(\zeta_n^L)}, \tag{18}$$

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

$$var\left(\upsilon | M_{nE} - s_H < \upsilon < M_{nI} - s_H\right) = \sigma_\upsilon^2 \left\{ \begin{array}{c} 1 + \frac{\zeta_n^L \phi(\zeta_n^L) - \zeta_n^U \phi(\zeta_n^U)}{\Phi(\zeta_n^U) - \Phi(\zeta_n^L)} \\ - \left[\frac{\phi(\zeta_n^L) - \phi(\zeta_n^U)}{\Phi(\zeta_n^U) - \Phi(\zeta_n^L)}\right]^2 \end{array} \right\}. \tag{19}$$

Note that one-sided truncation is just a special case with one threshold set to infinity, e.g.

$$E(\upsilon | M_{nI} - s_H < \upsilon < Inf) = \sigma_\upsilon \lambda(-\zeta_n^H) \tag{20}$$

and

$$var\left(\upsilon | M_{nE} - s_H < \upsilon < Inf\right) = \sigma_\upsilon^2 \left[1 + \zeta_n^L \lambda(-\zeta_n^L) - \lambda(-\zeta_n^L)^2\right], \tag{21}$$

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

$$\begin{aligned} & E\left[\ln \eta^* | M_{nE} - s_H < \upsilon < M_{nI} - s_H\right] && (22) \\ = \; & E\left[\Sigma_{\eta^* \upsilon} \Sigma_{\upsilon\upsilon}^{-1} \upsilon + \xi | M_{nE} - s_H < \upsilon < M_{nI} - s_H\right] && (23) \\ = \; & \frac{\sigma_{\eta^*}^2 + \sigma_{\varepsilon \eta^*}}{\sigma_\upsilon^2} E\left[\upsilon | M_{nE} - s_H < \upsilon < M_{nI} - s_H\right], && (24) \end{aligned}$$

and

$$
\begin{aligned}
& var\left[\ln \eta^{*}|M_{nE}-s_{H}<\upsilon<M_{nI}-s_{H}\right] & (25)\\
= \; & \Sigma_{\eta^{*}\upsilon}^{2}\Sigma_{\upsilon\upsilon}^{-2}var\left[\upsilon|M_{nE}-s_{H}<\upsilon<M_{nI}-s_{H}\right]+\Sigma_{\eta^{*}\eta^{*}}-\Sigma_{\eta^{*}\upsilon}\Sigma_{\upsilon\upsilon}^{-1}\Sigma_{\upsilon\eta^{*}} & (26)\\
= \; & \left(\frac{\sigma_{\eta^{*}}^{2}+\sigma_{\varepsilon\eta^{*}}}{\sigma_{\upsilon}^{2}}\right)^{2} var\left[\upsilon|M_{nE}-s_{H}<\upsilon<M_{nI}-s_{H}\right]+\sigma_{\eta^{*}}^{2}-\frac{\left(\sigma_{\eta^{*}}^{2}+\sigma_{\varepsilon\eta^{*}}\right)^{2}}{\sigma_{\upsilon}^{2}}, & (27)
\end{aligned}
$$

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 $\Sigma_{\eta^{*}\eta^{*}}=\sigma_{\eta^{*}}^{2}$. In sum, the expectation of the error term for exports is equation (24) combined with (18), while the expectation of the error term for MP is (24) combined with (20) (one-sided truncation). The export variance $\widetilde{\sigma}_{\eta^{*}E}^{2}$ is equation (27) combined with (19), while $\widetilde{\sigma}_{\eta^{*}I}^{2}$ is equation (27) combined with (21) (one-sided truncation).

A.4 Re-Expressing Entry and Sales Equations

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

$$
z(j)\geq\bar{z}_{nI}(j)=\delta_{1}\left[P_{n}^{\sigma-1}Y_{n}\varepsilon_{n}(j)\eta_{n}(j)\right]^{-1/(\sigma-1)}w_{H}d_{n}^{\rho_{1}}\Omega_{n}^{1/(\sigma-1)}, \tag{28}
$$

where $\Omega_{in}=(f_{inI}-f_{inE})/\left[(\omega_{in}\tau_{in})^{\alpha(\sigma-1)}-1\right]$. This condition can be re-expressed in terms of home sales. If firm j sells $s_{H}(j)$ at home, then its productivity level is

$$
z(j)=s_{H}(j)^{1/(\sigma-1)}w_{H}P_{H}^{-1}\frac{\sigma}{\sigma-1}\left(Y_{H}\mu\eta_{H}(j)\right)^{-1/(\sigma-1)}. \tag{29}
$$

Inserting (29) in (28) 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 (see the online appendix).

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

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

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

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

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 $\Omega_{in} = (f_{inI} - f_{inE}) / \left[(\omega_{in}\tau_{in})^{\alpha(\sigma-1)} - 1\right]$, which measures the cost of FDI relative to exports, is decreasing in τ_{in}:

$$\frac{\partial \ln \Omega_{in}}{\partial \ln \tau_{in}} = -\frac{\alpha(\sigma-1)(\omega_{in}\tau_{in})^{\alpha(\sigma-1)}}{(\omega_{in}\tau_{in})^{\alpha(\sigma-1)} - 1} < 0 \ . \tag{30}$$

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 MP

Here we show how the number of multinational firms (n_{inI}) depends on variable trade barriers (τ_{in}). Using (15) and our earlier derivation of $\partial \ln \Omega_{in} / \partial \ln \tau_{in}$ we have,

$$\frac{\partial \ln n_{inI}}{\partial \ln \tau_{in}} = \gamma \left[-\frac{(\omega_{in}\tau_{in})^{\alpha(\sigma-1)}(1-\alpha) - 1}{(\omega_{in}\tau_{in})^{\alpha(\sigma-1)} - 1} + \frac{\partial \ln \theta_n}{\partial \ln \tau_{in}} \right] \tag{31}$$

$$= \gamma \left[-\chi_I + \frac{\partial \ln \theta_n}{\partial \ln \tau_{in}} \right], \tag{32}$$

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,

$$\frac{\partial \ln n_{inI}}{\partial \ln \tau_{in}} < 0 \Longleftrightarrow \theta_n^{-\gamma} > (Y_i/Y)\, \tau_{in}^{-\gamma} \left[\Omega_{in}^{-\gamma/(\sigma-1)} (f_{inI} - f_{inE}) + \chi_I^{-1} f_{inE}^{1-\frac{\gamma}{\sigma-1}} \right], \tag{33}$$

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

(33) 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 (31) are positive, so that the number of multinational firms is clearly increasing in variable trade barriers.

A.6.3 Decomposition of Total Affiliate Sales

Here we show how to decompose total affiliate sales into an intensive and an extensive margins. The equivalent decomposition for total exports is similar and can be found in the online appendix. Consider the derivative of log total affiliate sales as in (16) with respect to variable trade barriers,

$$\frac{d \ln S_{inI}}{d \ln \tau_{in}} = \underbrace{\frac{\tau_{in}}{S_{inI}} w_i L_i E_{\varepsilon_n,\eta_n} \left[\int_{\bar{z}_{inI}(\varepsilon_n,\eta_n)}^{\infty} \frac{\partial s_{inI}(z,\eta_n)}{\partial \tau_{in}} dG(z) \right]}_{\text{intensive-margin}}$$
$$- \underbrace{\frac{\tau_{in}}{S_{inI}} w_i L_i E_{\varepsilon_n,\eta_n} \left[s_{inI}\left(\bar{z}_{inI}(\varepsilon_n,\eta_n), \eta_n\right) g\left(\bar{z}_{inI}(\varepsilon_n,\eta_n)\right) \frac{d\bar{z}_{inI}(\varepsilon_n,\eta_n)}{d\tau_{in}} \right]}_{\text{extensive-margin}}.$$

Intensive margin. The derivative of firm-level latent affiliate sales as in (17) with respect to variable trade barriers (assuming that $\partial\theta_n/\partial\tau_{in} = 0$) is,

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

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

$$\begin{aligned} & -\frac{\tau_{in}}{S_{inI}} w_i L_i E_{\varepsilon_n,\eta_n} \left[\int_{\bar{z}_{inI}(\varepsilon_n,\eta_n)}^{\infty} \frac{\partial s_{inI}(z,\eta_n)}{\partial \tau_{in}} dG(z) \right] \\ = \; & -(\alpha - 1)(\sigma - 1) \frac{\tau_{in}}{S_{inI}} \frac{S_{inI}}{\tau_{in}} \\ = \; & (1 - \alpha)(\sigma - 1). \end{aligned}$$

Extensive margin. Using the definitions of the MP equilibrium productivity threshold as in (A.2), the derivative of the cutoff with respect to variable trade barriers is,

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

Using the definition of affiliate sales as in (17) and the definition of the distribution of productivity shocks, aggregate affiliate sales can be written as

$$S_{inI} \quad = \quad \frac{w_i L_i}{(\gamma - \sigma + 1)} E_{\varepsilon_n, \eta_n} \left[s_{inI} \left(\bar{z}_{inI} \left(\varepsilon_n, \eta_n \right), \eta_n \right) g \left(\bar{z}_{inI} \left(\varepsilon_n, \eta_n \right) \right) \bar{z}_{inI} \left(\varepsilon_n, \eta_n \right) \right].$$

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

$$\frac{\tau_{in}}{S_{inI}} \frac{w_i L_i}{\tau_{in}} E_{\varepsilon_n, \eta_n} \left\{ s_{inI} \left(\bar{z}_{inI} \left(\varepsilon_n, \eta_n \right), \eta_n \right) g \left(\bar{z}_{inI} \left(\varepsilon_n, \eta_n \right) \right) \bar{z}_{inI} \left(\varepsilon_n, \eta_n \right) \left[1 + \frac{1}{(\sigma - 1)} \frac{d \ln \Omega_{in}}{d \ln \tau_{in}} \right] \right\},$$

and, using the new expression for S_{inI},

$$\frac{\tau_{in} \frac{w_i L_i}{\tau_{in}} E_{\varepsilon_n, \eta_n} \left\{ s_{inI} \left(\bar{z}_{inI} \left(\varepsilon_n, \eta_n \right), \eta_n \right) g \left(\bar{z}_{inI} \left(\varepsilon_n, \eta_n \right) \right) \bar{z}_{inI} \left(\varepsilon_n, \eta_n \right) \left[1 + \frac{1}{(\sigma-1)} \frac{d \ln \Omega_{in}}{d \ln \tau_{in}} \right] \right\}}{\frac{w_i L_i}{(\gamma - \sigma + 1)} E_{\varepsilon_n, \eta_n} \left[s_{inI} \left(\bar{z}_{inI} \left(\varepsilon_n, \eta_n \right), \eta_n \right) g \left(\bar{z}_{inI} \left(\varepsilon_n, \eta_n \right) \right) \bar{z}_{inI} \left(\varepsilon_n, \eta_n \right) \right]}$$
$$= \quad (\gamma - \sigma + 1) \left[1 + \frac{1}{(\sigma - 1)} \frac{d \ln \Omega_{in}}{d \ln \tau_{in}} \right].$$

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

$$\frac{d \ln S_{inI}}{d \ln \tau_{in}} = - (1 - \alpha) (\sigma - 1) - [\gamma - (\sigma - 1)] \chi_I.$$

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	1^{st}or 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 6, 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 sales potential (κ_n), 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 4.2. Standard errors robust to serial correlation in parentheses.

Table 4: 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	$-$

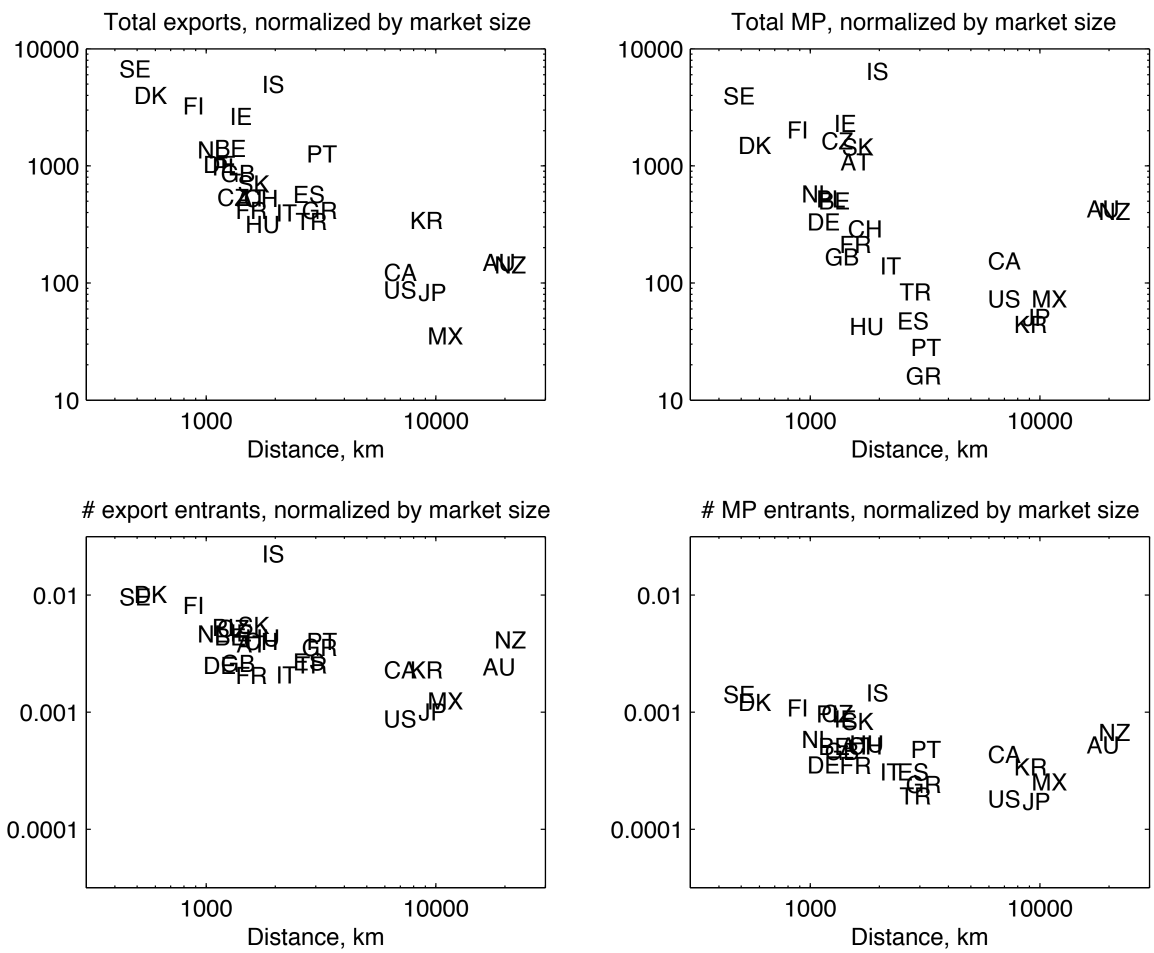
Notes: This table reports parameters estimated under (a) our main model and (b) a model that does not control for unobserved selection using an artificial sample constructed as described in Section 6.3.3. Reported estimates for export sales potential κ_n, and entry hurdles M_{nE} and M_{nI} are averages across destinations. The initial parameters for this exercise are $N = 6$,$\rho_1 = .1$, $\rho_2 = 0$, $\sigma = 8$, $\gamma(\sigma-1) = 1.1$, $f_{nE} = 0.01$ millions and $f_{nI} = 10$ millions.

Table 5: 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

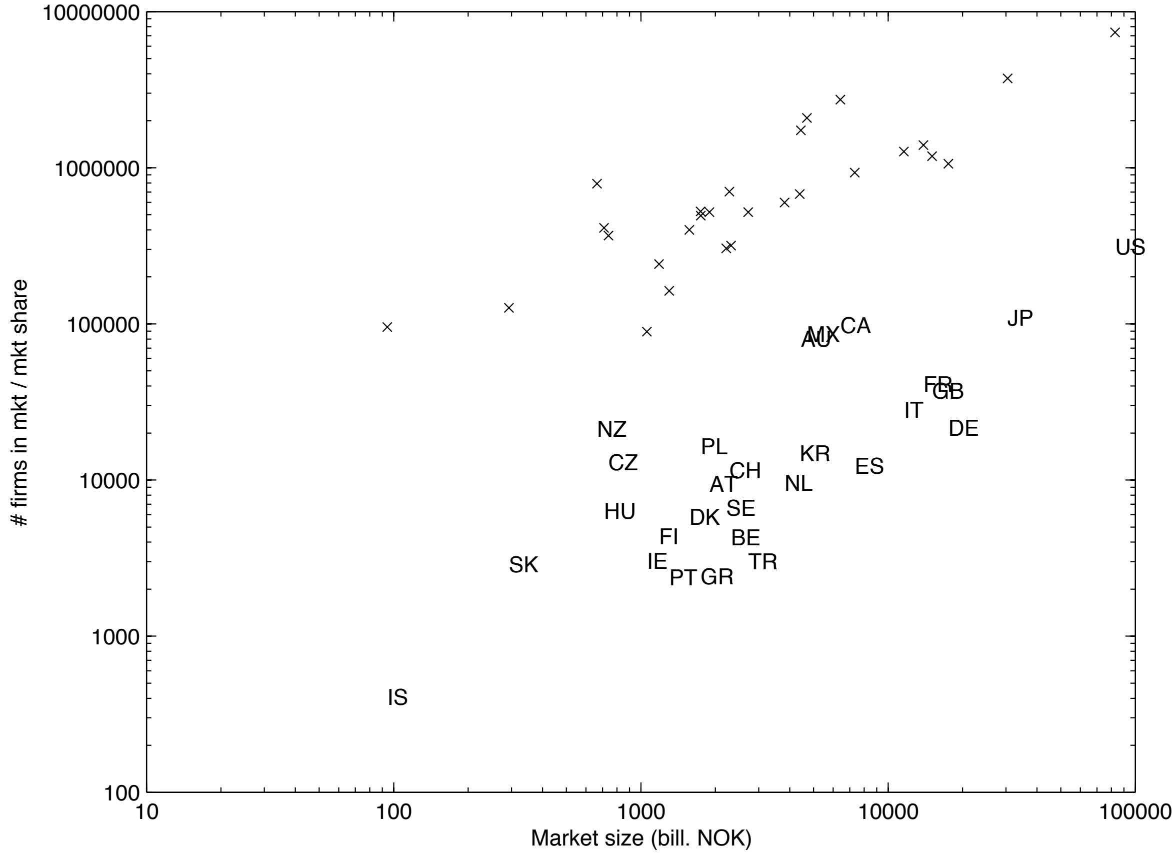
Notes: This table reports the predicted percentage change in welfare and Norwegian exports (due to entrants and incumbents) deriving from a complete shutdown of MP. The counterfactual exercise is describe in Section 7.2. Welfare is calculated under $\sigma = 8$. Other results are independent of σ.

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



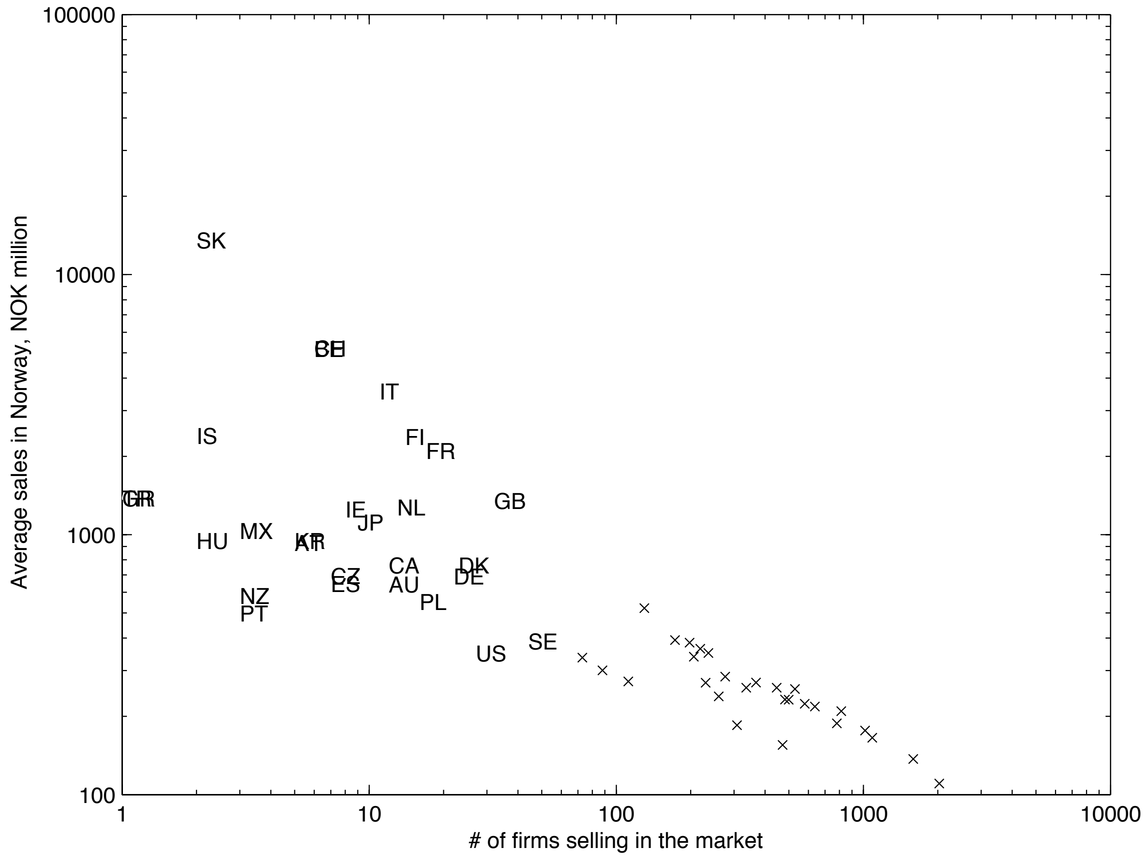
Notes: The top-left panel reports total exports from Norway to different countries, normalized by destination absorption, (on the vertical axis) vs. distance, measured in kilometers, between Norway and the destination (on the horizontal axis). The top-right panel reports a similar relationship but with 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. Total exports and MP are expressed in 1000 NOK while absorption is expressed in NOK billion. All quantities are plotted on a log scale.

Figure 2: Entry and Market Size



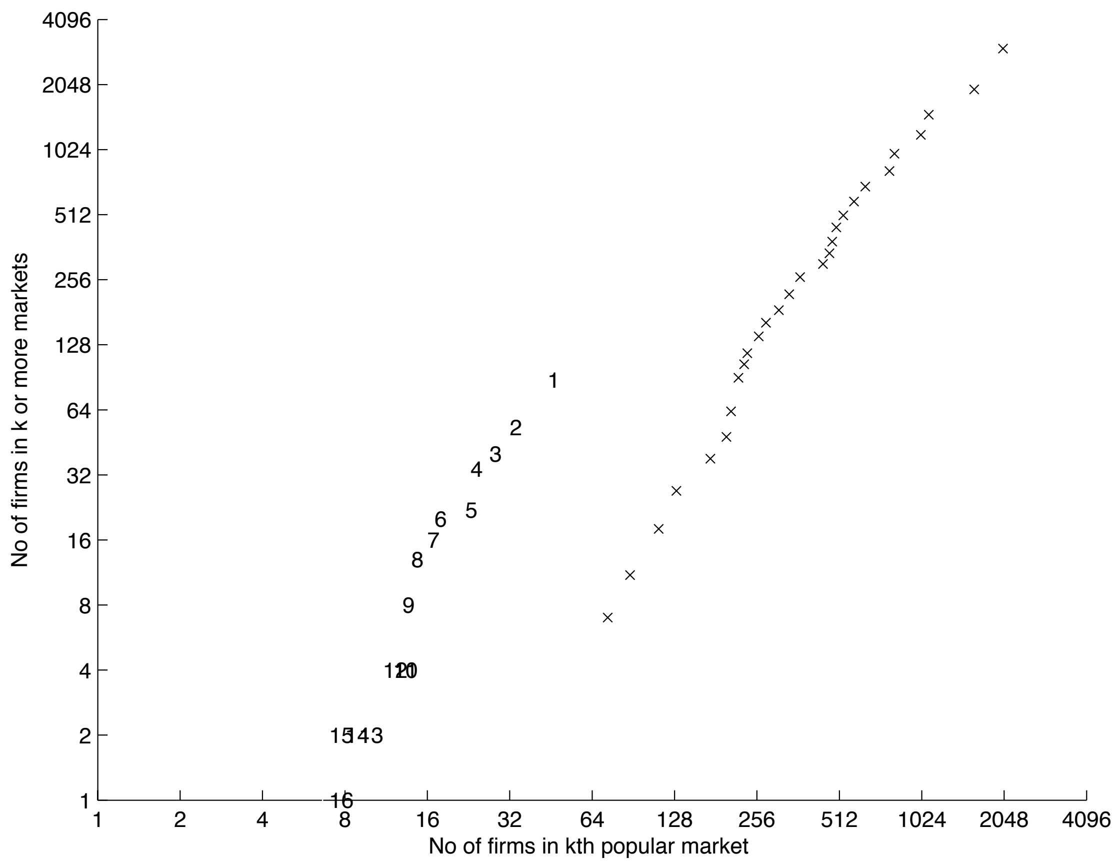
Notes: The graph reports the number of Norwegian entrants, divided by Norwegian market share, selling in a particular destination (on the vertical axis) vs. the size of the destination market (on the horizontal axis). Country codes represent MP entrants, whereas crosses represent exporters. Norwegian market share is measured as total exports to a destination relative to the destination absorption while market size is absorption measured in NOK billions. All quantities are plotted on a log scale.

Figure 3: Average Sales in Norway and the Number of Entrants



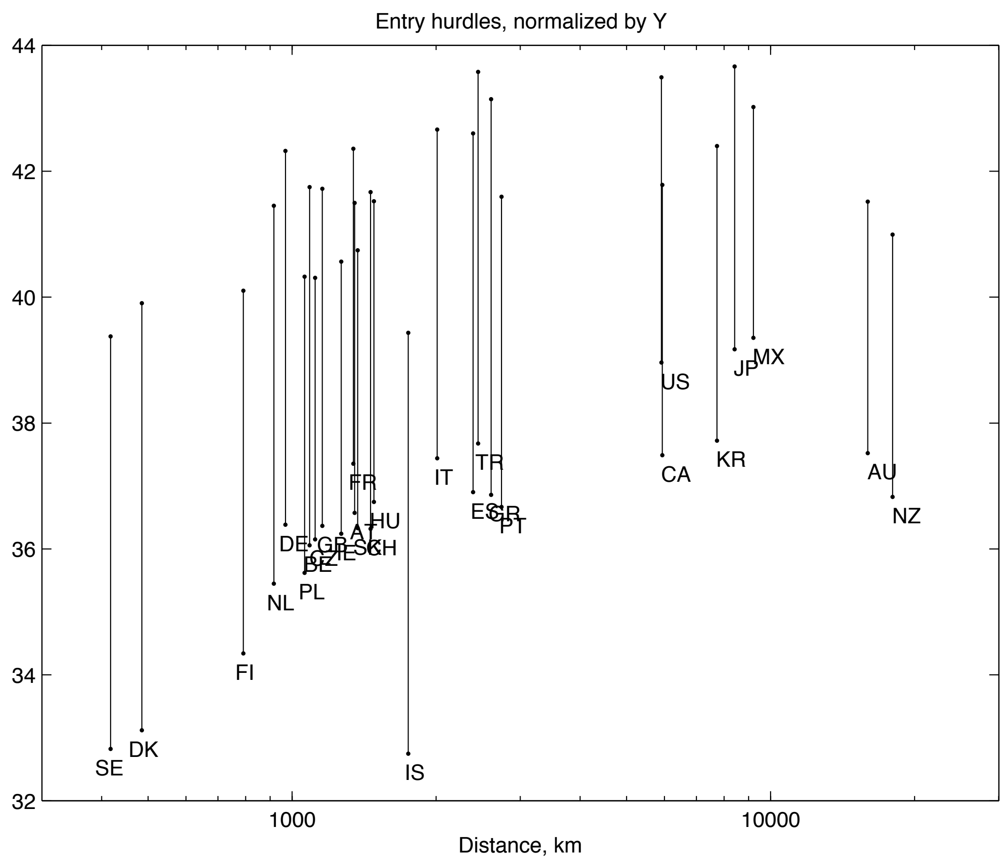
Notes: The graph reports the number of firms selling in a market (on the horizontal axis) versus average sales in Norway among the firms selling in this market (on the vertical axis). Country codes represent MP entrants, whereas crosses represent exporters. All quantities are plotted on a log scale.

Figure 4: Entry market hierarchy



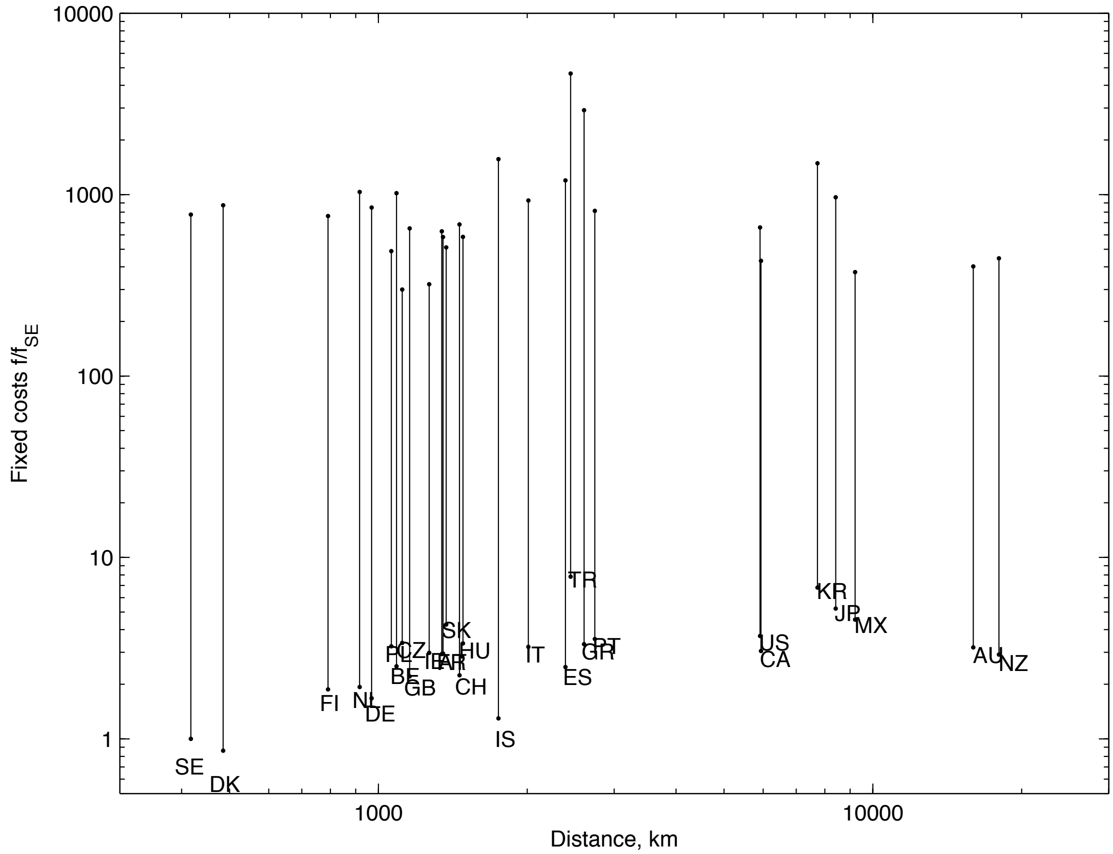
Notes: The graph reports the number of firms selling in the k^{th} most popular destination (on the horizontal axis) vs. the number of firms selling in k or more countries (on the vertical axis). Country codes represent MP entrants, whereas crosses represent exporters. All quantities are plotted on a log scale.

Figure 5: Entry Hurdles



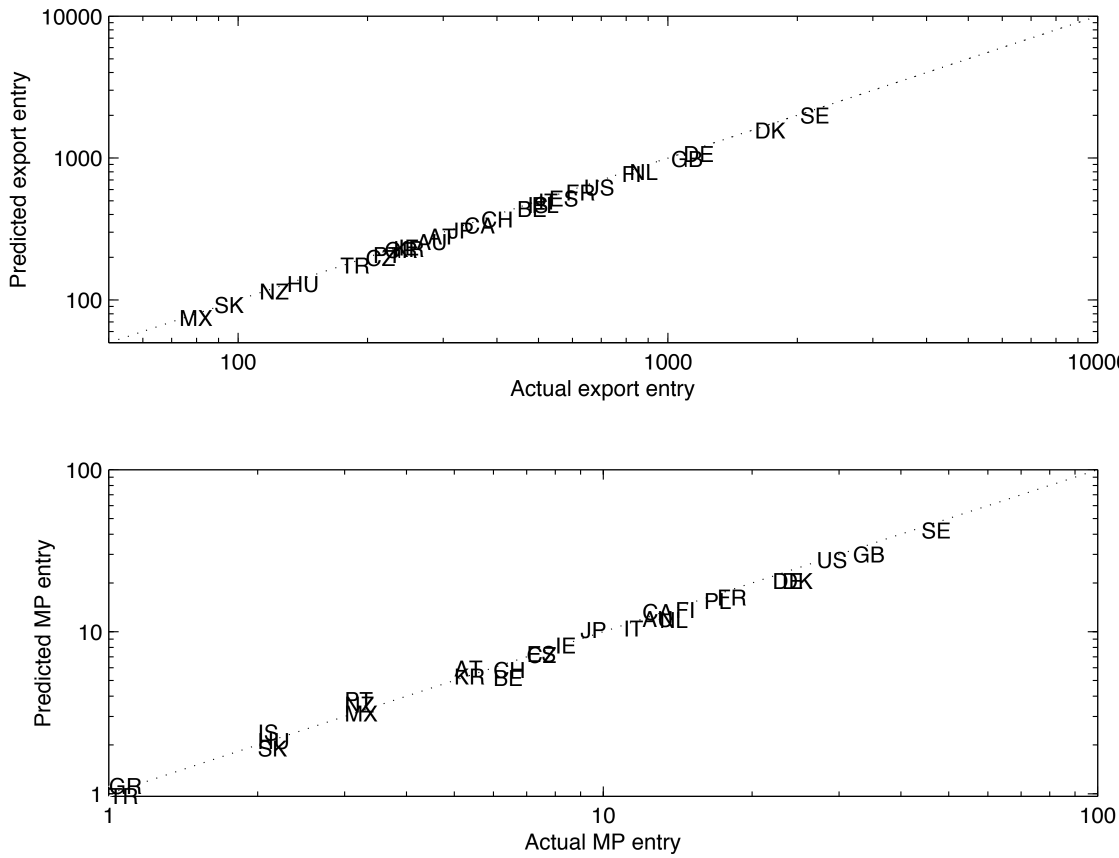
Notes: The graph reports the estimated export (M_{nE}) and MP (M_{nI}) hurdles, normalized by absorption (in NOK billion) vs. distance, measured in kilometers, between Norway and the destination. The lower end of a vertical line represents export hurdles, whereas the upper end represents MP hurdles. The hurdles 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 4.2. All quantities plotted on a log scale.

Figure 6: Entry Fixed Costs



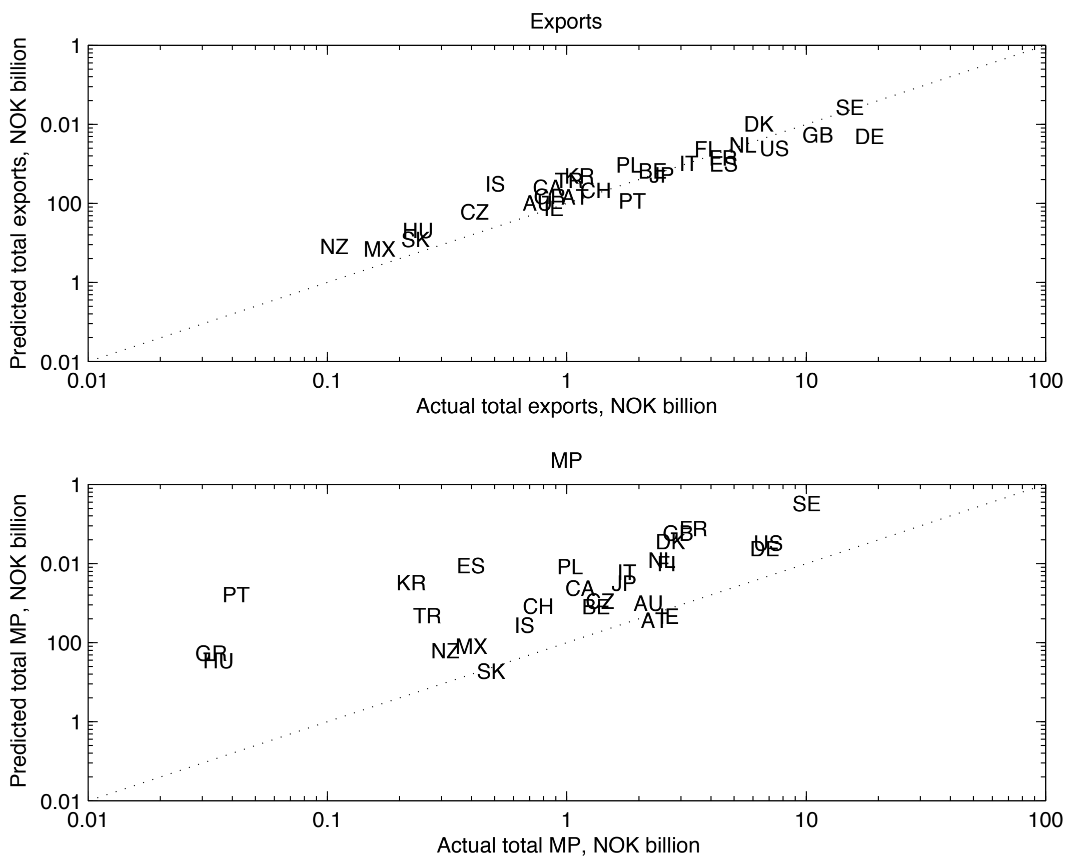
Notes: The graph reports the estimated export (f_{nE}) and MP (f_{nI}) fixed costs, normalized by the fixed cost of exporting to Sweden (on the vertical axis) vs. distance, measured in kilometers, between Norway and the destination (on the horizontal axis). The lower end of a vertical line represents export fixed costs, whereas the upper end represents MP fixed costs. 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 4.2. All quantities are plotted on a log scale.

Figure 7: Actual vs Predicted Entry



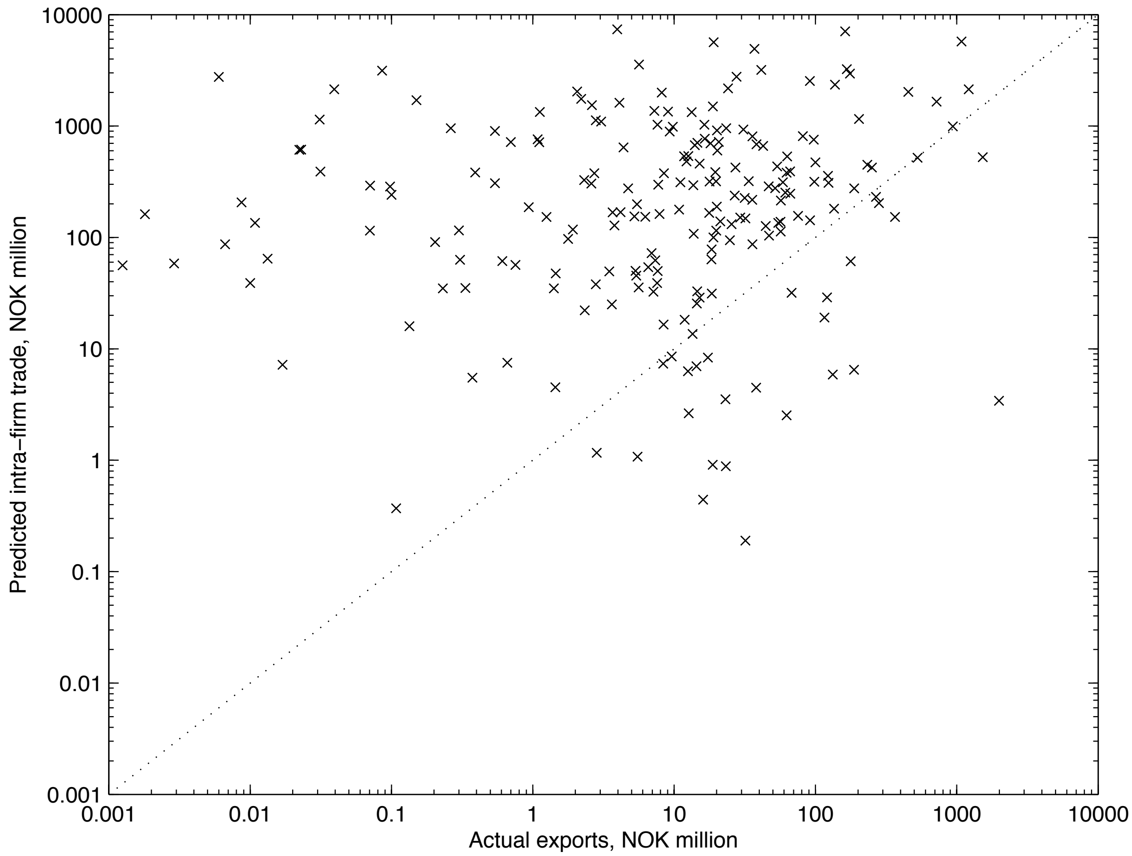
Notes: The graph reports the predicted number of firms entering in different markets (on the vertical axis) vs. the actual number of firms (on the horizontal axis). The top panel reports figures and predictions about the number of exporters while the bottom panel reports figures and predictions about the number of MP entrants. 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 6.3. All quantities are plotted on a log scale.

Figure 8: Actual vs Predicted Sales



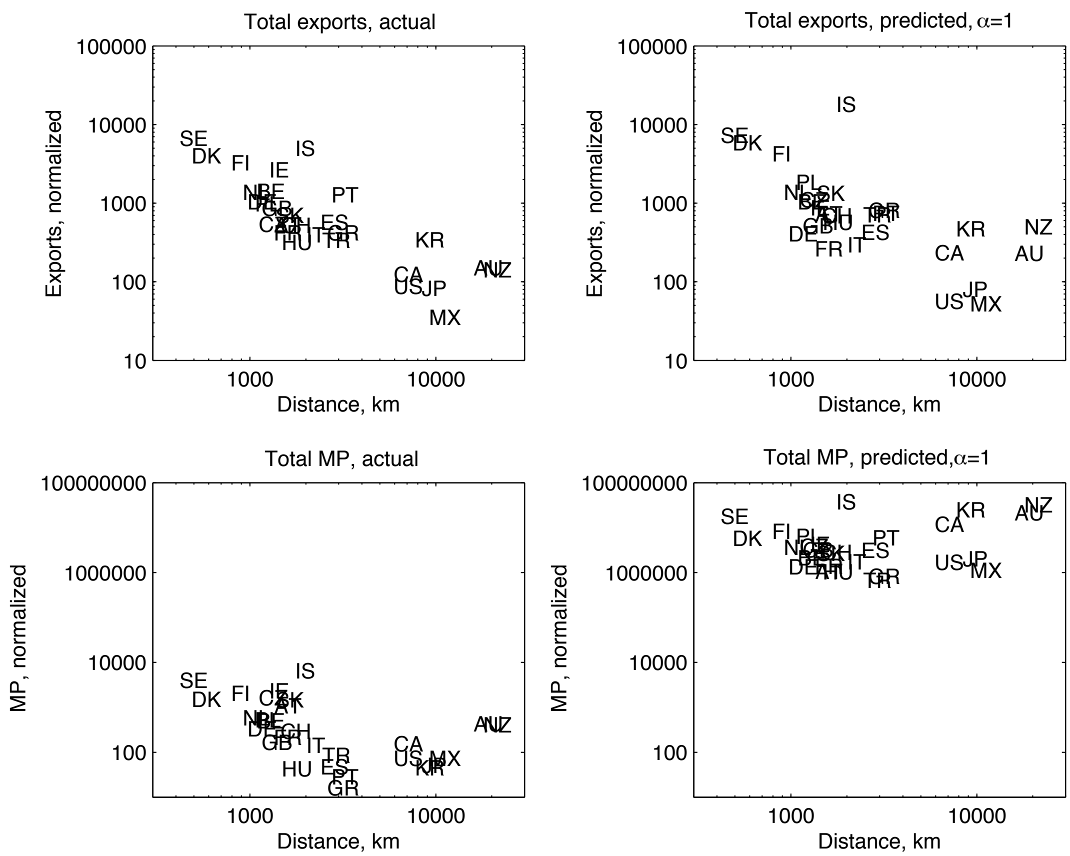
Notes: The graph reports predicted sales by destination (on the vertical axis) vs. actual sales by destination (on the horizontal axis). The top panel reports figures and predictions about exports while the bottom panel reports figures and predictions about affiliate sales. Predictions are based on the 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 6.3. All quantities are plotted on a log scale.

Figure 9: Out-of-Sample Prediction of Intra-Firm Trade



Notes: The graph reports predicted intra-firm trade (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 6). Predicted intra-firm trade is calculated under $\sigma = 8$. The discussion of the results shown in this Figure is in Section 6.3. All quantities are plotted on a log scale.

Figure 10: 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 7.1. All quantities are plotted on a log scale.