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February 2012

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During the past decade of declining FDI barriers, small domestic firms disproportionately contracted while large multinational firms experienced a substantial growth in Japan's manufacturing sector. This paper quantitatively assesses the impact of FDI globalization on intra-industry reallocations and aggregate productivity. We calibrate the firm-heterogeneity model of Eaton, Kortum, and Kramarz (2011) to micro-level data on Japanese multinational firms. Estimating the structural parameters of the model, we demonstrate that the model can strongly replicate the entry and sales patterns of Japanese multinationals. Counterfactual simulations show that declining FDI barriers lead to a disproportionate expansion of foreign production by more efficient firms relative to less efficient firms. A hypothetical 20% reduction in FDI barriers is found to generate a 30.7% improvement in aggregate productivity through market-share reallocation.

**Keywords:** Multinational firms, FDI, Firm heterogeneity, Investment Liberalization
**JEL classification:** F10, F23, L25, R12, R30

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# Heterogeneous Multinational Firms and Productivity Gains from Falling FDI Barriers[*]

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During the last decade of declining FDI barriers, small domestic firms disproportionately contracted while large multinational firms experienced a substantial growth in Japan's manufacturing sector. This paper quantitatively assesses the impact of FDI globalization on intra-industry reallocations and its implications for aggregate productivity. We calibrate the firm-heterogeneity model of Eaton, Kortum, and Kramarz (2011) to micro-level data on Japanese multinational firms facing fixed and variable costs of foreign production. Estimating the structural parameters of the model, we demonstrate that the model can strongly replicate the entry and sales patterns of Japanese multinationals. Counterfactual simulations show that declining FDI barriers lead to a disproportionate expansion of foreign production by more efficient firms relative to less efficient firms. A hypothetical 20% reduction in FDI barriers is found to generate a 30.7% improvement in aggregate productivity through market-share reallocation.

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## 1. Introduction

Declining FDI barriers are dramatically restructuring the global economy. Advances in transportation and communication technology and multilateral reductions in FDI related policy barriers have led to a disproportionate expansion of production by multinational firms relative to less efficient domestic firms.[1] Today the total value-added generated by multinational foreign affiliates is over 10% of global GDP, more than twice the share contributed 20 years ago (UNCTAD, 1990 and 2011).[2] Given their superior technology and management expertise, multinational firms have been viewed as strong contributors to technological diffusion and economic development (Markusen, 2004). Nonetheless, their potential displacement effects on domestic activity have also generated growing anxiety towards their recent rise.

This paper seeks to quantify the impacts of FDI globalization on intra-industry reallocations and its implications for aggregate productivity. The firm-heterogeneity model of trade predicts that economic integration will lead to aggregate productivity gains and displacement of less productive firms. With the high fixed costs of foreign market participation, declining barriers favor the most productive firms in expanding abroad, whereas less productive firms contract under increased foreign competition (Melitz, 2003). Many previous studies have quantified the intra-industry reallocations resulting from trade liberalization (Pavcnik, 2002; Bernard et al., 2003).[3] However, FDI plays a more dominant role in globalization and we know very little about the empirical magnitudes of reallocation being channeled through declining FDI barriers.[4]

We apply the simulation model developed by Eaton, Kortum, and Kramarz (2011, EKK

[1] While FDI barriers are not explicitly measurable, Gormsen (2011) estimates that FDI barriers have halved every 4.8 years and contributed to over 75% of the growth in FDI stocks in recent decades.

[2] Total value added (including domestic production) by multinationals amounted to over 25% of global GDP.

[3] Pavcnik (2002) finds that trade liberalization in Chile generated a 30% increase in aggregate productivity due to the reallocation of activity from less efficient to more efficient firms. Through ex-ante simulations of falling trade barriers, Bernard et al. (2003) quantified large reallocations of production activity from less to more productive firms among U.S. manufacturing firms.

[4] Today worldwide sales of foreign affiliates are more than twice those of exports (UNCTAD, 2011).

hereafter) to Japanese multinational enterprises (MNEs) and estimate a model of heterogeneous firms facing fixed and variable FDI barriers. We use the general equilibrium model to simulate how multinationals respond to declining FDI barriers and quantitatively assess the resulting extent of intra-industry reallocations and its implications for aggregate productivity improvements. In an era of global competition, the welfare of small domestic firms is a widely covered concern, but excessive protection of relatively less productive firms could have adverse impacts on aggregate productivity growth. Given the politically sensitive nature surrounding FDI globalization, a quantitative assessment will be useful for policy discussions on FDI.[5]

We first provide evidence that the EKK model designed for trade is also consistent with Japanese multinational activity. Dissecting the micro-level data, we find supporting evidence for high fixed costs of multinational entry, costly technology transfer, Pareto distribution of foreign affiliate sales, and a weak pecking order of productivity sorting for multinational activities across markets. Estimating the structural parameters of heterogeneous firms by the simulated method of moments, we conduct model validation exercises. The results show that simulated multinationals fit the actual Japanese multinational activity quite well in terms of the moments used in estimation as well as out-of-sample activity that occurred under a significantly different environment of FDI barriers from the period used for estimation.

Having validated the model for data on Japanese multinationals, we use the estimated model as a quantitative tool to examine how multinational firms respond to declining investment barriers. Applying a hypothetical 20% reduction in both variable and fixed investment barriers, we find that falling barriers lead to asymmetric changes across heterogeneous firms at the intensive and extensive margins. Increased competition from inward FDI reduces domestic production by all firms and forces the least productive firms to exit. Due

[5] The anxieties over globalization and the rise of multinationals are widely covered in the media. In 2008, 2 out of every 3 EU citizens believed globalization was beneficial only for large corporations while 78% of Americans viewed globalization favorably in 2002, which declined to 59% in 2007. After the 2008 financial crisis, the majority of Americans viewed it as a threat (Economist, February 19, 2009).

to high fixed setup costs of foreign production, the growth of foreign production is primarily yielded by the most productive firms. While the top quintile of firms grow by over 30%, the remaining bottom 80% of firms contract by over 3%. The resulting reallocation of production from less efficient to more efficient firms may generate up to a 30.7% improvement in aggregate productivity. Our numerical results are consistent with the actual asymmetric growth expansions observed over the last decade in Japan's manufacturing sector.

Our analysis is related to the literature that attempts to assess the gains from increasing multinational production.[6] Extending the neoclassical growth model to multinational production, Burstein and Monge-Naranjo (2009) and McGrattan and Prescot (2009) find that multinational firms generate welfare gains through "knowledge capital transfer". Using a Ricardian framework, Ramondo (2011) and Ramondo and Rodrigeuz-Claire (2009) find that openness to FDI leads to large gains through technology transfer. While these papers employ multi-country general equilibrium models to quantify welfare gains, their approach relies on aggregate measures of FDI activity and they do not explicitly account for the micro-level activities of individual firms and differences between fixed and variable FDI barriers.

By contrast, our application of the micro-simulation approach by EKK allows us to simulate firm-level changes from falling FDI barriers and quantify aggregate productivity gains through intra-industry reallocations. Since tracking the extent of market-share reallocation depends upon firm-level changes in sales and level of penetration across multiple foreign markets, it is important to model individual firm responses to FDI barriers. Combined with firm heterogeneity, fixed and variable barriers to FDI carry different consequences for firm-level conditions of entry and sales across markets because the overall magnitude of these impacts depends upon the distributional structure of firms and the sensitivity to these barriers. Our results show that the counterfactual changes in Japanese MNEs depend strongly on the nature of investment barriers; aggregate productivity improvements are larger from variable barriers

[6] Our analysis is also related to recent micro-level studies on the location decisions of heterogeneous multinationals (Grossman et al., 2006; Aw and Lee, 2008; Yeaple, 2009; Chen and Moore, 2010).

compared to fixed barriers, as is consistent with the findings for exporting firms in di Giovanni and Levchenko (2010).

Before describing the details, we must emphasize that our application of the EKK framework captures many features of multinational production, but does not account for the role of trade.[7] As previous work such as Helpman et al. (2004) shows that FDI and exporting decisions may be jointly related, our results must be interpreted with caution. If FDI and trade are substitutes, foreign activity by MNEs may displace part of their domestic activity. On the other hand, if FDI and trade are complementary, foreign operations may increase their domestic activity. However, existing evidence on the linkage between FDI and trade is mixed, making it difficult to predict the direction of bias in our simulations.[8] In this study, we ignore the interaction effects between trade and FDI within firms, focusing solely on the market-share reallocations between firms.[9]

The rest of the paper is organized as follows. Section 2 describes our data sources and recent trends in the Japanese manufacturing sector. Section 3 presents an EKK model of multinational production, with supporting evidence from the Japanese data. Section 4 summarizes the procedure used to estimate structural parameters of the model and model-validation exercises. Section 5 presents counterfactual simulation analysis. Section 6 concludes.

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7 This limitation is due to the lack of Japanese firm-level data on export sales by destination

8 Blonigen (2001) finds both complementary and substitution effects for the Japanese automobile multinationals investing in the U.S. while Yamashita and Fukao (2010) find that the overseas operations of Japanese MNEs do not reduce their domestic employment. Irarrazabal et al. (2010) find that with intra-firm trade, a reduction in FDI barriers could lead to increased domestic activity.

9 Recent studies such as Ramondo and Rodriguez-Claire (2009) and Garetto (2010) quantitatively examine FDI and exports in a unified framework by developing a structural model of traded inputs between multinational firms and their affiliates. However, these studies place less attention on the role of individual firm activity.

## 2. Data and the Stylized Facts of Japanese Multinational Firms

This section discusses the data sources for Japanese multinational and domestic firms. It then describes recent structural changes in the Japanese manufacturing sector to motivate our empirical study.

### 2.1 Data Sources

Data on Japanese firms come from the Basic Survey of Japanese Business Structure and Activities by the Japanese Ministry of Economy, Trade, and Industry (METI). The survey covers all business firms with 50 employees or more and capital of 30 million yen or more in both manufacturing and non-manufacturing sectors. Our analysis is based primarily on the 2006 survey. The 2006 sample accounted for 5% of total firms and 60% of total employees in the Japanese manufacturing sector.[10] Meanwhile, data on foreign affiliate activity are from the Basic Survey of Overseas Business Activities by METI. The survey covers manufacturing and non-manufacturing firms that are headquartered in Japan and own at least one foreign business enterprise.[11] In the 2006 survey, there were 2,165 parent firms in manufacturing, which accounted for 31% of total employees of manufacturing firms in the Basic Survey of Japanese Business Structure and Activities.

After linking domestic parent firm activity to their manufacturing foreign affiliates and excluding the affiliates that were not operating and/or had no sales information, our dataset consists of 2,032 parent firms with 7,626 foreign affiliates across 70 markets in 2006. In this sample, the total sales by foreign affiliates were 99.1 trillion yen. The average Japanese multinational maintained four foreign affiliates with foreign sales of 5.7 billion yen per affiliate. However, domestic sales are missing for some parent firms, making it difficult to measure a linkage between domestic and foreign sales. Because including these parent firms does not alter

[10] The surveyed sample included 12,855 manufacturing firms with 4.9 million employees in 2006.
[11] A foreign business is defined as one in which 10 percent of the affiliate's equity shares are owned by a Japanese parent firm.

our results quantitatively, we use the reduced sample of 1,656 parent firms with complete information on sales.

### 2.2 Structural Changes in the Japanese Manufacturing Sector

Dissecting the detailed firm-level data, we describe several important structural changes in the Japanese manufacturing sector that occurred during the past decade under a period of falling investment barriers. We first assign firms into percentile bins by their 1996 volume of global production which includes domestic, export, and foreign affiliate sales at the firm-level.[12] Table 1 tabulates the number of all firms and multinational parent firms for both years adjusting the sales intervals for the 1996 percentile bins into 2006 prices. Comparing these periods, we observe that the total number of firms declined by 8.9% from 14,117 to 12,855. On the other hand, the total number of multinational parents increased by 72.5% from 960 to 1,656. Decomposing the aggregate changes, we find that small firms disproportionately decreased in number, and large firms were more likely to become multinational. In terms of the extensive margin growth, foreign expansion was skewed towards larger firms.

=== Table 1 ===

Next, we examine production by Japanese firms. Between 1996 and 2006, the total volume of domestic production declined by 7.1%, whereas foreign production increased by 98.9%. The substantial growth of offshore production offsets the contraction in domestic production, whereby global production employing Japanese technology increased by 3.8% from 464.5 to 482.0 trillion yen. To illustrate the changes at the intensive margin, Table 2 shows the volume of production per firm in billions of 2006 yen across the percentile bins that are defined for 1996 and 2006, separately. In terms of the intensive margin, domestic production increased on average by 2.0%, and foreign production by 15.2%. On average, total production per firm increased by 14.0%.

[12] The following results are similar when the size is measured by domestic employment or when export sales are excluded.

=== Table 2 ===

Dissecting the aggregate changes reveals large differences across Japanese firms by size. In the bottom percentiles, firms experienced an increase in the average volume of their foreign production, but a fall in their domestic production. Together, their average volume of total production contracted. By contrast, firms in the middle and upper percentiles (30–99) increased their average production both at home and abroad. In the top 1%, a substantial increase in average offshore production dominated a fall in average domestic production, leading to a sizeable rise in total production per firm. Since these trends are drawn from cohort linked decile groups rather than panel linked firms, we cannot strictly interpret the changes occurring in the intensive margins. Nevertheless, the trends indicate that Japan's distributional production structure has substantially changed. Accounting for offshore production, global production per firm has increased disproportionately more for larger, multinational firms relative to smaller, domestic firms.

These findings have implications for aggregate productivity. As is shown in the literature on productivity dynamics, industry productivity growth can be attributed to reallocations of production shares of heterogeneous firms in that industry or within firm-level productivity improvements (Foster et al., 2001). Petrin et al. (2011) finds that micro-level reallocation of production resources from less to more productive plants generates a larger contribution to aggregate productivity growth for the manufacturing sector in the United States. However, prior studies on productivity dynamics have not necessarily distinguished between domestic and foreign production in measuring reallocation effects, and there has been little investigation of how foreign-market expansion may also improve aggregate productivity (Foster et al., 2001).

The observed reallocations in Table 2 are important because of the existence of firm heterogeneity in productivity, which is related to firm size and multinational status. Normalizing value added per worker at the median value, we found that average labor productivity increases with the firm size for both 1996 and 2006 samples. In 1996, for instance, the smallest 10% of firms were on average 43% less productive than the average firm whereas the largest 10% of firms possessed a labor productivity advantage of over 160%. Furthermore, Tomiura (2007) finds that multinational firms in Japan are 60% more productive than non-multinationals. As large multinationals are more productive than smaller domestic firms, the observed market share reallocations over the past decade would necessarily translate into potentially large productivity gains without any technological improvements within firms.

For Japan, changes in *domestic* reallocation efficiency were found to account for over 80% of all aggregate productivity growth over the last decade (Inui et al., 2009). While Japan experienced a domestic productivity slowdown that has averaged less than 0.5% per year from 1994–2005 (Inui et al. 2009), we know little about how the reallocation of activity towards more efficient multinational production has impacted resource use and aggregate productivity. In this respect, the Japanese manufacturing industry offers an interesting case study for assessing productivity gains from reallocation of technological resources via multinational activity.

## 3. Theoretical Framework

Our theoretical framework is adapted from the heterogeneous exporting firm model of EKK (2011) which incorporates stochastic entry and demand stocks into a Melitz model. We adapt their model to multinational activity by allowing firms to engage in foreign markets through FDI, excluding the role of trade. Instead of incurring iceberg trade costs, heterogeneous firms must pay technology transfer and management costs to serve foreign consumers via offshore production. This section briefly presents a modified version of the EKK model for multinational production. Key elements of the model are monopolistic competition, Pareto distribution of firm efficiency, and variable and fixed costs of operating offshore production.

### 3.1 Firm Heterogeneity

There are $N$ host countries with factor cost $w_n$. Each country has a continuum of potential producers, each producing a unique good $j$ with efficiency $z_i(j)$. A set of firms that originate from country $i$ can produce good $j$ in country $n$ with unit costs given by:

$$c_{ni}(j) = \frac{w_n d_{ni}}{z_i(j)} \tag{1}$$

Unit costs increase with host market's factor costs, $w_n$, and an iceberg form of efficiency loss $d_{ni}$, but decrease with firm-level productivity $z_i(j)$.[13] Each pair of countries $i$ and $n$ is separated by technology barriers that rise in $d_{ni}$. In this setting, $d_{ni}$ can be interpreted as the variable costs of operating offshore production that include information costs of working abroad, transaction costs of dealing with FDI policy barriers, or servicing network costs.[14] We assume that a firm incurs no additional cost to implement its production technology at home, implying that there is no efficiency loss, $d_{ii} = 1$.

As in Melitz (2003), each firm receives a random productivity draw from a Pareto distribution. Then, a measure of potential producers with efficiency of at least z is:

$$\mu_i^Z(Z \geq z) = T_i z^{-\theta}, \ \ z > 0 \tag{2}$$

$T_i$ indicates the average level of efficiency/technology in country $i$, and $\theta$ governs the distribution of firm-level productivities, which is assumed constant across countries. Since all goods are uniquely produced by a single firm and differ solely in the dimension of productivity, the terms "goods" and "firm" can be indexed interchangeably. As equation (1) leads to $z_i(j) = w_n d_{ni}/c_{ni}(j)$, the following equation describes the measure of goods that can be produced in country $n$ by firms from country $i$ with unit cost less than $c$:

[13] The efficiency loss of offshore production is similar in interpretation to Keller and Yeaple (2008), showing that complex technologies deter multinational production from imports by multinational parent firms. It is also consistent with the findings in Ramondo (2011) and Ramondo and Rodriguez-Clare (2009) that multinational costs increase with distance, language barriers, and national borders. Also, intra-firm trade is an alternative explanation for variable costs in multinational production (Irarrazabal et al. 2010).

[14] FDI policy restrictions may increase the costs of multinationals operating abroad in terms of ownership constraints, foreign-specific regulations, and weak legal protection of property and capital (World Bank Group, 2010).

$$\mu_{ni}(C \leq c) = \mu_i^z\left(\frac{w_n d_{ni}}{c}\right). \tag{3}$$

Using equation (2), we can write equation (3) as $\mu_i^z\left(\frac{w_n d_{ni}}{c}\right) = T_i(w_n d_{ni})^{-\theta}(c)^{\theta}$.

### 3.2 Demand and Entry Costs

With constant-elasticity-of-substitution (CES) preferences, each country has the following demand function for differentiated products:

$$X_n(j) = \alpha_n(j)\left(\frac{p_n(j)}{P_n}\right)^{-(\sigma-1)} X_n \tag{4}$$

where $X_n(j)$ is the quantity sold by firm *j* in country *n*, $X_n$ is an aggregate demand for manufacturing varieties, and $P_n$ is the CES price index averaged across all goods consumed in country *n*. $\sigma$ is the elasticity of substitution between any two goods with $\sigma > 1$, for which it is assumed $\theta - 1 > \sigma$. $\alpha_n(j)$ is an unobservable demand shock for firm *j* selling in country *n,* with higher values indicating a preferable shock to a variety produced by firm *j.*

A firm *j* enters market *n* by paying a fixed cost of setting up a production plant as follows:[15]

$$E_{ni}(j) = E_{ni}\varepsilon_n(j) \tag{5}$$

where $E_{ni}$ is a general fixed cost that is constant for all firms entering market *n* from country *i*. The costs include the physical costs of building a plant and the information/FDI barrier costs associated with establishing a new affiliate in a new market. The information costs are related to marketing research, foreign contacts, and local recruitment of workers. FDI policy barriers in the form of fixed costs may include additional regulations required to set up an affiliate. $\varepsilon_n(j)$ is a idiosyncratic fixed cost specific to firm *j* entering market *n*, which accounts for unobservable factors of fixed costs. Higher values indicate larger investment costs for firm *j* to enter market *n*.

A firm *j* from country *i* operating in market *n* will generate net profits as:

[15] EKK (2011) employ the marketing-based formulation of fixed costs in Arkolakis (2010) to account for an increasing fixed cost with the sales size. We first estimated such a form of entry condition, but found that the fixed entry cost is not quantitatively dependent on the sales size.

$$\pi_{ni}(j) = \left(1 - \frac{c_{ni}(j)}{p_n(j)}\right) \alpha_n(j) \left(\frac{p_n(j)}{P_n}\right)^{-(\sigma-1)} X_n - E_{ni}\varepsilon_n(j) \tag{6}$$

With monopolistic competition and Dixit-Stiglitz preferences, each firm maximizes its profit by charging a constant markup $\bar{m} = \sigma/(\sigma-1)$ over its unit cost, $c_{ni}(j)$, such that $p_n(j) = \bar{m}c_{ni}(j)$. Then, its total gross profit is proportional to demand with a factor of $1/\sigma$, yielding $X_n(j)/\sigma$. Firm *j* will enter market *n* if and only if its operating profit is sufficient to overcome the fixed cost of entry:

$$\eta_n(j) \left(\frac{p_n(j)}{P_n}\right)^{-(\sigma-1)} \frac{X_n}{\sigma} \geq E_{ni} \tag{7}$$

where $\eta_n(j) = \alpha_n(j)/\ \varepsilon_n(j)$ is an entry shock to firm *j* that invests in market *n*.

### 3.3 Entry and Sales Conditions

The condition in equation (7) can be used to express the entry hurdle condition that firm *j* enters market *n* from country *i* if and only if its unit cost is less than the threshold entry cost:

$$c_{ni}(j) \leq \bar{c}_{ni}(j) \tag{8}$$

where:

$$\bar{c}_{ni}(j) = \left(\eta_n(j) \frac{X_n}{\sigma E_{ni}}\right)^{1/(\sigma-1)} \frac{P_n}{\bar{m}} \tag{9}$$

Substituting the constant markup price and equation (9) into equation (4), we can express the latent sales conditional on entry:

$$X_{ni}(j) = \frac{\alpha_n(j)}{\eta_n(j)} \sigma E_{ni} \left(\frac{\bar{c}_{ni}(j)}{c_n(j)}\right)^{\sigma-1} \tag{10}$$

Equations (8), (9), and (10) provide the main theoretical predictions about the structure of heterogeneous multinational firms with varying efficiency. The entry hurdle in (9), $\bar{c}_{ni}(j)$, pins down the critical threshold for entry, whereby a lower $\bar{c}_{ni}(j)$ indicates that the market is less attractive for firms to engage in multinational production. As unit cost decreases with firm-level productivity, more efficient firms are more likely than less efficient firms to overcome the entry hurdle. Conditional on entry, equation (10) dictates the volume of sales generated by firm *j* in that market.

Analogous to the behavior of exporting firms found in EKK, the model then predicts that higher productivity firms are more likely than less productive firms to: (i) invest in a larger number of markets, (ii) penetrate the less attractive markets, and (iii) yield larger sales per market. With varying entry hurdles, firms first enter the most attractive market, and then invest progressively in less attractive markets, predicting a hierarchy of market destinations in which more productive firms progressively enter less attractive markets. However, the presence of entry and demand shocks in the model allows firms with identical productivity to deviate from identical patterns of market entry and volume of affiliate sales. Thus, the model predicts a weak pecking order.

### 3.4 Empirical Regularities of Japanese Multinational Production

Since we apply the EKK model of trade to FDI, it is necessary to examine whether empirical regularities of multinational activities are consistent with the model, as is found in exporting firm data. Using Japanese firm-level data of multinational entry and sales across foreign markets, we document a number of the stylized patterns in line with the theoretical implications of the EKK model.

*Market Entry and Market Size*

Figure 1 shows a relationship between market entry and market size. Panel A plots the number of parent firms investing in each market against the market size, as measured in real GDP in billions of 2000 U.S. dollars.[16] The number of firms investing in each market increases with the size of the host market. Panel B shows the average sales of foreign affiliates in each market against the market size. Sales per affiliate increase with the market size, as is consistent with the number of investing parent firms. Thus, larger markets may attract the entry of more

[16] Data on real GDP come from the World Development Indicators.

multinational firms, but have a weaker positive impact on average affiliate sales. The patterns observed in Panel A and Panel B can be well explained by the existence of fixed entry costs.

=== Figure 1 ===

*Sales Distributions*

Figure 2 plots the sales distributions of Japanese firms within individual markets. For the Japanese market, firm size is measured by domestic production that aggregates firms' sales in Japan and their export markets. We normalize each firm's sales relative to the mean of domestic sales and compute a fraction of firms with at least that much sales.[17] For other foreign markets, we use the total sales of foreign affiliates, including their sales to local, home, and third markets. Figure 2 shows a plot of the normalized sales and the fraction of firms for Japan, China, the U.S., and Thailand. The shapes of the sales distributions are similar across markets and closely following a linear line in the upper tail, supporting the assumption that underlying firm-level productivity of multinational sales is Pareto distributed. However, the distribution starts to deviate from a linear line in the lower tail. As argued by EKK, the deviations in the lower tail can be partly explained by market-entry shocks.

=== Figure 2 ===

*Market Entry and Sales in Japan*

Figure 3 describes the relationship between market entry and sales in Japan. We group firms into different sets according to their entry to foreign markets. First, Japanese firms are sorted into the set of firms with the *minimum* number of foreign markets they penetrated. Panel A in Figure 3 plots the average sales in Japan for each set of firms investing in at least $m$ markets or more. Sales in Japan rise monotonically with the number of markets where multinationals own an affiliate. Second, firms are grouped by the number of markets they

[17] The fraction is constructed by dividing (rank – 0.5) by the total number of firms/affiliates for each observation in a given market, where the rank is one for a firm/affiliate with the largest sales.

entered. Panel B presents a plot of average sales in Japan against the number of firms investing in *m* markets or more, with the marker indicating the number of markets they served. For the set of firms penetrating a single market, there are over 1000 firms with relatively low average sales in Japan. As the number of markets served by them increases, the set of these firms becomes smaller with higher levels of sales. Figure 3 identifies a significant link between domestic sales and market entry, indicating that larger firms are more likely than smaller firms to invest in a larger number of markets. This pattern is consistent with the productivity sorting pattern found in heterogeneous firm exporting decisions across multiple markets, highlighting the critical role of productivity in self-selection decisions of FDI activity.

=== Figure 3 ===

*Multinational Production Intensity*

Lastly, Figure 4 describes the relationship between sales in Japan and foreign affiliate sales. We compute the normalized sales of foreign affiliates in each market defined by $\left(X_{nJ}(j)/\overline{X}_{nJ}\right)/\left(X_{J}(j)/\overline{X}_{J}\right)$. To remove the market effect, firm *j*'s sales in market *n* are divided by the average sales in that market, and then are further divided by the normalized sales in market J, Japan, to remove the firm-size effect. The figure plots the 90$^{th}$ percentile and median normalized sales of foreign affiliates against the number of parent firms for each market. Normalized affiliate sales increase with the popularity of foreign markets as measured by the number of firm entry. However, the pattern is noisier for the markets in which less than 10 firms entered. The generally positive relationship suggests that fixed costs alone cannot explain the varying levels of multinational participation and point to the existence of variable FDI costs such as costly technology transfer.

=== Figure 4 ===

## 4. Estimation and Model Validation

In this section we estimate the structural parameters of the model and evaluate the model's ability to replicate real multinational activity. Before presenting the results, we briefly review the estimation strategy and simulation procedure for individual multinational firms. Because we closely follow the framework developed by EKK (2011), we describe details of the estimation framework in Appendix.

### 4.1 Respecification for Simulation

Following EKK (2011), we re-specify the entry and sales conditions in equations (8), (9), and (10) for quantification. We first isolate the heterogeneous component of unit costs by defining $u(s) = T_J z_J(s)^{-\theta}$ as the standardized unit costs for a Japanese firm *J*. Redefining the efficiency of potential producer in Japan in terms of standardized unit cost for firm *j,* we arrive at:

$$u(j) = T_J z_J(j)^{-\theta} \tag{11}$$

where *J* denotes Japan as a home country. Second, the country-level parameters in equations (9) and (10) are connected with the total number of foreign entries $N_{nJ}$ and FDI shares $X_{nJ}/X_n$, respectively. We can then express the entry hurdle as:

$$u(j) \leq \bar{u}_{nJ}\big(\eta_n(j)\big) = \kappa_2 N_{nJ} \eta_n(j)^{\tilde{\theta}} \tag{12}$$

where

$$\tilde{\theta} = \frac{\theta}{\sigma - 1} > 1$$

$$\kappa_2 = \int \eta^{\tilde{\theta}} g_2(\eta) d\eta.$$

Note that $\bar{u}_n\big(\eta_n(j)\big)$ is a standardized entry hurdle in market *n* for potential producer *j* from Japan. $\tilde{\theta}$ is observed heterogeneity in sales, with a lower value indicating a larger dispersion in sales. Conditional on entry, the sales condition for firm *j* in market *n* is given by:

$$X_{nJ}(j) = \frac{\alpha_n(j)}{\eta_n(j)} \overline{X}_{nJ} \frac{\kappa_2}{\kappa_1} \left(v_{nJ}(j)\right)^{-1/\tilde{\theta}} \tag{13}$$

where:

$$\kappa_1 = \kappa_0 \iint \alpha_n(j) \eta_n(j)^{(\tilde{\theta}-1)} g(\alpha, \eta) d\alpha d\eta$$

$$\kappa_0 = \frac{\tilde{\theta}}{\tilde{\theta}-1}.$$ [18]

$v_{nJ}(j) = \frac{u(j)}{\bar{u}_{nJ}(\eta_n(j))}$ follows a uniform distribution on $[0, 1]$.

To parameterize $\kappa_1$ and $\kappa_2$, $g(\alpha, \eta)$ is assumed to be joint lognormal, with variances ($\sigma_\alpha$ and $\sigma_\eta$), and correlation $\rho$. The joint lognormal distribution allows us to write $\kappa_1$ and $\kappa_2$ as follows:

$$\kappa_1 = \left[\frac{\tilde{\theta}}{\tilde{\theta}-1}\right] exp\left[\frac{\sigma_\alpha + 2\rho\sigma_\alpha\sigma_\eta(\tilde{\theta}-1) + \sigma_\eta(\tilde{\theta}-1)^2}{2}\right] \tag{14}$$

$$\kappa_2 = exp\left[\frac{(\tilde{\theta}\sigma_\eta)^2}{2}\right] \tag{15}$$

### 4.2 Estimation Procedure

Taken together, the entry and sales conditions are governed by four structural parameters: heterogeneity in observed sales $\tilde{\theta}$, variance in sales $\sigma_\alpha$, variance in entry shocks $\sigma_\eta$, and correlation $\rho$. We denote the set of these structural parameters by:

$$\Theta = (\tilde{\theta}, \sigma_\alpha, \sigma_\eta, \rho)$$

Comparing moments of the simulated and actual datasets on multinational firms, we search for an optimal set of structural parameters via the simulated method of moments.

In the first step of this estimation procedure, we use the entry and sales conditions in equations (12) and (13) to simulate individual multinational activities. An artificial producer, $s$, is generated by its efficiency draw, $u(s)$, sales shock, $\alpha_n(s)$, and entry shock $\eta_n(s)$. With an initial guess for the structural parameters and aggregate data, we can produce a dataset of artificial multinational firms with varying productivity and the location and sales of their foreign

[18] Refer to the derivation of the price index in the Appendix A.

affiliates.

In the second step, we construct a set of moment conditions from simulated multinationals and actual Japanese multinationals. We define a vector of deviations between actual and artificial moments for outcome $k$:

$$y(\Theta) = m^k - \hat{m}^k(\Theta). \tag{17}$$

Following the theoretical implications of the model, we choose four moment conditions: pecking order strings, affiliate sales distributions across markets, parent sales distribution in Japan, and multinational production intensity.

We seek to capture these patterns that were identified in the empirical regularities of Japanese firms. Specifically, the pecking order strings are defined as a group of multinational firms entering each possible combination of the five most popular countries in terms of multinational entry: China, United States, Thailand, Taiwan, and Indonesia in 2006. Next, the distribution of affiliate sales is a group of multinationals investing in each foreign market and belonging to the actual sales percentiles for q = 50$^{th}$, 75$^{th}$, 100$^{th}$. Then, the distribution of multinational parent sales in Japan is a group of multinationals entering each foreign market and belonging to the percentiles of actual sales in Japan for q = 50$^{th}$, 75$^{th}$, 100$^{th}$. Finally, the multinational production intensity is a group of multinationals whose ratio of sales in market $n$ to sales in Japan is below and above the 50$^{th}$ percentile for each market.

Finally, we estimate a set of structural parameters that match the simulated moments as closely as possible with moments from the actual data. Stacking a vector of moment conditions, we minimize the objective function:

$$\hat{\Theta} = \arg\min_{\Theta}\left\{[m^k - \hat{m}^k(\Theta)]' \ [m^k - \hat{m}^k(\Theta)]\right\}. \tag{18}$$

### 4.3 Estimation Results

Table 3 presents the estimation results of the structural parameters with bootstrapped standard errors. In column (1), we report the benchmark results. To mitigate the chance that noisier segments of the data adversely influence the estimates, we exclude markets with less than 10 foreign affiliates from the estimation. We find that the key distribution parameter of size dispersion, $\tilde{\theta} = \theta/(\sigma - 1)$, is 1.9. This estimate is slightly lower than EKK's estimate of 2.46 for French exporting firms, indicating that Japanese multinationals may have a greater dispersion in sales than French exporting firms do. Given that our estimates are generated from multinational, not exporting, activities, the parameter estimates are not strictly comparable. Nevertheless, it is reassuring that our estimate for firm heterogeneity is quantitatively similar to the estimate of French exporters found by EKK.[19]

We find that the estimate of variance in sales shock is 1.64, which is quite similar in magnitude to the corresponding estimate for French exporters. The estimate of variance in entry shock is 0.39, which is also quantitatively close to the corresponding estimate of 0.34 for French exporters. While there is no clear reference to interpret the size of these estimates, these results indicate that heterogeneity in productivity is not sufficient to account for the entry and sales patterns of actual Japanese multinationals. Comparing the variances of entry and sales shocks, we find that the model is more effective at explaining variations in market entry than variations in foreign affiliate sales. Lastly, we find that the correlation between entry and sales shocks is –0.62, suggesting that the entry shocks are negatively associated with the sales shocks.

=== Table 3 ===

We proceed to check the robustness of the benchmark estimates. First, a possible concern is that the exclusion of smaller markets could influence the benchmark estimates. Estimating the parameters for all the markets, we present the results in column (2). The results show that the estimate for size dispersion rises to 2.12, but the overall point estimate and bootstrapped standard errors are quite similar to the benchmark. Second, we check the sensitivity of the

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[19] The level of size dispersion is related to heterogeneity in firm efficiency via an elasticity of substitution. As Kang (2008) estimates that the elasticity of substation is 2.19 for the Japanese manufacturing sector in 1994-2004, a rough estimate of efficiency dispersion from our estimated parameter is 2.37. By contrast, Wakasugi et al. (2008) find that the dispersion parameter of total factor productivity was 1.69 for Japanese manufacturing firms in 2003.

benchmark parameters to a different set of moments. Among the moments used, the pecking order of entry may not fit as well for multinational production compared to export entry because FDI activity is encouraged by a multitude of investment motives, including market access, efficiency seeking, and policy incentives. To address this concern, we exclude the pecking order moments from the estimation. Column (3) shows that the estimated parameters and bootstrapped standard errors are similar to the benchmark results, suggesting that our results are robust to the different set of moments used.

Finally, we estimate the structural parameters for Japanese multinational activity in 1996. Column (4) shows that the estimate of size dispersion rises to 2.13, but the difference falls within the range of the bootstrapped standard errors from the benchmark result. While the other estimates differ slightly from the benchmark estimates, there is no substantial deviation. Taken together, our robustness checks demonstrate that the benchmark estimates of the four parameters are not sensitive to alternative specifications of the sample and the moments used for estimation.

### 4.4 Model Validation

Having checked the robustness of key structural parameters, we proceed to examine how well the estimated model performs in replicating real multinational activity. First, we assess the model's ability to replicate the actual data as captured by our moment conditions. Given the estimated parameters, we simulate multinational activity and compare the simulated moments with the moments from the estimation sample. In results not shown, we find a good fit of the data between simulated and actual moments, suggesting that the model is able to closely replicate the in-sample moments of the actual data.[20] As the same sample is used for both estimation and validation, the exercise is a conventional internal model validation test.

Since in-sample replications are based only on the information conditioned in the estimation of structural parameters, the internal validation test does not clearly show the

[20] Refer to section 6 in Arita and Tanaka (2011).

model's ability to predict multinational activity in an environment with a significantly different level of FDI barriers. To gain further confidence that the model can be used to simulate multinational activity when FDI barriers change, we examine the external validity of the model. We make use of data from a decade earlier on Japanese multinationals, and investigate how well the model is able to reproduce out-of-sample predictions of Japanese multinational activities in 1996 with our parameters estimated on 2006 decade. Using 1996 data to parameterize $N_{nJ}$ and $\overline{X}_{nJ}$, we simulate an artificial set of multinationals from the entry and sales conditions:

$$u(s) \leq \bar{u}_n\big(\eta_n(s)\big) = N_{nJ}^{1996}\kappa_2\eta_n(s)^{\tilde{\theta}} \tag{19}$$

$$X_{nJ}(s) = \overline{X}_{nJ}^{1996}\frac{\alpha_n(s)}{\eta_n(s)}\frac{\kappa_2}{\kappa_1}\left(\frac{u(s)}{\bar{u}_n(s)}\right)^{-1/\tilde{\theta}}. \tag{20}$$

Because FDI barriers were likely to change significantly from 1996 to 2006, this external validation approach is in the spirit of the "non-random holdout sample" (Keane and Wolpin, 2007). That is, we assess a model fit by asking how well the model can replicate multinational activity outside the support of the data along the dimension that the model is meant to predict, i.e., changes in FDI barriers.

Figures 5.1 and 5.2 present the out-of-sample simulations for 1996 activity. The figures are scatter plots of the number of simulated firms vs. the actual number of firms according to the bins defined by the moment conditions estimated in the model. Panel A presents the number of firms falling into each of the 32 pecking order strings for the real and simulated data. Panels B through D present the number of firms falling into the defined percentile groups across foreign markets of each respective moment. A 45-degree straight line is plotted as a reference to indicate a perfect fit between simulated and actual firms.

From Panels A through D, we find that the model fit is considerably strong along various dimensions of multinational activities. The good fit is evident from the four moments: pecking order strings, distribution of foreign affiliate sales across markets, distribution of sales back in Japan, and multinational production intensities. However, we tend to slightly under-simulate sales of foreign affiliates and domestic sales in Japan.[21] Although the out-of-sample predictions reveal slight deviations from the data, the overall simulations are externally consistent with the Japanese multinational activity a decade ago.[22] This gives us some degree of confidence that the model can be used to simulate multinational activity under reduced FDI barriers.

=== Figures 5.1 and 5.2 ===

## 5. Counterfactual Analysis

Internal and external model validation provides a degree of confidence that the model can be used to simulate multinational activity under falling FDI barriers. In this section, we use the model to perform counterfactual simulations to investigate the impacts of changes in FDI barriers on intra-industry reallocations and the implications for aggregate productivity.

### 5.1 Global General Equilibrium

For counterfactuals, we first need to account for adjustments of aggregate prices and wages that take place following an exogenous change in variable and fixed FDI barriers. Leaving details of the general equilibrium setting and data sources in Appendix D, we briefly summarize the counterfactual simulation procedure.

Following the approach in EKK (2011), we first set up a general equilibrium framework in which producers serve their home and host countries through FDI. Each country is endowed with labor, which is mobile within countries, but immobile across countries. Intermediates are a Cobb-Douglas combination of labor and intermediates. Final output is non-traded and a Cobb-Douglas combination of manufactures and labor. Fixed cost for FDI is paid by labor.

[21] In comparison with in-sample predictions for 2006 activity, the predictive ability of the model appears to be slightly weaker in out-of-sample predictions for 1996 activity (Arita and Tanaka, 2011).

[22] We also found some shortcomings of the model. First, large firms tend to invest in too many countries, but small firms invest in too few. Second, we tend to under-simulate the sales level of Japanese multinationals in both home and foreign markets. Lastly, the model poorly explains vertically motivated multinationals.

Profits accrue to the headquarter country of producers. As consumers own equal shares of each firm headquartered in their country, the profits are redistributed equally among the consumers. A country's GDP is equal to its total wage from production in its own country and its total profit from abroad. Lastly, some countries are net receivers for FDI, and we allow for FDI deficits.[23]

The general equilibrium framework is set up such that manufacturing production and consumption across countries are connected through FDI activity. Equilibrium in the world market for manufacturers leads to a system of equations. Based on the approach of Dekle, et al. (2008), changes in wages and prices can be solved as a result of an exogenous change in variable and fixed FDI costs. By solving changes in prices and wages jointly, we can calculate counterfactual changes across countries in FDI sales from Japan and the entry number of Japanese firms, $\hat{X}_{nJ}^{C}$ and $\hat{N}_{nJ}^{C}$.

Given the counterfactual changes in aggregate sales and entry from Japan to other countries, we can calculate the expected changes in the aggregate sales and entry. Then, we use the entry and sales conditions in equations (12) and (13) to specify the corresponding counterfactual conditions:

$$u(s) \leq \bar{u}_{nJ}^{C}\big(\eta_n(s)\big) = N_{nJ}^{C}\,\frac{\eta_n(s)^{\tilde{\theta}}}{\kappa_2} \tag{21}$$

$$X_{nJ}^{C}(s) = \overline{X}_{nJ}^{C}(s)\,\frac{\alpha_n(j)}{\eta_n(j)}\frac{\kappa_2}{\kappa_1}\left(\frac{u(s)}{\bar{u}_{n}^{C}(s)}\right)^{-1/\tilde{\theta}} \tag{22}$$

Holding the structural parameters fixed, we next simulate a set of artificial firms on the basis of equations (21) and (22), generating a counterfactual dataset of multinational entry and sales. For our counterfactual simulations, we fix productivity draws and entry and sales shocks specific to individual firms in order to ensure that all changes in firm-level activity relative to the baseline stem solely from a change in FDI barriers.

For our analysis, a hypothetical experiment should provide a useful insight into the response of individual firms to aggregate shocks. However, it should be emphasized that the model is

[23] FDI deficits are fixed to their 2006 levels in counterfactuals.

based on a set of highly stylized assumptions. As emphasized in counterfactual exercises by Eaton and Kortum (2002) and Chor (2010), counterfactuals should not be interpreted definitely, but should be viewed as an explorative investigation.

### 5.2 Global Reductions in FDI Barriers

In our first experiment, we examine the impacts of a 20% global reduction in both variable and fixed FDI barriers by applying an exogenous change in the variable costs, $\hat{d}_{ni} = 1/1.20$, and that in the fixed costs, $\hat{E}_{ni} = 1/1.20$, for all $n \neq i$. These reductions can be interpreted as a decline in the variable and fixed costs of manufacturing production abroad, which result from advances in communication and transportation technology and continued multilateral liberalization of FDI policy restrictions. Production barriers within a country are assumed to remain unchanged by setting $\hat{d}_{ii} = 1$ and $\hat{E}_{ii} = 1$. We first present counterfactual changes at the aggregate level and then the changes that occur at the firm level.

Column (1) in Table 4.1 presents the general equilibrium changes for real wages at the aggregate level. We find that falling FDI barriers lead to a general increase in real wages around the world (approximately 29%). This result is generated by two forces. First, foreign affiliate expansion by multinationals leads to a rise in income around the world due to the extra income that their headquarters country receives from higher profits generated from multinational activity abroad. Second, the increased production reduces the aggregate price level because more efficient multinational firms produce at lower marginal costs. Specifically, the countries that are more open to FDI such as Hong Kong, Singapore, and Belgium, would experience a larger increase in inward multinational activity, and receive greater welfare gains in terms of a steeper decline in prices and a more dramatic increase in real wages. On the other hand, the countries that have higher levels of outward FDI such as Japan, the United States, and Netherlands, may experience a modest increase in prices because of the increased wealth effects from multinational profits generated abroad. Thus, they receive smaller welfare gains in terms of a modest decline in prices and a modest increase in wages. In the case of Japan, small inward FDI and large outward FDI combine to yield a modest 0.7% increase in real wages.

===Table 4.1===

With the general equilibrium changes in wages and prices, we can predict aggregate changes in entry and sales by Japanese firms across foreign markets and in Japan. Columns (2) and (3) in Table 4.1 show that Japanese firms increase their entry and sales in the majority of foreign markets. On average, the entry of Japanese firms increases by 72.5% and their sales rise by 103.4%. However, these changes differ significantly across markets. As falling inward barriers raise competition in the Japanese home market through lower aggregate prices, Japanese firms decrease in number by 2.7% and reduce their aggregate domestic production by 3.5%. By contrast, falling outward barriers lead to foreign expansion by Japanese firms.

Table 4.2 presents the results for the aggregate number and production of Japanese firms according to these aggregate changes around the world. Multinational firms increase in number by 66.4% and expand their aggregate foreign production by 107.3%. Because foreign expansion dominates domestic contraction, the total volume of domestic and foreign production increases by 18.9%. Thus, our simulations show that falling FDI barriers abroad lead to a significant restructuring of the economy from domestic to multinational production.

===Tables 4.2, 4.3, and 4.4===

Simulating individual firm activity, we then dissect how falling FDI barriers affect firms differently according to productivity levels. Table 4.3 shows the counterfactual results for changes in the number of total firms and multinational firms, i.e., the extensive margin, across productivity decile groups. Due to high fixed entry costs in foreign markets, most firms in the lowest decile group are domestic whereas most multinational firms belong to the higher productivity groups. Falling investment barriers induce 1,004 domestic firms to become multinational: 176 from firms below the $50^{th}$ percentile in terms of productivity and 828 firms with productivity above the $50^{th}$ percentile. There is no growth at the extensive margin for the top 1% firms as they all are already multinational in the baseline. Furthermore, the increased competition from abroad leads to an exit of 350 domestic firms, which are concentrated in the bottom 10% decile group with a net exit rate of 25%.

These asymmetric changes along the extensive margin highlight the important role of fixed costs in multinational production and the self-selection decision to enter foreign markets. When fixed barriers fall, the impact at the extensive-margin is pronounced for those firms closest to the threshold productivity prior to the change. If fixed costs are sufficiently high, falling barriers will more likely provide foreign production opportunities for higher productivity firms. In addition, among potential producers below the cutoff productivity, higher productivity firms tend to overcome entry barriers across a larger number of markets.

Table 4.4 presents the changes in domestic and total production per firm and foreign production per multinational, i.e., the intensive margin. Falling inward barriers lead to the entry of foreign firms to the domestic market, and increased competition at home leads to an across-the-board reduction in the average domestic production. In contrast, falling outward barriers lead to a rise in foreign production per multinational firm across all firms, whereby intensive margin growth is significantly higher for higher productivity firms. Firms below the 70$^{th}$ percentile grow by less than 2 billion yen (or 3% of their total production), while the top 1% grow by 486.6 billion yen (or 57% of their total production). Because the intensive margin of foreign production increases modestly for firms below the 70$^{th}$ percentile, the average total production for low productivity firms decreases by 0.9 - 2.5%. In contrast, total production per firm increases for firms in the upper percentile groups, with an extremely large expansion for the top 1% of firms by 481.3 trillion or 56.3% of their total sales.

The decrease in variable costs yields asymmetric impacts along the intensive margin. A percentage decline in variable costs translates into a disproportionate increase in the volume of sales for firms that have larger foreign production across markets. For firms below the 70$^{th}$ percentile that generate less than 0.1% of all their sales abroad, the impacts of falling barriers on total production growth are small, contributing to a less than 0.9% increase in total sales. This contrasts with the firms above the 70th percentile that generate more than 50% of their sales abroad; falling barriers contribute to a more than 30% increase in their overall sales. These more productive firms penetrate a larger number of markets and yield greater sales per market, magnifying the overall scale effect.

The asymmetric changes at the extensive and intensive margins lead to significant intra-industry reallocation of market shares across firms. By calculating the percentage share of production according to quintile productivity groups, we depict the market shares in baseline and counterfactual simulations in Figure 6. Prior to any reduction in investment barriers, the baseline production structure is already heavily skewed—the top quintile of firms account for 56.6% of production. Following a 20% reduction in variable and fixed FDI barriers, the market share of this group increases to 64.5% while the remaining bottom firms lose market share.

=== Figure 6===

This reallocation from less to more productive firms may lead to large aggregate productivity gains. To quantify productivity improvements, we adopt the productivity decomposition approach of Foster et al. (2001). Specifically, we calculate the following components of aggregate productivity changes:

$$\sum_s \ln(z_s) \Delta Weight_s \tag{23}$$

$$\sum_s Weight_s \left[\ln\left(z_{exit\_s}\right) - \overline{\ln\left(z_s\right)}\right] \tag{24}$$

where $Weight_s$ is the output share of simulated firm $s$ in the total production of all firms, $z_s$ is a measure of the simulated firm's efficiency, and $\overline{\ln\left(z_s\right)}$ is the average efficiency level of the industry. Compared with the standard decomposition technique, our model does not allow for within-firm technology improvement. If we assume that firm productivity is identified solely by its efficiency draw $z$, then, the above two measures can be used to assess aggregate productivity changes stemming from the intra-industry reallocations. We find that a 20% reduction in FDI barriers translates into an approximate 29.6% gain from market-share reallocations and a 1.2%

gain from the exit effects. Together, aggregate productivity improves by 30.7%.

It is important to note that these aggregate productivity gains are primarily realized from expanding multinational production in Japan's investment partners, rather than in its domestic industry. Thus, it is more appropriate to attribute our measured productivity improvements to reallocations of Japanese technological resources abroad, of which gains are realized at the global, rather than domestic, level.

### 5.3 Variable vs. Fixed FDI Barriers

We now examine more closely the different consequences between reductions in variable and fixed FDI barriers on intra-industry reallocations and aggregate productivity changes. For this task, we run counterfactual simulations for (1) a 20% global decline in strictly variable FDI barriers, and (2) a 20% global decline in strictly fixed FDI barriers. These comparisons allow us to explicitly examine the impacts between variable and fixed FDI barriers.

Before presenting the results, we clarify the distinction between variable and fixed costs for FDI activity. Variable costs are associated with technology/management efficiency losses, transaction costs, and policy factors such as foreign taxes. The model predicts that falling variable costs reduce the unit cost of foreign production for each firm, which increases the probability for firms to enter a market and expands their production there. On the other hand, fixed costs capture the establishment costs of offshore production, including plant construction, information, and network costs to set up a foreign affiliate. A decline in the fixed costs encourages a firm to overcome the entry hurdle in a market. Beyond any secondary effects on the price level, falling fixed barriers are related to the intensive margin of multinational sales through the sales condition.

Table 5.1 reports the aggregate outcomes from reducing variable and fixed barriers, separately. The total number of firms declines by 2.21% for the variable barriers and by 1.53% for the fixed barriers, suggesting that variable costs have a larger impact. In contrast, fixed costs have a slightly higher impact on multinational firms than variable costs; multinationals increase in number by 28.6% for fixed costs and by 25.2% for variable costs. This suggests that fixed costs play an important role in accounting for the entry of multinationals. In terms of the volume of production, the variable costs have a significantly stronger impact than the fixed cost. Foreign production increases by 59.1% for the former and by 27.2% for the latter. Reductions in variable barriers leads to an increase in foreign competition, whereby domestic production contracts by 0.74% for the variable barriers. In the case of reducing fixed barriers, the wealth effects from increased Japanese multinational profits generated abroad dominate the pro-competitive effects of increased inward foreign multinational production, leading to an increase in domestic production by 0.28%. Together, the expansion of total production is larger from falling variable barriers.

=== Tables 5.1, 5.2, and 5.3===

Table 5.2 reports the counterfactual changes along the extensive margin across productivity decile groups. We find that reduced fixed barriers induce 455 additional firms to become multinational, while reduced variable barriers induce 415 additional firms to invest abroad. This suggests that fixed entry costs play a larger role in the extensive margin of FDI. Once again these impacts are more pronounced for higher productivity firms than lower productivity firms.

Table 5.3 reports the changes along the intensive margin. In terms of foreign production, we find that falling variable barriers induce the top 1% of firms to increase their intensive margin by 314.8 billion yen, and by 82.5 billion yen in the case of fixed barriers. Thus, relative to reductions in fixed barriers, reductions in variable barriers yield more dramatic growth along the intensive margin of multinational production.[24] Overall we find a larger reallocation of total production for variable barriers relative to changes in fixed barriers.

[24] Reductions in variable inward barriers lead to a reduction in average domestic production across all firms except for the lowest decile group which increases because of exiting by the smallest firms. While all firms decrease domestic production, due to the disproportionate exiting of small firms, there is an increase in average domestic production of all firms. With wealth effects, the reductions in fixed barriers lead to an increase in domestic production for all firms.

As variable investment barriers fall, the most productive firms expand their market share progressively, which in turn yields an increasing level of reallocation effects. By contrast, an increase in productivity gains is modest for declining fixed barriers, which have a stronger impact on the extensive margin than the intensive margin. Because changes along the extensive-margin generate a weak expansionary effect on the incumbent multinational firms, there would be a small contribution of the reallocation effects to aggregate productivity improvements. To clarify this point, Figure 7 shows the counterfactual changes in market shares from falling variable and fixed barriers as compared with the baseline. It is evident that variable barriers lead to a larger reallocation of market share from less to more productive firms.

=== Figure 7 and 8===

Assessing the impact of these reallocations on aggregate productivity, we find that falling variable barriers lead to an approximate 17.3% improvement in aggregate productivity. By contrast, falling fixed costs lead to a much smaller improvement of 4.5%. Figure 8 plots the simulated gains in aggregate productivity from varying the level of changes in variable and fixed levels of FDI barriers. The simulations indicate that aggregate productivity improvements are driven by reductions in variable FDI barriers as is in line with the findings for exporting firms in di Giovanni and Levchenko (2010). Previous studies on gains from FDI have not explicitly distinguished between these types of barriers. Our numerical results demonstrate the importance of modeling each type of barriers as they carry substantially different quantitative implications for aggregate productivity improvements.

### 5.3 Discussion

Our simulations present the first attempt to explicitly quantify the intra-industry reallocations occurring from FDI globalization. This raises a question about the quantitative relevance of our results. To assess the contribution of FDI globalization to aggregate productivity growth, we relate counterfactual simulations to the actual structural changes that occurred in Japan's manufacturing sector over the last decade (1996–2006). Given that the model simulations are based exclusively on reductions in FDI barriers and cannot account for all other economic factors that affected Japan between 1996 and 2006, such a comparison is limited. Nonetheless, this period of falling FDI barriers serves as a useful benchmark to gauge the quantitative magnitude on various changes in FDI barriers and to assess what dimensions of the actual historical changes are captured well in our simulations.

=== Table 6===

Table 6 compares counterfactual simulations generated from 25%, 20%, and 10% reductions in variable and fixed barriers against the actual changes that occurred over the last decade. We find that the counterfactual simulations are able to capture several important dimensions of the actual historical changes. First, a 20% reduction in FDI barriers delivers a similar magnitude of multinational growth that occurred within the last decade, fairly capturing the growth in foreign production abroad (106.2% vs. the actual 99.0% growth) and the growth in the number of multinational firms (66.7% vs. the actual 72.0% growth).

Second, the simulations roughly follow the asymmetric growth pattern experienced in Japan. In the actual changes, large expansions in multinational activity and contractions in domestic activity led to higher realized growth for the top productivity quintile (14.7%) relative to the lower 80% of firms (6.5%). The model generates similar patterns of high growth for the top firms (7–36%) relative to the less productive firms. Unlike the actual changes, our simulations find a contraction of the bottom 80% of firms. This difference is expected given that our model is based on static simulations that do not account for any growth aspects that occurred during the ten year period. Importantly, the intra-industry reallocations theorized by the model are strongly supported by both the data and simulations: larger, more productive firms expand at a disproportionate rate relative to smaller, less productive firms in both the real and simulated realizations of data.

Overall, a 15–25% reduction in variable and fixed FDI barriers delivers substantial reallocation of Japanese technological resources, which loosely follows the structural changes that occurred over the last decade. This level of reduction roughly translates into aggregate productivity improvements in the range of 10–40%. To place this in perspective, over the last decade, Japan's domestic aggregate productivity grew by less than 10%.[25] Thus our numerical results suggest that the disproportionate expansion of highly productive multinationals over the last decade may have generated improvements in Japanese technological resource reallocation that resulted in larger aggregate productivity gains than those realized from both within firm technological improvements and domestic reallocation of activity.

## 6. Conclusion

This paper applied a simulation framework to quantitatively investigate how multinationals respond to declining FDI barriers and the implications for aggregate productivity. Our work makes the following contributions. First, using a detailed dataset of Japanese manufacturing firms, we found that the sales and entry patterns were consistent with a heterogeneous firm model of multinationals facing both fixed and variable barriers. An adapted version of the EKK model was capable of replicating both in-sample and out-of-sample activity, supporting both the internal and external validity of the model. Second, our counterfactual simulations illustrated how falling FDI barriers could lead to important changes in intra-industry reallocations. Consistent with the structural changes observed in the data, more efficient firms disproportionately expand while less efficient firms suffer net contractions. Lastly, we found that the type of FDI barriers has significantly different consequences for aggregate productivity improvements, whereby reductions in variable FDI costs generate more pronounced intra-industry reallocations than reductions in fixed FDI costs.

Our numerical simulations are the first attempt to measure the impact of FDI globalization on intra-industry reallocations and its implications for aggregate productivity. We provide important quantitative evidence that falling FDI barriers have contributed to structural changes in

[25] Aggregate productivity estimates vary but fall within the range of 0-2% per year for the last two decades (Inui et al., 2009).

Japan's manufacturing sector. As investment barriers continue to decline across the world, our work suggests that the further restructuring towards multinational production in Japan and other advanced economies will be an important source of global economic development.

Our application of the EKK framework to multinational production is a promising approach to quantify the aggregate implications of FDI integration. Further improvements in this micro-simulation framework could lead to a rich computational tool useful for policy analysis. Since our application focused exclusively on FDI, a natural extension is to combine the exporting and FDI activities into an integrated micro-simulation framework. This would allow the analysis to capture the role of intra-firm trade in multinational production. Another extension is to apply the model to more FDI-specific policy issues. Moving beyond ad-hoc hypothetical reductions in FDI barriers, the model could be used to investigate changes in foreign taxes on multinationals and reductions in FDI specific regulations. Lastly, as our work has focused primarily on the manufacturing sector, an examination of the heavily regulated service sector would also be an important case study of interest for policy makers.

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**Table 1. Firm Distribution by Initial Size of Year 1996**

| Initial Size Interval (percentile) | # All Firms | | | # Multinationals | | |
|---|---|---|---|---|---|---|
| | Year | | Change from 1996 | Year | | Change from 1996 |
| | 1996 | 2006 | | 1996 | 2006 | |
| 0-10 | 1,411 | 1,376 | -35 | 0 | 3 | 3 |
| 10-20 | 1,410 | 1,276 | -134 | 5 | 13 | 8 |
| 20-30 | 1,411 | 1,178 | -233 | 3 | 20 | 17 |
| 30-40 | 1,412 | 1,229 | -183 | 11 | 40 | 29 |
| 40-50 | 1,412 | 1,202 | -210 | 16 | 36 | 20 |
| 50-60 | 1,414 | 1,191 | -223 | 27 | 73 | 46 |
| 60-70 | 1,411 | 1,299 | -112 | 51 | 113 | 62 |
| 70-80 | 1,413 | 1,229 | -184 | 75 | 185 | 110 |
| 80-90 | 1,412 | 1,409 | -3 | 184 | 359 | 175 |
| 90-99 | 1,270 | 1,309 | 39 | 464 | 677 | 213 |
| 99-100 | 141 | 157 | 16 | 124 | 137 | 13 |
| Total | 14,117 | 12,855 | -1,262 | 960 | 1,656 | 696 |

*Notes*: Percentile bins are determined by parent firms' total sales in 1996; all firms include domestic and multinational firms in manufacturing; we exclude the firms whose domestic sales are missing.
Source: Basic Survey of Japanese Business Structure and Activities, and Basic Survey of Overseas Business Activities from METI.

**Table 2 Average Volume of Production by Size Interval in 1996 and 2006**

| Size Interval (percentile) | Domestic Production per Firm | | | Foreign Production per Multinational | | | Total Production per Firm | | |
|---|---|---|---|---|---|---|---|---|---|
| | Year 1996 | Year 2006 | Change from 1996 | Year 1996 | Year 2006 | Change from 1996 | Year 1996 | Year 2006 | Change from 1996 |
| 0-10 | 0.86 | 0.83 | -0.03 | 0.00 | 0.10 | 0.10 | 0.86 | 0.83 | -0.03 |
| 10-20 | 1.47 | 1.43 | -0.04 | 0.17 | 0.25 | 0.08 | 1.47 | 1.43 | -0.04 |
| 20-30 | 2.01 | 1.99 | -0.02 | 0.31 | 0.27 | -0.04 | 2.01 | 2.00 | -0.01 |
| 30-40 | 2.64 | 2.66 | 0.02 | 0.24 | 0.57 | 0.33 | 2.64 | 2.68 | 0.03 |
| 40-50 | 3.49 | 3.56 | 0.06 | 0.70 | 0.81 | 0.11 | 3.50 | 3.58 | 0.08 |
| 50-60 | 4.67 | 4.87 | 0.19 | 0.65 | 1.04 | 0.39 | 4.68 | 4.93 | 0.25 |
| 60-70 | 6.54 | 7.02 | 0.48 | 1.09 | 1.26 | 0.18 | 6.58 | 7.15 | 0.57 |
| 70-80 | 10.1 | 11.0 | 0.97 | 1.47 | 2.17 | 0.69 | 10.2 | 11.4 | 1.24 |
| 80-90 | 19.1 | 21.4 | 2.34 | 2.93 | 4.23 | 1.30 | 19.5 | 22.6 | 3.13 |
| 90-99 | 86.9 | 100.1 | 13.2 | 19.2 | 29.7 | 10.6 | 93.9 | 116.7 | 22.7 |
| 99-100 | 1,664 | 1,570 | -94.3 | 306.8 | 638.8 | 331.9 | 1,934 | 2,143 | 208.9 |
| All | 29.5 | 30.1 | 0.59 | 49.7 | 57.3 | 7.65 | 32.9 | 37.5 | 4.59 |

*Notes*: Percentile bins are determined by parent firms' total sales in each year, separately; production is in billions of 2006 Yen; domestic production includes domestic and export sales; total production includes both domestic and foreign production.

Sources: Basic Survey of Japanese Business Structure and Activities, and Basic Survey of Overseas Business Activities from METI.

**Table 3. Estimation Results of Structural Parameters**

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| Markets | Markets with over 10 affiliates | All Markets | Markets with over 10 affiliates | Markets with over 10 affiliates |
| Year | 2006 | 2006 | 2006 | 1996 |
| Moments | All | All | No Pecking Order String | All |
| Variable | | | | |
| $\tilde{\theta}$ | 1.99 | 2.12 | 1.95 | 2.13 |
| (size dispersion) | (0.43) | (0.95) | (0.64) | (0.53) |
| $\sigma_a$ | 1.64 | 1.64 | 1.66 | 1.36 |
| (variance of sales shock) | (0.07) | (0.10) | (0.08) | (0.11) |
| $\sigma_\eta$ | 0.39 | 0.52 | 0.34 | 0.45 |
| (variance of entry shock) | (0.31) | (0.16) | (0.42) | (0.43) |
| $\rho$ | -0.62 | -0.55 | -0.64 | -0.99 |
| (correlation of sales and entry shocks) | (0.34) | (0.25) | (0.51) | (0.56) |

*Notes*: Figures indicate parameter estimates of each variable; parentheses are bootstrapped standard errors from the initial fixed parameter estimates with 1000 repetitions; each bootstrapping simulates 100,000 firms and uses randomly sampled Japanese firms.

**Table 4.1 Aggregate Outcomes of Counterfactual 20% Reductions in FDI Barriers**

| Country | Code | (1) Relative Change in Real Wage | (2) % Change in Japanese Firm Entry | (3) % Change in Japanese Firm Sales |
|---|---|---|---|---|
| Argentina | ARG | 1.08 | 93.1 | 81.1 |
| Australia | AUS | 1.14 | 84.8 | 98.8 |
| Belgium | BEL | 1.46 | 39.5 | 155.9 |
| Brazil | BRA | 1.05 | 105.3 | 88.8 |
| Canada | CAN | 1.17 | 73.9 | 116.6 |
| China | CHN | 1.25 | 64.6 | 71.5 |
| Czech Republic | CZE | 1.23 | 67.4 | 79.0 |
| France | FRA | 1.18 | 66.9 | 125.4 |
| Germany | DEU | 1.09 | 98.2 | 101.4 |
| Hong Kong | HKG | 4.92 | -42.1 | 277.2 |
| Hungary | HUN | 1.31 | 63.3 | 109.1 |
| India | IND | 1.02 | 111.5 | 82.8 |
| Indonesia | IDN | 1.03 | 98.4 | 72.1 |
| Italy | ITA | 1.07 | 100.8 | 93.4 |
| Japan | JPN | 1.01 | -2.67 | -3.45 |
| South Korea | KOR | 1.05 | 109.4 | 89.2 |
| Malaysia | MYS | 1.22 | 73.3 | 78.3 |
| Mexico | MEX | 1.06 | 97.3 | 80.2 |
| Netherlands | NLD | 1.31 | 18.6 | 146.2 |
| New Zealand | NZL | 1.21 | 70.7 | 96.7 |
| Philippines | PHL | 1.11 | 88.3 | 89.0 |
| Poland | POL | 1.11 | 87.4 | 87.4 |
| Singapore | SGP | 1.74 | 16.4 | 192.1 |
| South Africa | ZAF | 1.07 | 96.6 | 84.0 |
| Spain | ESP | 1.12 | 91.0 | 100.5 |
| Sweden | SWE | 1.31 | 59.3 | 128.2 |
| Taiwan | TWN | 1.10 | 94.8 | 118.4 |
| Thailand | THA | 1.24 | 64.9 | 71.9 |
| Turkey | TUR | 1.06 | 99.3 | 84.9 |
| United Kingdom | GBR | 1.23 | 56.9 | 139.3 |
| United States | USA | 1.07 | 98.4 | 99.7 |
| Vietnam | VNM | 1.17 | 73.2 | 72.8 |
| Average | | 1.29 | 72.5 | 103.4 |

**Table 4.2 Counterfactual Results for Aggregate Firm Activities**

| Variable | Baseline | Counterfactual Change from Baseline | % Change from Baseline |
|---|---|---|---|
| Number of Firms: | | | |
| All | 13,123 | -350 | -2.67 |
| Multinationals | 1,511 | 1,004 | 66.4 |
| Aggregate Production: | | | |
| Domestic | 394.3 | -13.6 | -3.45 |
| Foreign | 99.8 | 107.1 | 107.3 |
| Total | 494.1 | 93.5 | 18.9 |

*Note*: Production is in trillions of Yen.

**Table 4.3 Counterfactual Results for the Extensive Margin**

| Initial Productivity Group (percentile) | # Multinationals | | # All Firms | |
|---|---|---|---|---|
| | Baseline | Counterfactual Change from Baseline | Baseline | Counterfactual Change from Baseline |
| 0-10 | 0 | 6 | 1,313 | -345 |
| 10-20 | 0 | 21 | 1,312 | -2 |
| 20-30 | 0 | 34 | 1,313 | -1 |
| 30-40 | 2 | 53 | 1,312 | -1 |
| 40-50 | 22 | 62 | 1,312 | -1 |
| 50-60 | 45 | 82 | 1,312 | 0 |
| 60-70 | 79 | 118 | 1,312 | 0 |
| 70-80 | 146 | 177 | 1,313 | 0 |
| 80-90 | 322 | 259 | 1,312 | 0 |
| 90-99 | 766 | 191 | 1,181 | 0 |
| 99-100 | 130 | 0 | 130 | 0 |
| Total | 1,511 | 1,004 | 13,123 | -350 |

**Table 4.4 Counterfactual Results for the Intensive Margin**

| Initial Productivity Group (percentile) | Domestic Production per Firm | | Foreign Production per Multinational | | Total Production per Firm | |
|---|---|---|---|---|---|---|
| | Baseline | Counterfactual Change from Baseline | Baseline | Counterfactual Change from Baseline | Baseline | Counterfactual Change from Baseline |
| 0-10 | 13.7 | -0.14 | 0.00 | 1.34 | 13.7 | -0.13 |
| 10-20 | 14.6 | -0.37 | 0.00 | 1.27 | 14.6 | -0.35 |
| 20-30 | 16.0 | -0.42 | 0.00 | 1.54 | 16.0 | -0.38 |
| 30-40 | 17.9 | -0.52 | 0.69 | 0.90 | 17.9 | -0.45 |
| 40-50 | 19.5 | -0.48 | 0.75 | 1.31 | 19.5 | -0.36 |
| 50-60 | 22.0 | -0.50 | 1.04 | 1.50 | 22.0 | -0.29 |
| 60-70 | 26.1 | -0.67 | 1.58 | 1.92 | 26.2 | -0.24 |
| 70-80 | 31.5 | -0.67 | 2.36 | 3.14 | 31.7 | 0.42 |
| 80-90 | 41.4 | -0.88 | 5.01 | 6.16 | 42.6 | 2.84 |
| 90-99 | 76.5 | -1.61 | 32.0 | 31.44 | 97.3 | 29.1 |
| 99-100 | 293.0 | -6.17 | 563.2 | 486.7 | 855.4 | 481.3 |
| All | 30.0 | -0.24 | 66.1 | 16.22 | 37.7 | 8.4 |

*Note*: Production is measured in billions of Yen.

**Table 5.1 Counterfactual Aggregate Results for Variable and Fixed Costs**

| Variable | Baseline | Counterfactual % Change from Baseline | |
|---|---|---|---|
| | | Variable Cost | Fixed Cost |
| Number of Firms: | | | |
| All | 13,123 | -1.32 | -0.37 |
| Multinationals | 1,511 | 28.0 | 30.56 |
| Aggregate Production: | | | |
| Domestic | 394.3 | -0.74 | -0.28 |
| Foreign | 99.8 | 64.0 | 19.7 |
| Total | 494.1 | 12.11 | 4.41 |

*Note*: Production is in trillions of Yen.

**Table 5.2 Counterfactual Changes from Baseline at the Extensive Margin**

| Initial Productivity Group (percentile) | **# Multinationals** | | **# All Firms** | |
|---|---|---|---|---|
| | Variable Cost | Fixed Cost | Variable Cost | Fixed Cost |
| 0-10 | 3 | 3 | -171 | -48 |
| 10-20 | 9 | 11 | 0 | 0 |
| 20-30 | 11 | 14 | 0 | 0 |
| 30-40 | 14 | 15 | 0 | 0 |
| 40-50 | 20 | 22 | 0 | 0 |
| 50-60 | 29 | 31 | 0 | 0 |
| 60-70 | 45 | 50 | 0 | 0 |
| 70-80 | 70 | 79 | 0 | 0 |
| 80-90 | 114 | 123 | 0 | 0 |
| 90-99 | 100 | 108 | 0 | 0 |
| 99-100 | 0 | 0 | 0 | 0 |
| Total | 415 | 455 | -172 | -48 |

*Note*: Baseline is fixed as in Table 4.3.

**Table 5.3 Counterfactual Changes from Baseline at the Intensive Margin**

| Initial Productivity Group (percentile) | Domestic Production per Firm | | Foreign Production per Multinational | | Total Production per Firm | |
|---|---|---|---|---|---|---|
| | Variable Cost | Fixed Cost | Variable Cost | Fixed Cost | Variable Cost | Fixed Cost |
| 0-10 | 0.08 | 0.10 | 0.86 | 0.83 | 0.08 | 0.10 |
| 10-20 | -0.03 | 0.06 | 0.95 | 0.95 | -0.03 | 0.07 |
| 20-30 | -0.07 | 0.06 | 0.61 | 0.27 | -0.05 | 0.07 |
| 30-40 | -0.04 | 0.07 | 0.60 | 0.21 | -0.02 | 0.09 |
| 40-50 | -0.04 | 0.07 | 0.69 | 0.23 | 0.00 | 0.10 |
| 50-60 | -0.05 | 0.10 | 0.79 | 0.28 | 0.03 | 0.15 |
| 60-70 | -0.03 | 0.12 | 1.13 | 0.38 | 0.13 | 0.22 |
| 70-80 | -0.03 | 0.14 | 1.60 | 0.60 | 0.35 | 0.40 |
| 80-90 | -0.05 | 0.18 | 3.50 | 1.21 | 1.53 | 1.06 |
| 90-99 | -0.08 | 0.34 | 18.21 | 6.03 | 15.76 | 7.65 |
| 99-100 | -0.35 | 1.52 | 314.8 | 82.5 | 313.5 | 83.8 |
| All | 0.18 | 0.20 | 18.4 | 1.65 | 5.11 | 1.84 |

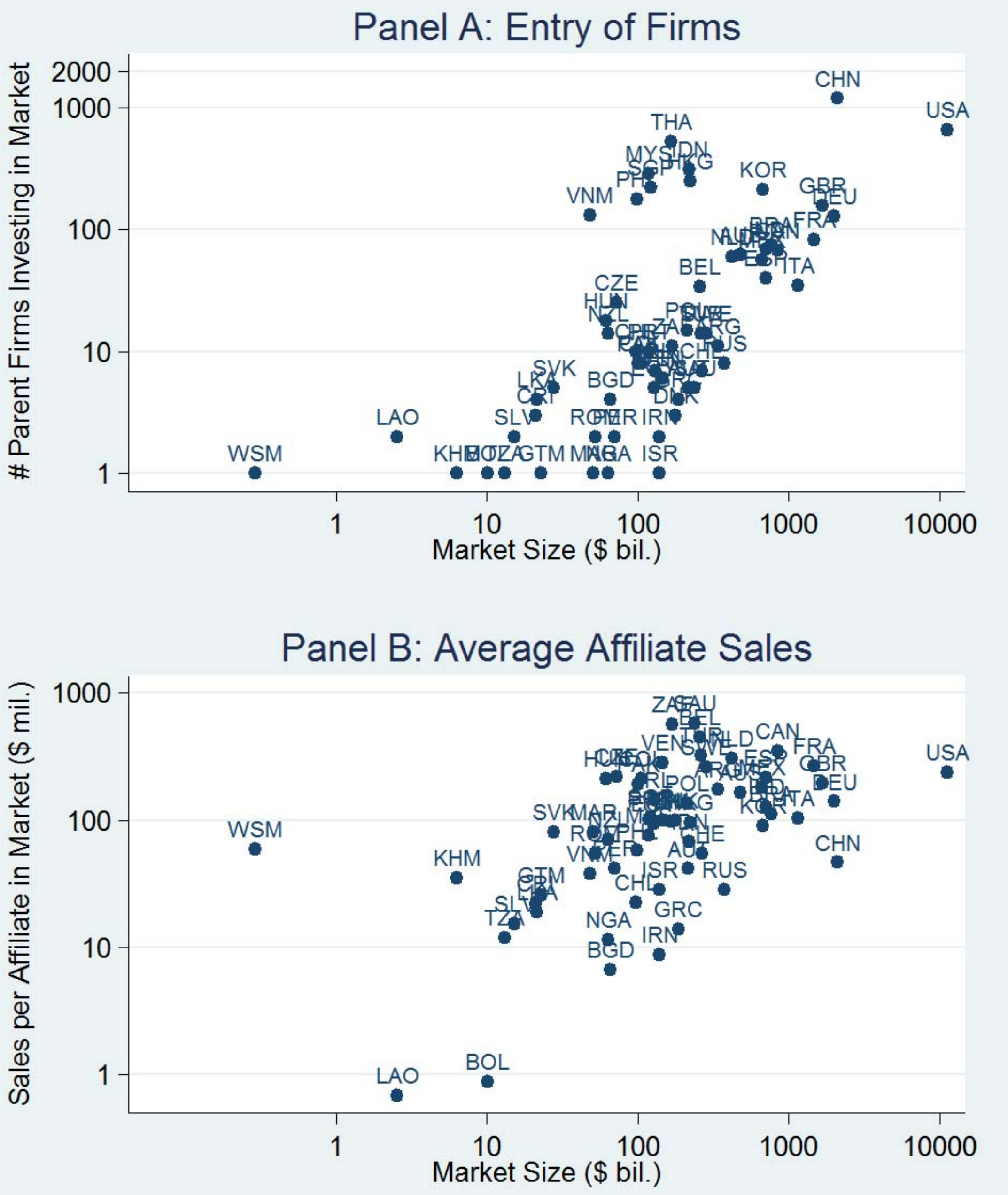
*Note*: Production is measured in billions of Yen.

**Table 6. Summary of Counterfactual Results**

| Counterfactual Percentage Change | Actual % Change between 1996 and 2006 | Counterfactual Reductions in Variable Barriers: 25% / Fixed Barriers: 25% | Variable: 20% / Fixed: 20% | Variable: 15% / Fixed: 15% | Variable: 20% / Fixed: 0% | Variable: 0% / Fixed: 20% |
|---|---|---|---|---|---|---|
| Volume of Production | | | | | | |
| Domestic | -7.0 | -4.6 | -3.4 | -4.1 | -0.7 | 0.3 |
| Foreign | 99.0 | 148.1 | 106.2 | 71.0 | 64.0 | 19.7 |
| Total | 4.0 | 25.5 | 16.8 | 11.2 | 12.1 | 4.4 |
| Production Growth by Bottom 80% Firms* | 6.5 | -4.4 | 18.9 | -4.6 | -0.9 | 0.4 |
| Production Growth by Top 20% Firms* | 14.7 | 36.3 | 30.0 | 21.2 | 21.0 | 7.8 |
| Number of Firms | | | | | | |
| All | -9.0 | -3.5 | -2.7 | -2.4 | -1.3 | -0.4 |
| Multinational | 72.0 | 85.9 | 66.4 | 48.6 | 28.0 | 30.6 |
| Aggregate Productivity | | | | | | |
| Contributed by: | | 37.4 | 27.2 | 20.1 | 18.1 | 4.1 |
| Market-Share Reallocation | n.a. | 35.9 | 26.0 | 19.1 | 17.6 | 4.0 |
| Exit of Least Productive Firms | n.a. | 1.5 | 1.2 | 1.0 | 0.5 | 0.1 |

*Notes*: Figures are in percentage; aggregate productivity is a percentage change in industry-level productivity of simulated firms resulting from market-share reallocation and exit effects; * refers to a percentage point change.

# Figure 1. Entry and Sales by Market Size



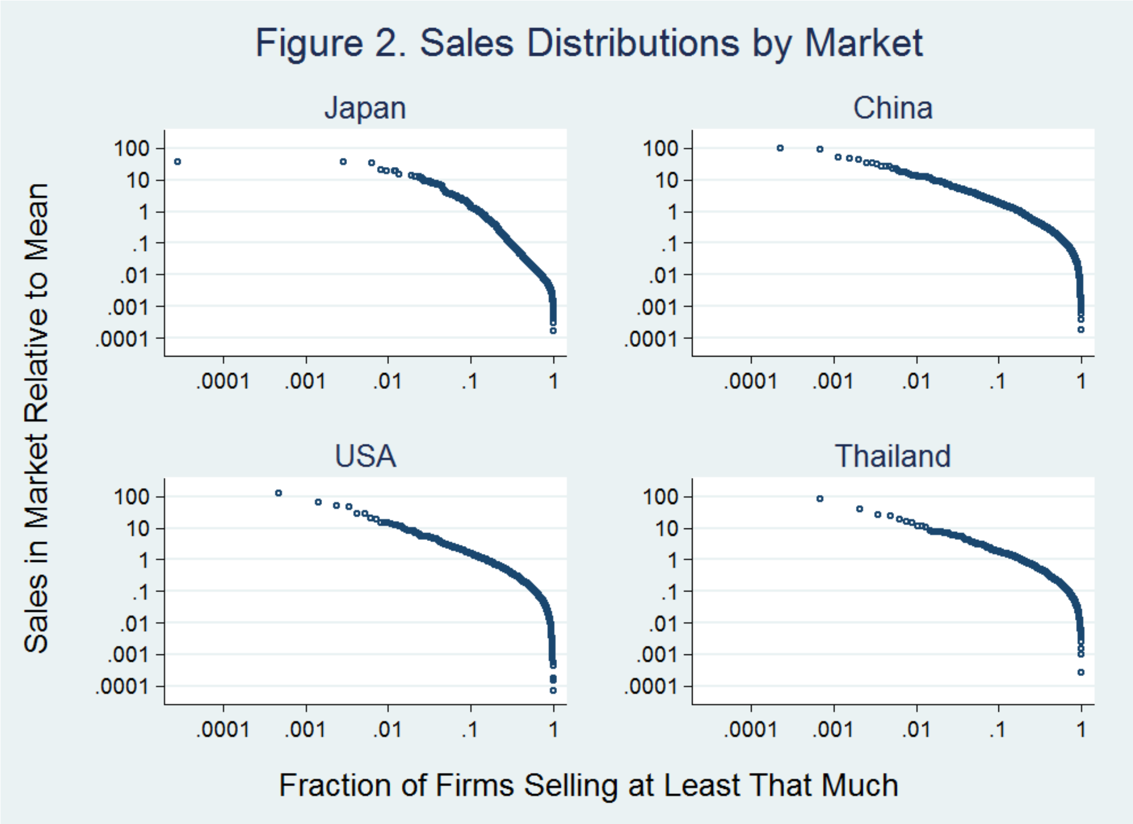
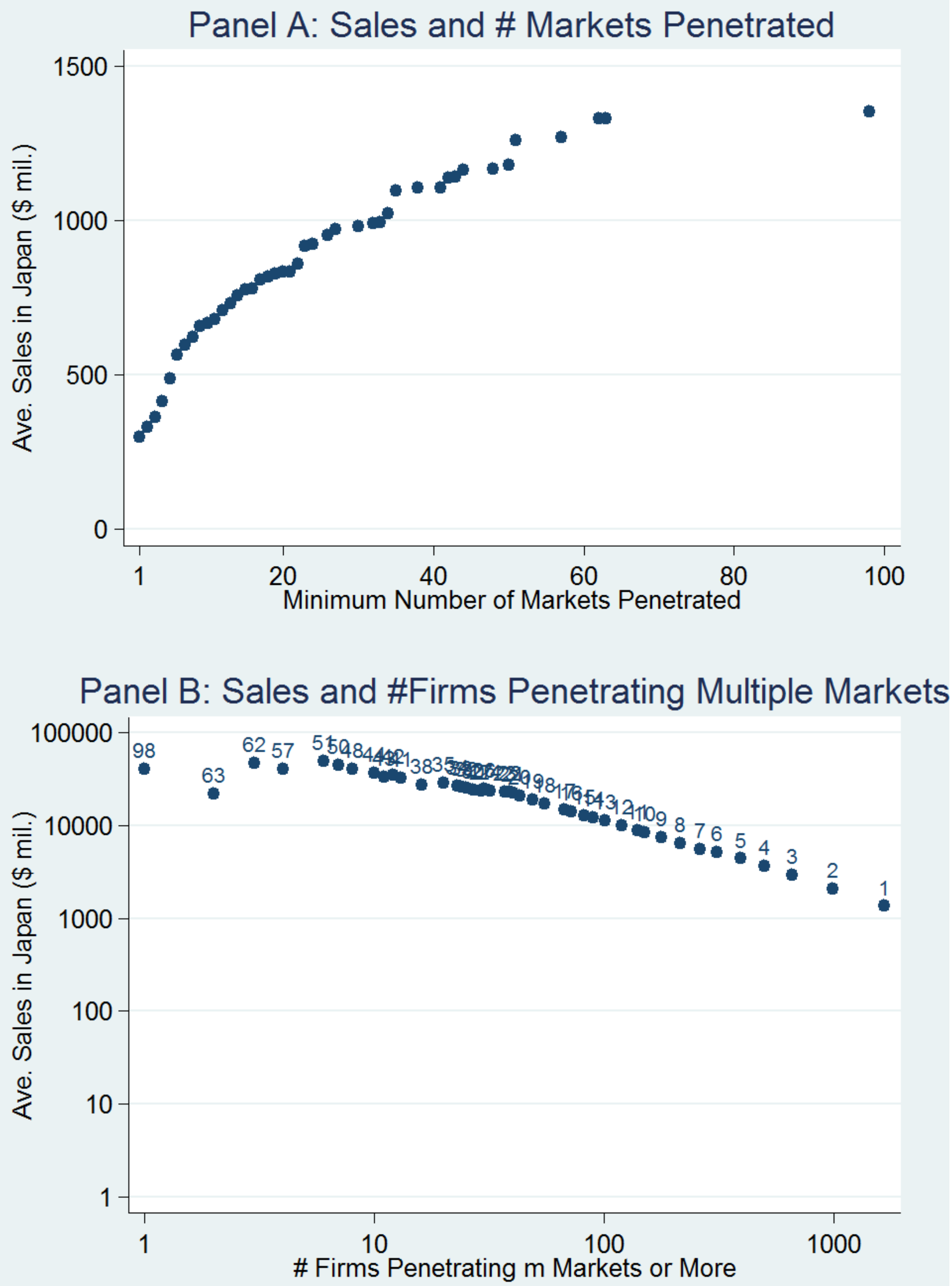


Figure 2. Sales Distributions by Market
Japan
China
USA
Thailand
100
10
1
.1
.01
.001
.0001
Sales in Market Relative to Mean
.0001
.001
.01
.1
1
Fraction of Firms Selling at Least That Much

# Figure 3. Sales in Japan and Market Entry



## Figure 4. Multinational Production Intensity

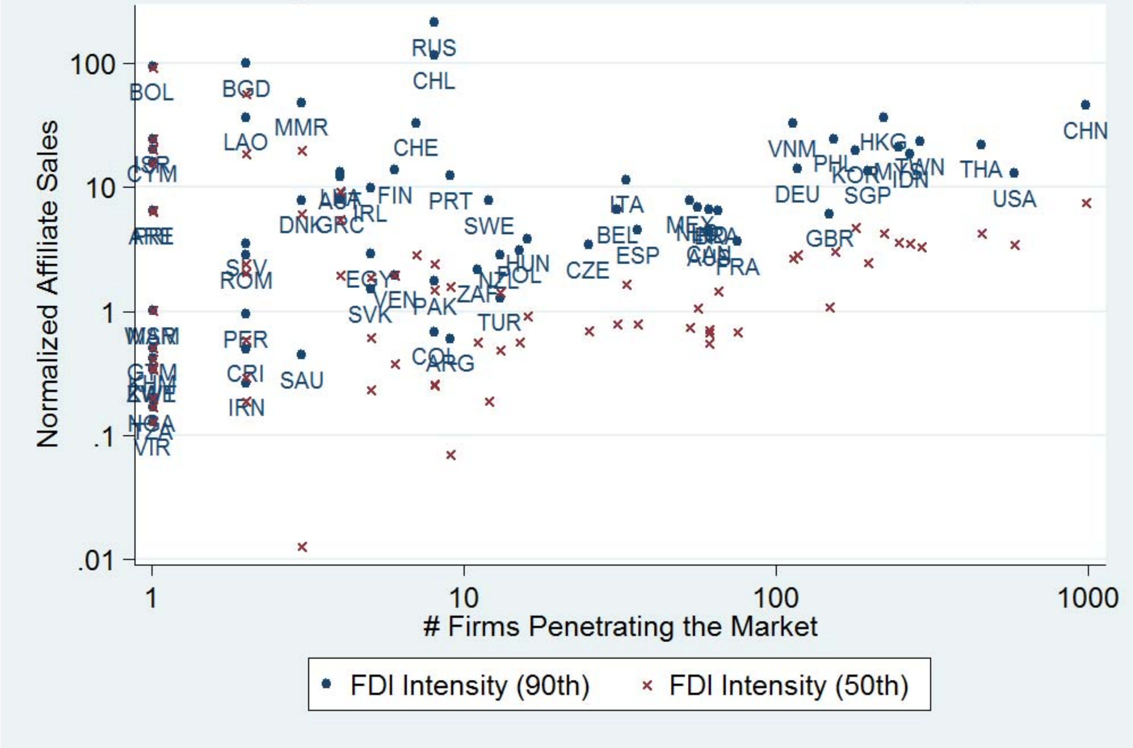


Figure 5.1. Out-of-Sample Predictions for 1996

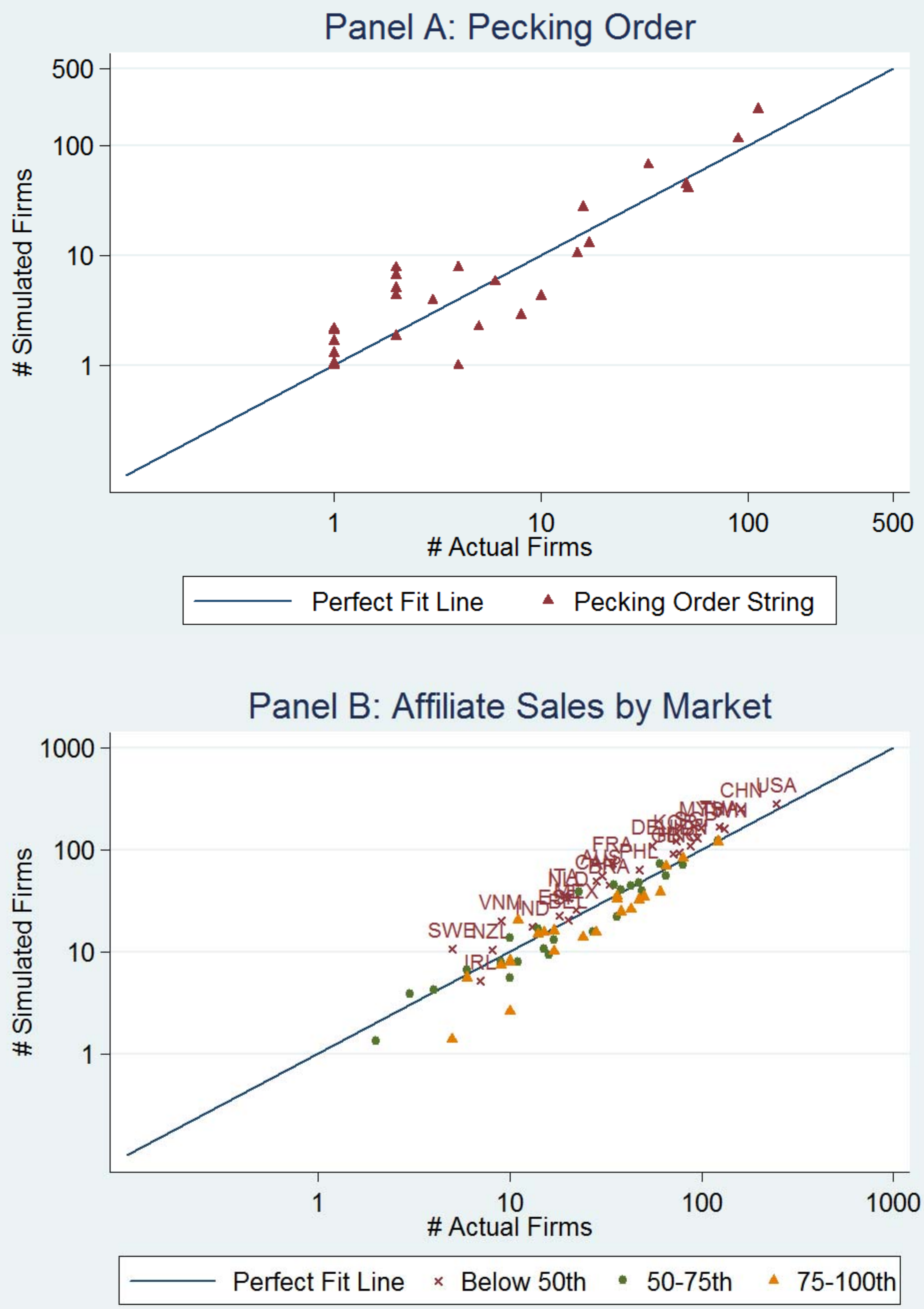


Figure 5.2. Out-of-Sample Predictions for 1996

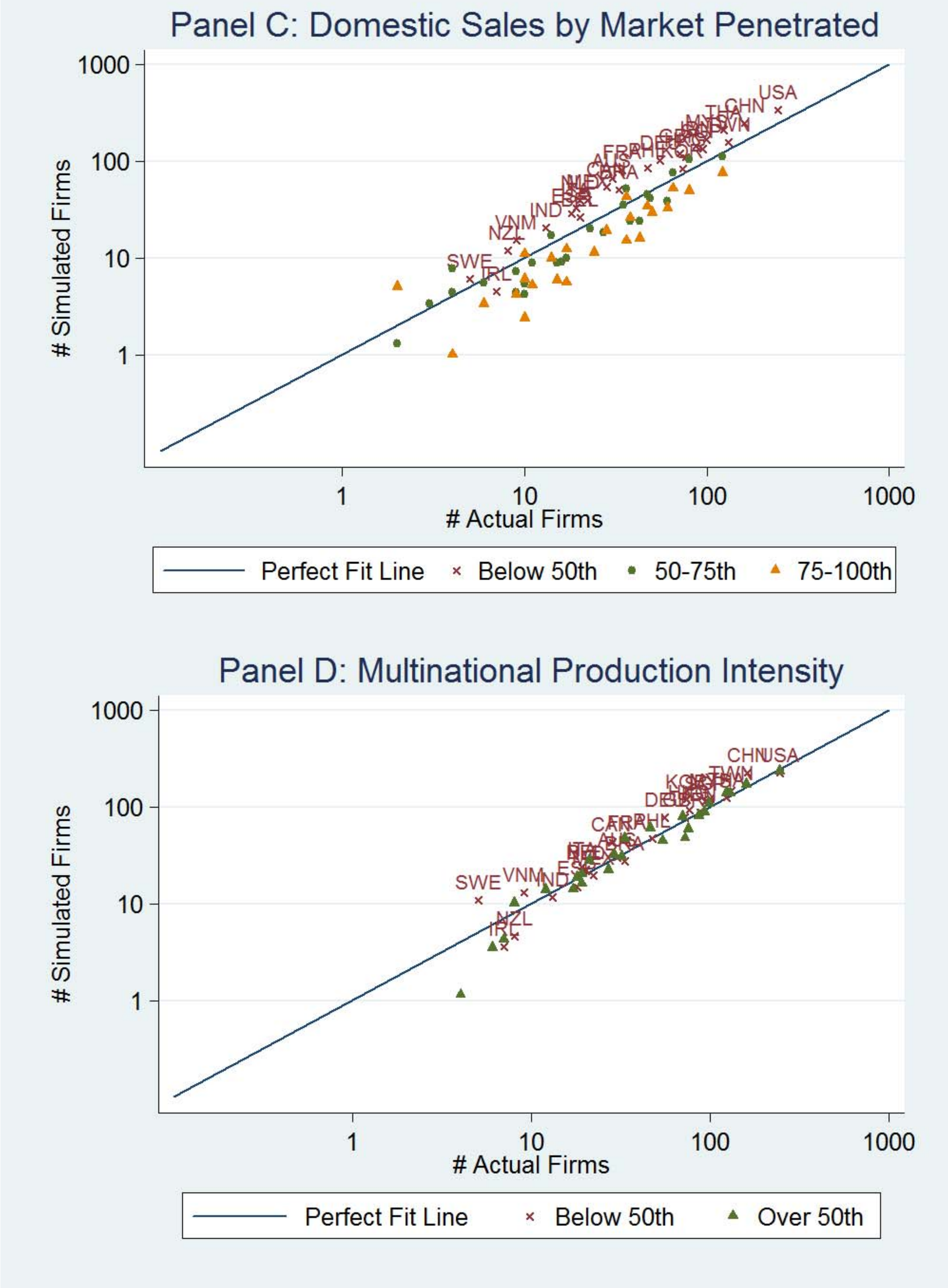


Figure 6. Market-Share Reallocation by Productivity Quintile

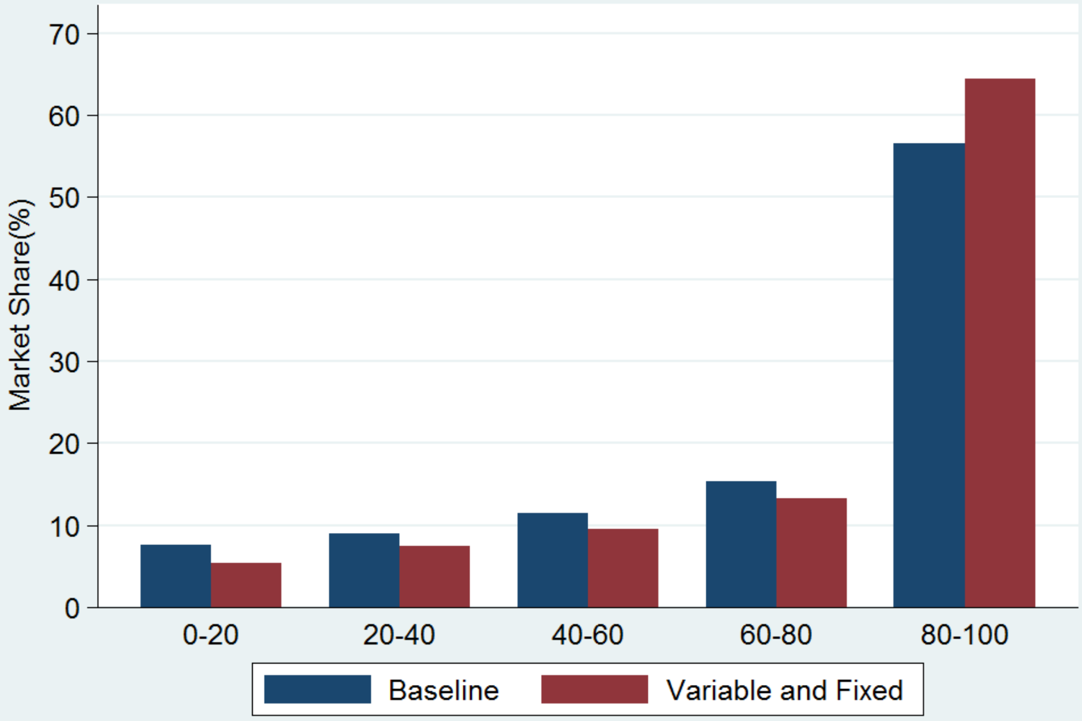



Figure 7. Reallocation by Productivity for Variable or Fixed Barriers

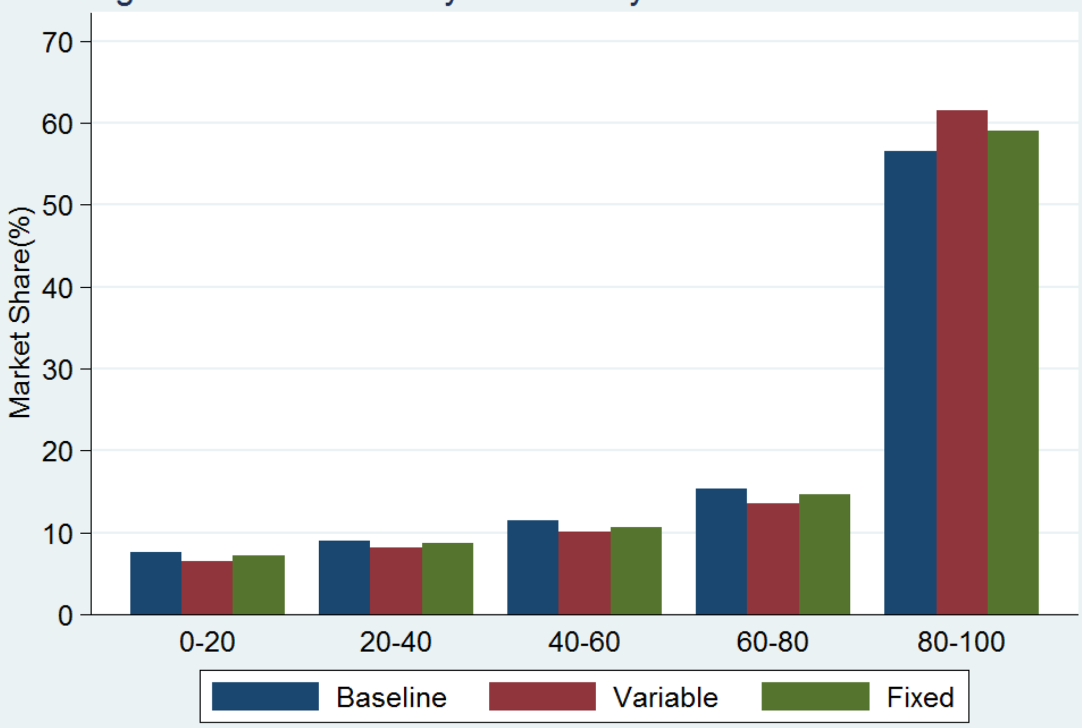
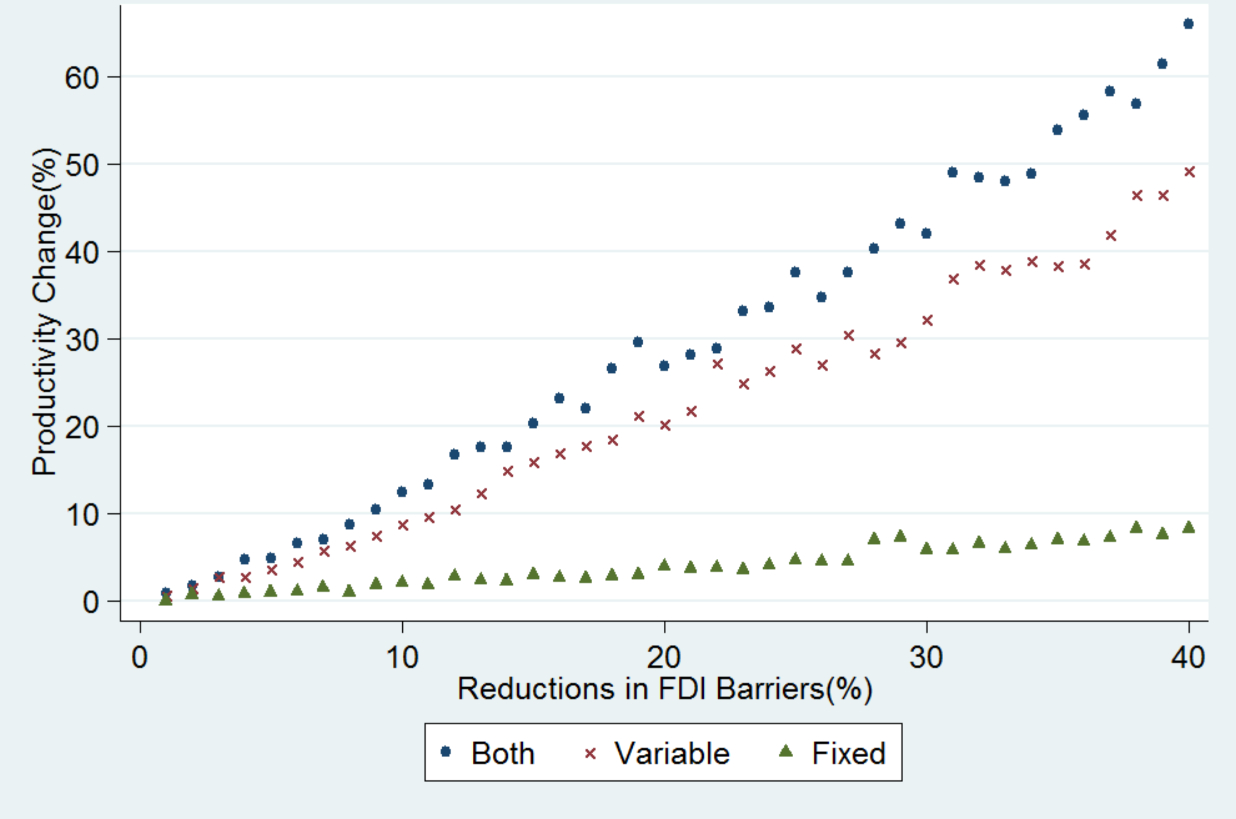


Figure 8. Counterfactual Changes in Aggregate Productivity



## APPENDIX

### A. The Price Index

Following Eaton et al. (2011), a representative consumer in market *n* faces the following price index, $P_n$:

$$P_n = \bar{m}\left[\iint \left(\sum_{i=1}^{N} \int_0^{\bar{c}_{ni}(\eta)} \alpha_n(j) c^{-(\sigma-1)} d\mu_{ni}(c)\right) g(\alpha,\eta) d\alpha d\eta\right]^{-1/(\sigma-1)} \quad \text{(A1)}$$

where $g(\alpha,\eta)$ is a joint density function from which we draw demand and entry shocks specific to individual producers, $\alpha_n(j)$ and $\eta_n(j)$. To solve for the price index, we first rewrite the integral over $\mu_{ni}(c) = T_i(w_n d_{ni})^{-\theta}(c)^{\theta}$ in equation (A1):

$$P_n = \bar{m}\left[\iint \left(\alpha_n(j) \sum_{i=1}^{N} \Phi_{ni} \int_0^{\bar{c}_{ni}(\eta)} \theta c^{\theta-\sigma} dc\right) g(\alpha,\eta) d\alpha d\eta\right]^{-1/(\sigma-1)} \quad \text{(A2)}$$

where $\Phi_{ni} = T_i(w_n d_{ni})^{-\theta}$. Note that $d\mu_{ni}(c) = \Phi_{ni}\theta c^{\theta-1} dc$.

From the laws of integration, we can solve for the integral over *c*:

$$P_n = \bar{m}\left[\iint \left(\alpha_n(j) \sum_{i=1}^{N} \Phi_{ni} \frac{\theta}{\theta-(\sigma-1)} \bar{c}_{ni}(\eta)^{\theta-(\sigma-1)}\right) g(\alpha,\eta) d\alpha d\eta\right]^{-1/(\sigma-1)} \quad \text{(A3)}$$

Substituting the threshold unit cost, $\bar{c}_{ni}(\eta)$, into equation (A3), and rearranging gives:

$$P_n = \bar{m}\left[\kappa_0 \iint \left(\alpha_n(j) \sum_{i=1}^{N} \Phi_{ni} \left(\left(\eta_n(j) \frac{X_n}{\sigma E_{ni}}\right)^{1/(\sigma-1)} \frac{P_n}{\bar{m}}\right)^{\theta-(\sigma-1)}\right) g(\alpha,\eta) d\alpha d\eta\right]^{-1/(\sigma-1)} \quad \text{(A4)}$$

where $\kappa_0 = \frac{\theta}{\theta-(\sigma-1)}$.

By moving the price-index term to the left side, we obtain the following:

$$P_n = \bar{m}(\kappa_1 \psi_n)^{\frac{-1}{\theta}} X_n^{\left(\frac{1}{\theta}-\frac{1}{\sigma-1}\right)} \quad \text{(A5)}$$

where:

$$\kappa_1 = \kappa_0 \iint \alpha_n(j) \eta_n(j)^{\frac{\theta-(\sigma-1)}{\sigma-1}} g(\alpha,\eta) d\alpha d\eta$$

$$\psi_n = \sum_{i=1}^{N} \Phi_{ni} (\sigma E_{ni})^{\frac{-[\theta-(\sigma-1)]}{\sigma-1}}.$$

### B. Respecification for Simulation

Substituting the price index in equation (A5) into equation (9), and rearranging gives:

$$\bar{c}_{ni}(j) = \left(\frac{\eta_n(j)}{\sigma E_{ni}}\right)^{1/(\sigma-1)} \left(\frac{X_n}{\kappa_1 \psi_n}\right)^{\frac{1}{\theta}} \quad \text{(B1)}$$

Replacing equation (B1) into equation (10), we arrive at:

$$X_{ni}(\alpha,\ \eta) = \alpha_n(j) \eta_n(j)^{\frac{\theta-(\sigma-1)}{\sigma-1}} \frac{\kappa_0}{\kappa_1} \pi_{ni} X_n \quad \text{(B2)}$$

where:

$$\pi_{ni} = \frac{\Phi_{ni}(\sigma E_{ni})^{\frac{-[\theta-(\sigma-1)]}{\sigma-1}}}{\psi_n}.$$

From this point, we focus on a country pair between a host country *i* and a home country J, where J denotes Japan. We proceed to express equations (B1) and (B2) in terms of a standardized unit cost. Rearranging equation (11) gives $z_J(j) = T_J^{\frac{1}{\theta}} u(j)^{\frac{-1}{\theta}}$. Substituting this expression into equation (1), we obtain $c_{nJ}(j) = \left(\frac{u(j)}{\Phi_{nJ}}\right)^{\frac{1}{\theta}}$. The threshold unit cost for entry is then given by:

$$\bar{c}_{nJ}(j) = \left(\frac{\bar{u}(j)}{\Phi_{nJ}}\right)^{\frac{1}{\theta}} \quad \text{(B3)}$$

Using equations (B1) and (B3), we can rewrite the entry condition as follows:

$$u(j) \le \bar{u}(j) \quad \text{(B4)}$$

where:

$$\bar{u}(j) = \eta_n(j)^{\frac{\theta}{\sigma-1}} \frac{X_n \pi_{nJ}}{\kappa_1 \sigma E_{nJ}} \tag{B5}$$

We can also express the sales condition in terms of the standardized unit cost. Replacing the unit cost for firm $j$ and the threshold unit cost in equation (10), we obtain:

$$X_{nJ}(j) = \frac{\alpha_n(j)}{\eta_n(j)} \sigma E_{nJ} \left(\frac{\bar{u}(j)}{u(j)}\right)^{\frac{\sigma-1}{\theta}} \tag{B6}$$

Finally, we parameterize the entry and sales conditions by connecting the conditions with actual data on aggregate multinational production. We first express the total number of firm entries to market *n* from Japan as:

$$N_{nJ} = \int \left[\mu_{nJ}(\bar{c}_{nJ}(\eta))\right] g_2(\eta) d\eta \tag{B7}$$

Substituting $\mu_{nJ}(c) = \Phi_{nJ}(\bar{c}_{nJ}(j))^{\theta}$ and equation (B1) into equation (B7), we obtain:

$$N_{nJ} = \kappa_2 \frac{X_n \pi_{nJ}}{\kappa_1 \sigma E_{nJ}} \tag{B8}$$

Replacing equation (B8) into (B5) gives:

$$\bar{u}(j) = \eta_n(j)^{\frac{\theta}{\sigma-1}} \frac{N_{nJ}}{\kappa_2} \tag{B9}$$

This expression corresponds to equation (12).

We then proceed to connect the sales condition with data by replacing $X_n \pi_{nJ}$ in equation (B8) with data. Integrating equation (B2) across the joint density $g(\alpha, \eta)$, total sales by firms from Japan in country *n* are given by:

$$X_{nJ} = \iint \alpha_n(j) \eta_n(j)^{\frac{\theta-(\sigma-1)}{\sigma-1}} \frac{\kappa_0}{\kappa_1} \pi_{ni} X_n \, g(\alpha, \eta) d\alpha d\eta \tag{B10}$$

Rearranging gives $X_{nJ} = \pi_{ni} X_n$. Substituting this expression in equation (B8), we obtain:

$$\sigma E_{nJ} = \frac{\kappa_2}{\kappa_1} \frac{X_{nJ}}{N_{nJ}} \tag{B11}$$

Replacing equation (B11) into equation (B6) gives:

$$X_{nJ}(j) = \frac{\alpha_n(j)}{\eta_n(j)} \overline{\mathrm{X}}_{nJ} \frac{\kappa_2}{\kappa_1} \left(\frac{\bar{u}(j)}{u(j)}\right)^{\frac{\sigma-1}{\theta}} \tag{B12}$$

where $\overline{\mathrm{X}}_{nJ} = X_{nJ}/N_{nJ}$. This expression corresponds to equation (13).

C. **Estimation Framework**

Our estimation procedure is based on Eaton et al. (2011). We proceed to (1) simulate artificial firms under a particular set of parameter values, (2) construct a set of four moments, and (3) search an optimal set of structural parameters by the simulated method of moments. Throughout this section, we denote home country *i,* by *J* (Japan) and an artificial firm *s* by $s = 1, 2, \ldots, S$.

**C.1 Simulation of Multinational Firms**

We use the entry and sales conditions in equations (12) and (13) to simulate individual multinational activities. An artificial producer *s* is generated from its efficiency draw, $u(s)$, sales shock, $\alpha_n(s)$, and entry shock $\eta_n(s)$. These simulated draws are generated from the stochastic distributions as dictated by the four structural parameters in Θ: heterogeneity in observed sales $\tilde{\theta}$, variances in sales $\sigma_a$ and entry shocks $\sigma_\eta$, and correlation between these shocks $\rho$. With aggregate data on the number of Japanese firms investing in country *n*, $N_{nJ}$, and their aggregate sales $\mathrm{X}_{nJ}$ in that country and Θ, we can produce an artificial dataset of heterogeneous multinationals on the location and sales of their foreign affiliates.

To simulate the total number $S$ of firms, we first fix Θ and construct realizations for standardized unit cost, $u(s)$, for each firm *s*. Demand and entry shocks, $\alpha_n(s)$ and $\eta_n(s)$, are generated from a joint lognormal distribution for each firm $s$ across country $n$.[26] These realizations of stochastic components are fixed throughout the estimation. We then compute the entry hurdle condition (12) for each artificial firm across each market and define an indicator variable *Z* of whether each firm establishes local production in each market *n*:

$$Z_{nJ}(s) = \begin{cases} 1 & \text{if } u(s) \leq \bar{u}_n(s) \\ 0 & \text{otherwise} \end{cases} \quad \text{(C1)}$$

When the entry indicator is equal to one, a simulated firm from country *J* (Japan) enters the market. Conditional on entry, we compute its sales in market *n* according to the sales condition (13). We then construct the matrix of sales for each artificial firm across each market that indicates where each artificial firm sets up a foreign affiliate and how much sales it generates in that country.

### C.2 Moments

With an artificial dataset of individual multinational entry and sales, we construct a vector of moments. Each moment is defined as the share of multinational parent firms that fall into a set of mutually exclusive bins. We denote $N^k$ as the number of actual firms achieving an outcome $k$ in the actual data, and $\widehat{N}^k$ as the number of simulated firms achieving the same outcome. For each moment, the number of simulated firms falling into each outcome is weighted as follows:

$$\widehat{N}^k = \frac{1}{S}\sum_{s=1}^{S} \bar{u}(s) Z_{nJ}^k(s) \quad \text{(C2)}$$

where $\bar{u}(s)$ is the importance weight of each simulated firm. We define a vector of deviations between actual and artificial moments for outcome $k$:

$$y(\Theta) = m^k - \widehat{m}^k(\Theta) \quad \text{(C3)}$$

Following the theoretical implications of the model, we choose four moment conditions: pecking order strings, affiliate sales distributions across markets, parent sales distribution in Japan, and multinational production intensity. Corresponding to these moments, we also construct a vector of moments from the actual data on Japanese multinational firms. As described in empirical regularities of Japanese firms, we seek to capture these characteristics for simulated multinationals. Given that *N* is the number of foreign markets penetrated by Japanese firms, each moment is defined as follows:

1. Pecking order string

We compute the share of multinationals entering each possible combination of the five most popular countries for Japanese multinationals: China, the United States, Thailand, Taiwan, and Indonesia in 2006. Determining the market popularity by the number of their foreign affiliates

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[26] We assume that $\alpha_n(s)$ and $\eta_n(s)$ have a joint bivariate lognormal distribution:

$$\begin{bmatrix} \ln\alpha_n(s) \\ \ln\eta_n(s) \end{bmatrix} \sim \mathrm{N}\left[\begin{pmatrix} 0 \\ 0 \end{pmatrix}, \begin{pmatrix} \sigma_\alpha^{2} & \rho\sigma_\alpha\sigma_\eta \\ \rho\sigma_\alpha\sigma_\eta & \sigma_\eta^{2} \end{pmatrix}\right].$$

To draw these realizations of random shocks, we use the Choleski decomposition factor to construct $\ln a$ and $\ln\eta$ with:

$$\begin{bmatrix} \ln\alpha_n(s) \\ \ln\eta_n(s) \end{bmatrix} \sim \left[\begin{pmatrix} \sigma_\alpha\sqrt{1-\rho^2} & \rho\sigma_\alpha \\ 0 & \sigma_h \end{pmatrix}\right]\left[\begin{pmatrix} a_n(s) \\ h_n(s) \end{pmatrix}\right].$$

To avoid drawing the firms that end up not selling anywhere, productivity draws are bounded to the firms that sell in Japan and at least one foreign market. In doing so, we use the importance sampling from $u(s) = v(s)\bar{u}_J^*(s)$, where random realizations of $v(s)$ are independently drawn from a uniform distribution over interval [0,1] and $\bar{u}_J^*(s)$ is the firm-specific hurdle for entering the Japanese market and at least one foreign market. As this measure serves as a sampling weight, we ensure that all draws are to be $u(s) \leq \bar{u}_J^*(s)$, which corrects an upward bias in generating more efficient firms.

we set each string such that multinationals entering the most popular market (China) invest in less popular markets progressively. Then, we make another combination for that string such that multinationals entering the first (China) and third (Thailand) invest in less popular markets progressively. By adding up all possible combinations, we have $2^5$ moments.

2. Sales distributions across foreign markets
We calculate $q^{th}$ percentiles for multinational sales in each market *n,* for q =50, 75, 100. For each set of firms that enter market *n,* we use these percentiles to set up sales intervals. We then calculate the share of multinationals that fall into each of these bins. The $q^{th}$ percentiles are calculated from the actual data and the simulated firms are set according to these bins. ($N \times 3$ moments).

3. Distribution of multinational parent sales in Japan
This moment links the level of sales in Japan to the set of firms that enter market *n.* We calculate $q^{th}$ percentiles (q = 50, 75, 100) over domestic sales in Japan for each set of firms that enter market $n$. These intervals are calculated from the actual data. We then assign the firms that fall into these bins and calculate the share of multinationals ($N \times 3$ moments).

4. Multinational production intensity
We make two intervals for firms whose ratio of sales in market *n* to sales in Japan is below and above the $50^{th}$ percentile. Then, we compute the share of simulated firms that sell in each market *n* and fall into either of these percentiles.

**C.3 Simulated Method of Moments**

Equation (C3) shows that an optimal set of parameters can be judged from the distance between actual and artificial moments, with the smaller distance indicating better parameters. To estimate the parameters, we employ simulated method of moments as introduced by McFadden (1989). This estimation method matches moments of simulated and real data, and searches for a set of parameters that minimizes the total distance between them. Under the true set of parameter values, $\Theta_0$, the following moment condition is assumed to hold:

$$\mathrm{E}[y(\Theta_0)] = 0 \tag{C4}$$

An objective function is specified under the following weighted quadratic form:

$$\widehat{\Theta} = \arg\min_{\Theta}\{y(\Theta)' \,\mathrm{W}\, y(\Theta)\} \tag{C5}$$

where $\widehat{\Theta}$ is a set of estimated parameters, and W is assumed to be an identity matrix in practice.

To search for the parameters that best fit the model, we employ the Nelder-Mead simplex method (Nelder and Mead, 1965). To mitigate optimization errors, we introduce random variations to the starting values and repeat the minimization algorithm for a fixed set of artificial and real moments 1000 times. Finally, we take the optimal parameters that give the minimum distance.

The search procedure above should provide the best fitting parameters. However, they may be subject to sampling errors of real Japanese multinationals and simulation errors of artificial multinationals. To address these issues, we compute bootstrapped standard errors for the initial optimal estimates. First, we resample Japanese multinational firms from the actual dataset with replacement. A dataset of simulated multinationals is also generated from a new set of idiosyncratic parameters $u^{\mathrm{b}}(s), \alpha_n^b(s),$ and $\eta_n^{\mathrm{b}}(s)$. Then, we follow the simulated method of moments to estimate a new set of structural parameters, $\widehat{\Theta}_b$. Repeating 25 times, we calculate:

$$V(\Theta) = \frac{1}{25}\sum_1^{25}(\widehat{\Theta}_b - \widehat{\Theta}^*)(\widehat{\Theta}_b - \widehat{\Theta}^*)' \tag{C6}$$

where $\widehat{\Theta}^*$ is the initial set of the best fitting structural parameters. Taking the square root of the diagonal elements, we obtain the bootstrapped standard errors. They serve to gauge the potential influence of sampling and simulation errors in the best fitting parameters.

## D. Counterfactual Simulations

### D.1 General Equilibrium Framework

Following the approach in EKK (2011), each country is endowed with an amount of labor, $L_i$, which is mobile across sectors but not countries, and has a wage rate $W_i$. Intermediates are a Cobb-Douglass combination of labor and intermediates with an input bundle of $W_n^{\beta} P_n^{1-\beta}$. Final output is also non-traded and is a Cobb-Douglas combination of manufactures and labor, with manufactures having a share $\gamma$.

Profits are earned by the country where the firm is headquartered and consumers own equal shares of each firm headquartered in their country. This allows profits to be redistributed equally among the consumers of their country. Country *i's* total GDP, $Y_i^A$ is equal to its total wages generated from production in the country, $W_i L_i$ and its total profits abroad $\Pi_i$. Lastly, countries have FDI deficits $D_i$, where some countries are net receivers of FDI and some are net providers. Net profits earned in destination *n* are gross profits $X_n/\sigma$ minus total entry costs incurred there, where total profits are $\Pi_n^D = \frac{\sigma-1}{\sigma\theta} X_n$. In equilibrium, firms or multinationals from country *i* earn a share $\pi_{ni}$ from the total level of profits $\Pi_n^D$ from each market:

$$\Pi_i = \sum_{n=1}^{N} \pi_{ni} \Pi_n^D = \frac{\sigma-1}{\sigma\theta} Y_i \quad \text{(D1)}$$

Country *i's* total GDP, $Y_i^A$ is equal to its total wages generated from production in the country, $W_i L_i$ and its total profits from abroad $\Pi_i$:

$$Y_i^A = W_i L_i + \Pi_i \quad \text{(D2)}$$

Total demand for manufacturing production in country *i*, $X_i$, must be equal to final demand and use of manufactures in intermediates:

$$X_i = \gamma\left(Y_i^A\right) + \left[\frac{(1-\beta)(\sigma-1)}{\sigma}\right] X_i \quad \text{(D3)}$$

The first component is the share of manufacturing production from final demand and the second component is the share from its use as intermediates. Using the profit expression (D1) and the income equation (D2), the demand equation (D3) can be respecified as:

$$X_i = \gamma\left(W_i L_i + \frac{\sigma-1}{\sigma\theta} Y_i\right) + \left[\frac{(1-\beta)(\sigma-1)}{\sigma}\right] X_i \quad \text{(D3)}$$

Assuming that gross manufacturing production in market $X_n$ is equal to gross manufacturing of all production with *n*'s technology $Y_i$ plus an FDI sales deficit $D_n$, we have:

$$Y_i = \frac{[\gamma\sigma(W_i L_i) + [-\beta\sigma+\beta-1] D_i]\theta}{\sigma\theta - \sigma\gamma + \gamma - (\sigma-1)(1-\beta)\theta} \quad \text{(D4)}$$

$$X_n = \frac{[\gamma\sigma(W_i L_i) + [-\beta\sigma+\beta-1] D_i]\theta}{\sigma\theta - \sigma\gamma + \gamma - (\sigma-1)(1-\beta)\theta} + D_n \quad \text{(D5)}$$

With $\pi_{ni} = \frac{\Phi_{ni}(\sigma E_{ni})^{\frac{-[\theta-(\sigma-1)]}{\sigma-1}}}{\psi_n}$ from (B2) and $\psi_n = \sum_{i=1}^{N} \Phi_{ni} (\sigma E_{ni})^{\frac{-[\theta-(\sigma-1)]}{\sigma-1}}$ from (A5), we can write:

$$\pi_{ni} = \frac{T_i\left(W_n^{\beta} P_n^{1-\beta} d_{ni}\right)^{-\theta} (\sigma E_{ni})^{-[\theta-(\sigma-1)]/(\sigma-1)}}{\sum_{i=1}^{N} T_i (W_n^{\beta} P_n^{1-\beta} d_{ni})^{-\theta} (\sigma E_{ni})^{-[\theta-(\sigma-1)]/(\sigma-1)}} \quad \text{(D6)}$$

and the following price equation:

$$P_n = \bar{m}\kappa_1^{-1/\theta} \left[\sum_{i=1}^{N} T_i (W_n^{\beta} P_n^{1-\beta} d_{ni})^{-\theta} (\sigma E_{ni})^{-[\theta-(\sigma-1)]/(\sigma-1)}\right]^{-1/\theta} \left(\frac{X_n}{W_n}\right)^{\left(\frac{1}{\theta}\right)-1/(\sigma-1)} \quad \text{(D7)}$$

Equilibrium in the world market for manufacturers, $Y_i = \sum_{n=1}^{N} \pi_{ni} X_n$, sets up a system of equations where changes in real wages and price levels, $W_n$ and $P_n$, can be solved following an exogenous decrease in $d_{ni}$ and/or $E_{ni}$. As is the case for welfare gains from trade in the heterogeneous firm model, the reductions in FDI barriers would lead to welfare gains from a decline in price levels $P_n$ (through better access to cheaper goods) and a rise in real wages $W_n$

(through increased production from rising productivity).

Following Dekle, Eaton, and Kortum (2008), rather than estimating all the parameters embedded in the model, the equations can be respecified in terms of the counterfactuals and their rate of change. The merit of this method is that it requires no information on the initial level of technology, variable FDI barriers, and fixed costs to entry. Under this specification, the change of wages $\widehat{W}_n$ and the changes in manufacturing price indices $\widehat{P}_n$ around the world can be solved from exogenous changes in $\hat{d}_{ni}$ or $\widehat{E}_{ni}$ (where the hat indicates the ratio of counterfactual to baseline). Given Θ, $\sigma$, $\beta$, $\gamma$ and global FDI shares (not just for Japan), a simple iterative algorithm may be used to jointly solve for changes in wages and prices resulting from an exogenous decrease in FDI barriers.

**D.2 Data for Counterfactuals**

In addition to the benchmark parameters estimated in Θ, the counterfactual exercise requires additional parameters that need to be calibrated. We use Kang's (2008) estimate of the elasticity of substitution for the Japanese manufacturing sector and set $\sigma$ = 2.1. For labor shares $\beta$, we take the averages reported in UNIDO across countries and set $\beta$ = 2.4.

To construct a dataset on bilateral FDI activity, we rely on several data sources. We use the RIETI FDI Database for aggregate sales of foreign affiliates of Japanese multinationals in 2006. For other bilateral pairs, affiliate sales are estimated from the UNCTAD data on FDI stocks and flows for the period 1990-2006. In doing so, we first construct bilateral FDI stocks in 2006 for each country pair. Missing figures for bilateral FDI stocks are approximated by the cumulative stocks of FDI flows over 1990-2006. As FDI flows were negative for certain country pairs and periods, an estimate of FDI stocks in 2006 becomes negative for some country pairs. In this case, we replace zero FDI stocks. When the figures remain missing, we assume zero FDI stocks for the corresponding country pairs.

Furthermore, we estimate total FDI stocks in manufacturing sectors by multiplying the figures by 21%. This figure is an average share of manufacturing FDI as reported in the World Investment Report (2010). Finally, we multiply the FDI stocks by 2.0198 to convert into sales by foreign affiliates. This factor is based on the estimated relationship between FDI stocks and affiliate sales, as shown in the World Investment Report (2010).

We use the World Bank's World Development Indicators for data on GDP and manufacturing value-added. To construct a measure of the production that employs domestic technology, we approximate domestic production from value-added. Following an estimate for the average ratio of total sales to value-added in UNIDO, valued-added is converted into total sales by a multiplying factor of 2.745. Second, we subtract total sales of inward FDI from total domestic sales to discount the contribution of foreign technology. Lastly, FDI deficits are calculated by subtracting total sales of outward FDI from total sales of inward FDI.

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