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Laura Alfaro
Maggie X. Chen

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Selection, Reallocation, and Spillover: Identifying the Sources of Gains from Multinational Production

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ABSTRACT

Quantifying the gains from multinational production has been a vital topic of economic research. Positive productivity gains are often attributed to knowledge spillover from multinational to domestic firms. An alternative, less stressed explanation is …rm selection whereby competition from multinationals leads to market reallocation and survival of only the most productive domestic firms. We develop a model that incorporates both aspects and identify their relative importance in the gains from multinational production by exploring their distinct predictions on domestic productivity and revenue distributions. We show that knowledge spillover shifts both distributions rightward while selection and reallocation raise the left truncation of the distributions and shift revenue leftward. Using a rich firm-level panel dataset that spans 60 countries, we find firm selection and market reallocation constitute an important source of productivity gains while its relative importance varies across nations. Ignoring the role of this source can lead to significant bias in understanding the nature of gains. We also perform counterfactual analysis and quantify both the aggregate and the decomposed welfare effects of multinational production.

Laura Alfaro
Harvard Business School
Morgan Hall 263
Soldiers Field
Boston, MA 02163
and NBER
lalfaro@hbs.edu

Maggie X. Chen
Dept. of Economics
George Washington University
2115 G ST, NW, #367
Washington, DC 20052
xchen@gwu.edu

1 Introduction

Nations with greater openness to multinational production exhibit, on average, higher productivity and faster economic growth.[1] This positive relationship, likely conditional on other factors, is often attributed to *knowledge spillover* whereby foreign multinationals generate positive technology externalities to domestic firms. Such spillover can arise from a variety of mechanisms such as direct knowledge transfer through partnership, the possibility to learn from the innovation and experiences of foreign firms, and the interaction and movement in labor markets. In pursuit of these potential knowledge spillovers, governments in many developed and developing countries have substantially reduced barriers to foreign direct investment (FDI) and offered special incentives to attract foreign firms.

There is, however, a less stressed, alternative explanation, centering on *firm selection*. First, there is a self-selection of multinational firms. Helpman et al. (2004) show that firms with greater productivity are more likely to overcome the fixed cost of foreign investment and engage in multinational production overseas. Countries with greater openness to multinational production thus attract foreign firms that are, by selection, more productive. Second, there is a selection of domestic firms. Greater openness to multinational production leads to tougher competition in product and factor markets, reallocating resources from domestic towards multinational firms and from the less productive towards the more productive domestic firms. The least efficient domestic firms, as a result, are forced to exit the markets, inducing an increase in the average productivity.[2]

The above mechanisms all imply a positive relationship between multinational production and host-country productivity, making it extremely difficult to distinguish the sources of productivity gains. But these mechanisms represent sharply different economic causalities and implications. The self-selection of multinational firms suggests that higher host-country productivity can reflect the productivity of self-selected multinational firms, instead of the

[1] See Harrison and Rodríguez-Clare (2011) and Kose et al. (2011) for recent overviews of the literature that examines the relationship between multinational production, productivity and economic growth. At the macro level, the cross-country correlations between average FDI-to-GDP ratio and average TFP and TFP growth are 0.27 and 0.26, respectively (Sources: World Bank, WDI and Penn World Tables. Data: 1980-2005). Evidence in the macro literature shows that FDI exerts a positive effect on economic growth when host countries have sufficient human capital stock and relatively developed financial markets (Borensztein et al., 1998; Alfaro et al., 2004).

[2] While the role of firm selection is under-stressed in evaluating gains from multinational production, it is well established in determining the productivity gains from trade liberalization, see Melitz (2003). An important empirical study in this area, Pavcnik (2002), finds 19.3 percent manufacturing productivity growth from trade liberalization in Chile during 1979-1986, of which 12.7 percent was due to reallocation of resources from less to more efficient producers and 6.6 percent from increased productivity within plants.

causal effect of multinational production.[3] In contrast, domestic firm selection and knowledge spillover imply multinational production *causes* higher aggregate, domestic productivity. How the latter two affect domestic production is, however, countervailing. Tougher domestic firm selection results in a contraction of domestic production and exits of domestic firms whereas knowledge spillover creates positive externalities and promotes the growth of domestic production.

The main objective of this paper is to disentangle the roles of firm selection and knowledge spillover in determining the aggregate productivity and welfare impact of multinational production and quantify the relative importance of these distinct sources of gains. As it is difficult to separate these effects without building a theoretical framework that explicitly incorporates the two aspects, we develop a standard model of monopolistic competition and heterogeneous firms to address simultaneously the selections of domestic and multinational firms and the knowledge spillover from multinational to domestic production. Our model provides a framework that enables us to distinguish the different channels by exploring different distribution properties of multinational and domestic production.

The theoretical framework suggests that while both firm selection and knowledge spillover predict a positive relationship between openness to multinational production and aggregate productivity, the effects operate in distinct ways and bear different predictions for the distributions of domestic and multinational production. In particular, multinational firms self-select into multinational production, basing the decision on their ex-ante productivity, host-country characteristics such as market size and production cost, and bilateral country factors that can influence fixed costs of multinational production. Competition then leads to a reallocation of labor and capital from domestic to the more productive multinational competitors and from less to more efficient domestic firms. Specifically, the reallocation of labor erodes the revenue of individual domestic firms while the reallocation of capital results in greater cutoff revenue for new and continuing domestic firms. Both of these effects cause an increase in the cutoff productivity and force the least efficient domestic firms to exit the markets. Finally, knowledge spillover from foreign multinational production should induce a rightward shift of the productivity distribution of surviving domestic firms, while the distribution becomes more left truncated due to tougher domestic selection. The revenue distribution, on the other

[3] A related issue is that multinationals firms can also be attracted to host countries with higher productivity, which will similarly lead to a positive correlation between multinational production and host-country productivity. Our empirical strategy, as discussed below, will address both these issues to identify the causal effects of multinational production.

hand, is predicted to have a weaker, or even contrary-direction, shift as market reallocation offsets the positive effect of knowledge spillover.

These predictions are evaluated empirically using a large cross-country firm panel dataset, drawn from Orbis, that contains comprehensive financial, operation, and ownership information for over 1 million public and private manufacturing companies in 2002-2007. The database exhibits two notable strengths: broad cross-country coverage and detailed ownership information. These two features allow us to identify multinational production across countries and explore the heterogeneous effect of foreign investments.

Our estimation consists of two steps. We first estimate the self-selection of multinational firms as a function of multinationals' ex-ante headquarter productivity, a vector of host-country industry dummies, and bilateral factors of multinational headquarters and host countries. The ex-ante headquarter productivity of multinational firms is expected to have an important effect on the decision to participate in multinational production but, in the meantime, unlikely to be directly correlated with the future productivity of host-country firms, making a suitable exclusion condition for identifying the causal effects of multinational production. Next, in departure from traditional approaches which rely on the relationship between multinational production and host-country average productivity and attribute increases in average productivity to knowledge spillover only, we disentangle the roles of knowledge spillover and firm selection by estimating the effect of expected multinational production on various distribution properties of domestic production, including the cutoff productivity and revenue and the productivity and revenue distributions of domestic firms. The estimated impact on cutoff productivity and revenue determines the selection effect due to labor and capital market reallocations, while the estimated effect on the productivity distribution quantifies the magnitude of knowledge spillover.

Our empirical analysis suggests that multinational production leads to not only knowledge spillover but also tougher firm selection and factor reallocation in domestic markets. New entry of multinational firms is found to raise the cutoff productivity of domestic firms, pushing the least productive domestic firms to exit the markets. New multinational production also leads to an increase in the minimum revenue of continuing domestic firms, implying an increase in fixed production cost and capital price. Further, the estimates show a significant decrease in the aggregate price, suggesting increased competition and market reallocation. Following the entry of multinational firms, the revenue distribution of domestic firms shifts leftward, at both the 25th and 50th percentiles. In contrast, the productivity distribution

of domestic firms shifts rightward at the 25th and 50th percentiles suggesting knowledge spillover for low- and intermediate-productivity domestic firms, while the distribution becomes more left truncated due to selection and reallocation.

When quantifying the welfare and productivity gains from multinational production, we find the aggregate welfare to increase by 9.5 percent and the aggregate productivity to increase by 1.4 percent across countries when the probability of entry by new multinational firms increases by 100 percent. The productivity of domestic firms increases by 0.9 percent, with knowledge spillover and domestic selection accounting for 69 and 31 percent, respectively. Attributing increases in average domestic productivity entirely to knowledge spillover, an assumption often made in previous analysis, is shown to over-estimate the importance of spillover by nearly 50 percent. These results highlight that ignoring the role of firm selection and market reallocation in assessing the gains from multinational production could lead to significant bias in understanding the nature and the sources of welfare and productivity gains. Further, analysis using measures of industry pair's similarity in labor and capital-good demand reveals evidence of labor and capital reallocations between related industries, reinforcing the gains from factor reallocations.

We also take advantage of the wide country coverage of our data and explore differences across countries. Our analysis shows the relative importance of each source to exhibit significant country heterogeneity. The wide country variance unveiled by our estimates is consistent with the plethora of results documented in the literature as discussed below. In particular, we find the relative importance of firm selection and market reallocation to be greater, on average, in developed nations than in developing ones.

Our study is related to several strands of existing literature. First, as mentioned, our paper builds on an extensive literature that assesses the existence of productivity spillover from multinationals to domestic firms.[4] One of the earliest contributions in this literature is Aitken and Harrison (1999) who find evidence of negative spillover in a panel of Venezuelan manufacturing enterprises from 1975-1989. The authors attribute this result to a market-stealing effect whereby foreign multinational firms steal the market shares of domestic firms. The paper by Aitken and Harrison (1999) soon spawned a large series of empirical studies. Keller and Yeaple (2009), for example, show strong evidence of positive spillover from foreign multinational to domestic firms in the United States. Similar results are also found in Aghion et al. (2012) for a panel of medium and large Chinese enterprises in 1998-2007.

[4]The literature on multinational production is vast. See Markusen (1995, 2002), Caves (1996), and Harrison and Rodriguez-Clare (2010) for excellent overviews of the broader literature.

Javorcik (2004) explores spillovers through vertical production linkages in Lithuania between 1996-2000, and shows multinational production leads to positive externalities via backward production linkage, from multinational affiliates to local intermediate input suppliers. Fons-Rosen et al. (2011) find negative spillovers within 4-digit NACE industries across European nations but positive spillovers from financial FDI at 2-digit level in western Europe, which the authors associate to spillovers being outweighed by potential business stealing effects in eastern Europe. Studies by Arnold and Javorcik (2009) and Guadalupe et al. (2011) account for the endogenous acquisition decisions of foreign multinational firms and find foreign multinationals to acquire best performing domestic firms. They also show that foreign ownership leads to significant productivity spillover in acquired plants even after addressing the acquisition decisions.

In contrast to the productivity spillover literature, evidence on the domestic selection effect of multinational production is very limited. Analysis that disentangles the relative importance of knowledge spillover and firm selection is even more scarce. Ramondo (2009), using a panel of domestic and foreign plants in the Chilean manufacturing sector, finds foreign plants' entry to be correlated negatively with the market shares of domestic firms and positively with the productivity of domestic incumbents. A few studies took the step to evaluate the factor market effects of multinational production. Aitken, Harrison, and Lipsey (1996) investigate the impact of foreign owned plants on the wages of domestically owned establishments in Mexico and Venezuela. Their analysis suggests an increase of industry wages due to foreign multinational production, especially for skilled workers and plants in Venezuela. Similarly, Feenstra and Hanson (1997) find that a higher level of maquiladora activity leads to a higher share of total wages going to skilled (non-production) workers in Mexico, a result they interpret as increased demand for skilled labor from foreign multinational firms. Exploring the effect of multinational production on domestic financial markets, Harrison and McMillan (2003) find domestic firms to be more credit constrained than foreign firms and borrowing by foreign firms to exacerbate their credit constraints.[5]

Our paper contributes to the above literature by disentangling the roles of firm selection and knowledge spillover in determining the aggregate impact of multinational production on host-country productivity. First, our micro theoretical foundation captures simultaneously

[5]In contrast to Harrison and McMillian (2003), Harrison, Love and McMillian (2004) find FDI inflows to be associated with a reduction in firms' financing constraints using data from Worldscope on 7,079 firms in 28 countries. Harrison and Rodriguez-Clare (2011) argue that these contrasting results point to policy complementarities, such as those between FDI and local financial markets (see Alfaro et al. 2004, 2010).

the two distinct aspects of multinational production and develops a novel empirical strategy to distinguish their relative importance. Our predictions are grounded in a standard model of firm heterogeneity, but apply to a broader class of theoretical setups. Second, our empirical analysis accounts for the endogenous self-selection of multinational firms and the possibility that multinational production and host-country productivity are driven by the same unobserved economic characteristics and the potential reverse causality between host-country productivity and the entry decision of multinational firms. Third, the framework employed enables us to perform policy counterfactual analysis and quantify the aggregate and the decomposed gains from openness to multinational production. Our analysis offers new evidence on the selection and the market reallocation effects of foreign investment and, further, the cross-country heterogeneity in the gains from multinational production.

The paper is also related to a recent strand of studies that evaluate the welfare effects of multinational production with emphasis on interactions between trade and multinational production, the role of geography, and technology compatibility; see Ramondo and Rodriguez-Clare (2011), Irrarazabal, Moxnes, Opromolla (2011), and Carluccio and Fally (2011). Albeit our model does not address the above features of multinational production, our paper complements these studies by quantifying the sources of productivity and associated welfare gains from multinational production, specifically via firm selection, market reallocation, and knowledge spillover, a distinction that has been previously under-stressed.

More broadly, our work also connects to the literature that emphasizes the productivity effect of resource allocation across establishments. A growing strand of literature argues that the allocation of resources across heterogeneous plants, influenced by policies broadly defined, matters in explaining income differences (see, Hsieh and Klenow, 2009; Alfaro et al, 2009). Echoing these studies, our paper shows that the reallocation of capital and labor as a result of increased multinational production could lead to important productivity gains.

Our study provides crucial implications on policy designs aimed to influence FDI flows. If foreign firms have knowledge spillover effects to domestic firms, special treatment may be justified. If instead, as our results suggest, increases in productivity can also arise from tougher selection on domestic firms as a result of competition for scarce labor and capital, it would be important to improve domestic conditions, including conditions of labor (in particular, skilled-labor) supply and credit access, while in the meantime eliminating barriers to facilitate gains from competition and reallocation of resources.[6]

[6] See a recent theoretical study by Monge (2011) for policy implications on the optimal taxation of multinational firms in the presence of knowledge spillover.

The rest of the paper is organized as follows. Section 2 presents the theoretical framework. Section 3 describes the data employed in the empirical analysis. Sections 4 and 5 report the estimation results and the productivity and welfare gain estimates, respectively. Section 6 discusses additional robustness. Section 7 concludes.

2 Model

In this section, we employ a standard model of monopolistic competition and heterogeneous firms, adapted from the work of Melitz (2003) and Helpman *et al.* (2004), to illustrate the self-selection and the effects of multinational firms.

2.1 Setup

Suppose the world consists of two countries, H and F, and two sectors, one homogeneous and one differentiated. The homogeneous good serves as the numeraire. There is a continuum of firms in each country. Each firm produces a different variety of the differentiated product and has a distinct productivity level θ.

Given a CES utility function, the demand function for each variety of the differentiated product is given by

$$x(\theta) = \frac{E}{P}\left[\frac{p(\theta)}{P}\right]^{-\varepsilon}, \tag{1}$$

where $x(\theta)$ denotes the quantity of demand, E the aggregate expenditure on the differentiated product, $p(\theta)$ the price of the product variety, $P \equiv \left[\int_{\theta\in\Omega} p(\theta)^{1-\varepsilon} d\theta\right]^{\frac{1}{1-\varepsilon}}$ the aggregate price, Ω the set of available varieties, and $\varepsilon \equiv 1/(1-\alpha) > 1$ the demand elasticity.

Without loss of generality, we assume countries H and F are identical and focus on country H. If firms of country H choose to produce and sell at home, they must employ one unit of labor for each unit of output and incur a marginal cost w/θ, where w is the common wage rate. Firms must also pay a per-period fixed cost cf_D, where c denotes unit capital price and f_D denotes the units of capital (e.g., machinery) required in the production. The profit-maximizing strategy is to set $p(\theta) = w/(\alpha\theta)$, which yields the domestic revenue and profit functions, denoted as $r_D(\theta)$ and $\pi_D(\theta)$, respectively, below:

$$r_D(\theta) = E\left(\frac{\alpha P\theta}{w}\right)^{\varepsilon-1}; \quad \pi_D(\theta) = \frac{r_D(\theta)}{\varepsilon} - cf_D = \frac{E}{\varepsilon}\left(\frac{\alpha P\theta}{w}\right)^{\varepsilon-1} - cf_D. \tag{2}$$

Firms of country F may also invest and produce in country H to serve country H's consumers via multinational production.[7] If that is the case, foreign multinational firms must pay a fixed cost cf_M in each period. Following Helpman *et al.* (2004), the fixed cost of production is assumed to be higher for foreign firms than for domestic firms, i.e., $f_M > f_D$. The revenue and the profit earned by foreign firms in country H, denoted as $r_M(\theta)$ and $\pi_M(\theta)$, respectively, are given by:

$$r_M(\theta) = E\left(\frac{\alpha P\theta}{w}\right)^{\varepsilon\square 1}; \quad \pi_M(\theta) = \frac{r_M(\theta)}{\varepsilon}\square\, cf_M = \frac{E}{\varepsilon}\left(\frac{\alpha P\theta}{w}\right)^{\varepsilon\square 1}\square\, cf_M. \tag{3}$$

Domestic firms produce in the domestic market if $\pi_D(\theta) \geqslant 0$. Setting $\pi_D(\theta) = 0$ yields the cutoff productivity level θ_D for domestic firms to survive:

$$\pi_D(\theta_D) = 0 \Longrightarrow \theta_D = \left(\frac{\varepsilon cf_D}{E}\right)^{\frac{1}{\varepsilon\square 1}}\left(\frac{w}{\alpha P}\right). \tag{4}$$

Domestic firms with $\theta \geqslant \theta_D$ produce in the home market and those with $\theta < \theta_D$ exit.

Foreign firms invest and produce in the domestic market if $\pi_M(\theta) \geqslant 0$. The cutoff productivity level for foreign firms is obtained by setting $\pi_M(\theta) = 0$:

$$\pi_M(\theta_M) = 0 \Longrightarrow \theta_M = \left(\frac{\varepsilon cf_M}{E}\right)^{\frac{1}{\varepsilon\square 1}}\left(\frac{w}{\alpha P}\right). \tag{5}$$

Both the domestic and multinational cutoffs are an increasing function of c, w, and the respective fixed costs and a decreasing function of E and P. Given the above two equations, the ratio of the domestic and foreign cutoff productivity levels is given by:

$$\frac{\theta_M}{\theta_D} = \left(\frac{f_M}{f_D}\right)^{\frac{1}{\varepsilon\square 1}} \tag{6}$$

Since $f_M > f_D$, we have $\theta_M > \theta_D$. This implies that the minimum productivity to survive in each country is higher for foreign multinational firms than for domestic firms.

Now consider the productivity of domestic firms. We assume that when there is foreign multinational production, there can be potential knowledge spillover—transferring foreign

[7] In our model, we abstract from the choice between multinational production and export and essentially assume prohibitive trade costs to keep the analysis tractable (for seminal theoretical work in this area, see Markusen, 1984). Our main analytical hypotheses shall remain qualitatively similar when the choice between multinational production and export is taken into account.

technology knowhow—from foreign multinational to domestic firms.[8] To capture this effect, the productivity of domestic firms is assumed to be a function of two components: a raw/ex-ante productivity θ_a drawn from a distribution function $G(\theta_a)$ and a slope parameter $\tau_\theta(z_M)$ where z_M is a simple indicator variable that denotes foreign multinational production. Equation (5) suggests that there will be multinational production when θ_M is non-prohibitive and, equivalently, when f_M is finite, i.e., $z_M = I(\theta_M < \infty) = I(f_M < \infty)$. Specifically, we assume

$$\theta \equiv \tau_\theta(z_M)\theta_a = \tau_\theta^{z_M} \cdot \theta_a \tag{7}$$

where $\tau_\theta > 1$ implies positive knowledge spillovers.

Let N_D denote the equilibrium mass of incumbent domestic firms in each country. Given the country symmetry and the ex-ante probability of foreign investment $_M \equiv [1 \square G(\theta_M)] / [1 \square G(\theta_D)]$, $N_M = {}_M N_D$ represents the equilibrium mass of firms that engage in multinational production and, equivalently, the number of foreign owned firms in each country. The total mass of varieties available to consumers in each country and the total mass of firms competing in each country are hence $N = N_D + N_M$.

2.2 Aggregate Outcomes

Let $\widetilde{\theta}_D$ and $\widetilde{\theta}_M$ denote, respectively, the weighted average productivity levels of domestic and foreign firms:

$$\widetilde{\theta}_D \equiv \widetilde{\theta}(\theta_D) = \frac{1}{1 \square G(\theta_D)} \left[\int_{\theta_D}^{\infty} \theta^{\varepsilon \square 1} g(\theta) d\theta \right]^{\frac{1}{\varepsilon \square 1}}; \quad \widetilde{\theta}_M \equiv \widetilde{\theta}(\theta_M) = \frac{1}{1 \square G(\theta_M)} \left[\int_{\theta_M}^{\infty} \theta^{\varepsilon \square 1} g(\theta) d\theta \right]^{\frac{1}{\varepsilon \square 1}}. \tag{8}$$

The aggregate productivity of all firms in each country, $\widetilde{\theta}$, can be written as:

$$\widetilde{\theta} = \left\{ \frac{1}{N} \left[N_D \widetilde{\theta}_D^{\varepsilon \square 1} + N_M \widetilde{\theta}_M^{\varepsilon \square 1} \right] \right\}^{\frac{1}{\varepsilon \square 1}}. \tag{9}$$

As shown in Melitz (2003), this productivity average summarizes the effects of the distribution of productivity levels on aggregate outcomes. The aggregate price index P, the expenditure

[8] It is worth noting that knowledge spillover can also occur in the reverse direction, from domestic to foreign multinational firms. Here, we do not consider this possibility given our focus on the host-country effect of multinational production. In addition to within-industry spillover, we also consider in Section 6 the case of knowledge spillover between industries channeled through vertical production linkages.

level E, and welfare per worker W in each country can all be written as functions of the productivity average $\widetilde{\theta}$ and the number of varieties available in the market N:

$$P = N^{\frac{1}{1-\varepsilon}} p\left(\widetilde{\theta}\right) = N^{\frac{1}{1-\varepsilon}} \frac{w}{\rho\widetilde{\theta}}; \quad E = N r_D\left(\widetilde{\theta}\right); \quad W = \frac{E}{L} N^{\frac{1}{\varepsilon-1}} \rho\widetilde{\theta}. \tag{10}$$

2.3 Equilibrium Conditions

There is a large pool of prospective entrants into the industry. To enter, firms must make an initial investment, modeled as a fixed entry cost $cf_E > 0$. Firms then draw their initial productivity upon entry. If a firm obtains a low productivity draw, the firm may decide to immediately exit and not produce. If a firm produces, it then faces a constant probability δ of a bad shock in every period that would force it to exit.

Now consider the steady state equilibria in which the aggregate variables remain constant over time. Since each firm's productivity level does not change over time, its optimal per-period profit will also remain constant. An entering firm with productivity θ would immediately exit if its profit level were negative or would produce and earn $\pi(\theta)$ in every period until it is hit with the bad shock and is forced to exit.

The zero cutoff profit condition implies that

$$r(\theta_D) = \varepsilon c f_D; \quad r(\theta_M) = \varepsilon c f_M. \tag{11}$$

Since the average productivity levels $\widetilde{\theta}_D$ and $\widetilde{\theta}_M$ are determined by the cutoff productivity levels θ_D and θ_M, the average profit and revenue levels are also tied to the cutoff levels:

$$\begin{aligned} \overline{r}_D &= r(\widetilde{\theta}_D) = \left[\frac{\widetilde{\theta}_D}{\theta_D}\right]^{\varepsilon-1} r(\theta_D); \qquad \overline{r}_M = r(\widetilde{\theta}_M) = \left[\frac{\widetilde{\theta}_M}{\theta_M}\right]^{\varepsilon-1} r(\theta_M) \\ \overline{\pi}_D &= \pi(\widetilde{\theta}_D) = \left[\frac{\widetilde{\theta}_D}{\theta_D}\right]^{\varepsilon-1} \frac{r(\theta_D)}{\varepsilon} - cf_D; \; \overline{\pi}_M = \pi(\widetilde{\theta}_M) = \left[\frac{\widetilde{\theta}_M}{\theta_M}\right]^{\varepsilon-1} \frac{r(\theta_M)}{\varepsilon} - cf_M. \end{aligned} \tag{12}$$

Given equations (2) and (3), the average profits of domestic and foreign firms in the domestic market, $\overline{\pi}_D$ and $\overline{\pi}_M$, can be written as $\overline{\pi}_D = \lambda_D c f_D$ and $\overline{\pi}_M = \lambda_M c f_M$ respectively, where $\lambda_D \equiv \left[\widetilde{\theta}(\theta_D)/\theta_D\right]^{\varepsilon-1} - 1$ and $\lambda_M \equiv \left[\widetilde{\theta}(\theta_M)/\theta_M\right]^{\varepsilon-1} - 1$. The average profit of all firms competing in the domestic market is given by:

$$\overline{\pi} = \overline{\pi}_D + \; _M\overline{\pi}_M = \lambda_D c f_D + \; _M\lambda_M c f_M, \tag{13}$$

where $_M \equiv [1 \square G(\theta_M)] / [1 \square G(\theta_D)]$.

Assuming that there is no time discounting, each firm's value function is given by:

$$v(\theta) = \sum_{t=0}^{\infty} (1 \square \delta)^t \pi(\theta) = \frac{\pi(\theta)}{\delta}. \tag{14}$$

The present value of the average profit flows and entry's net value are given, respectively, by

$$\overline{v} = \sum_{t=0}^{\infty} (1 \square \delta)^t \overline{\pi} = \frac{1}{\delta} \overline{\pi}, \tag{15}$$

$$v_E = \frac{1}{\delta} [1 \square G(\theta_D)] \overline{\pi} \square c f_E. \tag{16}$$

The free entry condition implies that the expected value of future profits must, in equilibrium, equal the fixed entry cost.

$$v_E = 0 \Longrightarrow \overline{\pi} = \frac{\delta c f_E}{_D}, \tag{17}$$

where $_D \equiv 1 \square G(\theta_D)$ is the ex-ante probability of survival after entry. The above equation, together with equations (11) and (12), determine $\overline{\pi}$, θ_D and θ_M.

Now consider the factor market clearing conditions. The labor market clearing condition requires that the total demand for labor in the domestic market equals the total supply of labor L, i.e., $N_D (\overline{r}_D + \ _M \overline{r}_M) / \alpha^{\varepsilon \square 1} = N_D \overline{r} / \alpha^{\varepsilon \square 1} = L$ where $N_D \overline{r}_D / \alpha^{\varepsilon \square 1}$ is the domestic labor demand by domestic firms and $N_D \ _M \overline{r}_M / \alpha^{\varepsilon \square 1}$ is the domestic labor demand by foreign firms. This, in turn, determines the equilibrium mass of incumbent domestic firms producing in each country:

$$N_D = \frac{\alpha^{\varepsilon \square 1} L}{\overline{r}} = \frac{\alpha^{\varepsilon \square 1} L}{\varepsilon (\overline{\pi} + c f_D + \ _M c f_M)}, \tag{18}$$

which then yields the number of foreign firms N_M and the total number of firms competing in the domestic market N.

In the capital market, we assume that firms finance a constant share of their fixed foreign investment cost in home countries and the rest abroad.[9] The total demand for capital by domestic and foreign multinationals in each country is then given by $N_D \ _M f_M$. The capital market clearing condition requires that $N_D (f_D + \ _M f_M + \delta f_E / \ _D) = K$, where $N_D f_D$,

[9] In terms of capital accumulation, Graham and Krugman (1991), Lipsey (2002), and Harisson and McMillian (2003) show that investors often fail to fully transfer capital upon taking control of a foreign company; instead, they tend to finance an important share of their investment in the local market. If foreign firms borrow heavily from local banks, instead of bringing scarce capital from abroad, they may exacerbate domestic firms' financing constraints by crowding them out of domestic capital markets.

$N_D \ _M f_M$, and $N_D \delta f_E / \ _D$ represent, respectively, the demand for capital in the domestic market by domestic producers, domestic and foreign multinationals, and domestic entrants and K is the aggregate supply of capital.[10] Given (16) and (21), this leads to

$$c = \frac{\alpha^{\varepsilon \square 1} L \left(f_D + \ _M f_M + \delta f_E / \ _D \right)}{K \varepsilon \left[(\lambda_D + 1) f_D + (\lambda_M + 1) \ _M f_M \right]}. \tag{19}$$

2.4 The Impact of Multinational Production

We now use the present model to examine the impact of multinational production, including: What happens to the productivity distribution of domestic firms? How is the aggregate productivity and welfare affected? The analysis draws from comparisons of steady state equilibria and thus captures the long-run impact of multinational production.

Selection of Domestic Firms Inspection of the zero cutoff profit conditions reveals that openness to multinational production induces an increase in the domestic cutoff productivity level θ_D. Assuming the effect of knowledge spillover is inadequate to offset the negative competition effect, the least productive firms with productivity levels between the ex-post cutoff θ_D and the ex-ante cutoff, denoted as θ_A, can no longer earn positive profits and therefore exit. As in Melitz (2003), this selection effect operates through domestic factor markets where domestic and multinational firms compete for a common source of labor and capital. The increased factor demand by multinational firms bids up the real wage and capital price and forces the least productive firms to exit.[11]

Now we examine the effects of multinational production on the market share of domestic firms. We focus on domestic firms with productivity higher than the ex-ante cutoff θ_A. Let $r_A(\theta)$ denotes the domestic firm's ex-ante revenue before the entry of foreign multinational

[10] We abstract from considerations regarding international capital flows in the theoretical framework. The international trade literature suggests that firms engage in FDI not because of differences in the cost of capital but because certain assets are worth more under foreign than local control. If lower cost of capital were the only advantage a foreign firm had over domestic firms, it would still remain unexplained why a foreign investor would endure the troubles of operating a firm in a different political, legal, and cultural environment instead of simply making a portfolio investment.

[11] As noted in Melitz (2003), an alternative channel of the selection effect is through the increase in product market competition after the entry of multinational firms. Domestic firms face an increased number of foreign competitors that are, on average, more productive than the domestic firms. However, this channel is not operative in either Melitz's (2003) or our model due to the property of monopolistic competition under the CES preferences: the price elasticity of demand for any variety does not respond to changes in the number or prices of competing varieties. A solution offered in the literature is to introduce variable markups as in Melitz and Ottaviano (2008). However, since factor market competition is a more critical aspect in the case of multinational production (compared to trade), we focus on the former in our theoretical analysis. See Section 6.1 for further discussion on the implications and the robustness of our results.

firms. Recall that the aggregate revenue of firms earned in each country is exogenously given by $R = N_D\left(\overline{r}_D + \ {}_M\overline{r}_M\right) = \alpha^{\varepsilon \square 1}L$. Hence, $r_A(\theta)/R$ and $r_D(\theta)/R$ represent, respectively, the domestic firm's market share before and after the entry of foreign firms.

The impact of foreign multinational production on the domestic firm's market share is twofold. On the one hand, the increase in the average productivity and the increase in the number of firms serving the market contribute to a decrease in the aggregate price P in open economy, which in turn exerts a negative effect on domestic firm revenue. On the other hand, knowledge spillover from foreign firms exerts a positive effect on firm productivity and consequently revenue. The two effects lead to the following inequalities:

$$\frac{r_D(\theta)}{\tau_\theta^{z_M(\varepsilon \square 1)}} < r_A(\theta) < \frac{r_D(\theta) + \ {}_M r_M(\theta)}{\tau_\theta^{z_M(\varepsilon \square 1)}}, \ \ \forall \theta > \theta_A. \tag{20}$$

The first part of the inequality indicates that, in the absence of knowledge spillover, all domestic firms incur a loss in domestic sales in the presence of foreign multinational production. The second part of the inequality indicates that firms that engage in multinational production incur an unambiguous increase in total revenue because the revenue from the foreign market more than offsets their loss of domestic sales.

Aggregate Productivity Next consider the effect of multinational production on aggregate productivity $\widetilde{\theta}$. Inspections of equation (18) reveals that openness to multinational production leads to a decrease in the number of domestic firms N_D and an increase in the aggregate productivity of domestic firms $\widetilde{\theta}_D$. This, as described above, arises from the reallocations in factor markets and the tougher selection of domestic firms. In addition to the selection effect, openness to multinational production can also induce an increase the aggregate productivity of domestic firms because of knowledge spillover. Surviving domestic firms benefit from the positive productivity externalities from foreign firms and witness an increase in their productivity levels. The increase in domestic productivity, in conjunction with the productivity advantage of new foreign multinational firms, leads to an increase in the country's aggregate productivity.

Welfare In addition to distinguishing the effects of multinational production on spillover and selection, the theoretical framework adopted in our analysis also enables us to perform welfare analysis and decompose the gains of multinational production. When the foreign investment fixed cost is sufficiently low, the decrease in the number of domestic firms following the openness to multinational production will be dominated by the number of foreign firms.

However, when the foreign investment fixed cost is sufficiently high, it is possible that foreign firms replace a larger number of domestic firms. When there is an increase in total product variety, this effect, together with increased aggregate productivity, contributes positively to welfare as indicated by equation (10).

2.5 Empirical Strategy

In this sub-section, we describe the empirical framework through which we examine the self-selection and the effects of multinational production. To do so, we first examine the decision of foreign firms to invest in a host country and then explore the properties of the model to identify the effects of multinational production on domestic selection, factor market reallocation, and knowledge spillover.

(1) The Self-Selection of Multinational Firms A foreign firm will invest in a host country if $\pi_M(\theta) > 0$ or equivalently $\theta > \theta_M$. Given equation (5), we consider the following empirical specification

$$\begin{aligned} \Pr\left[z_M(\theta) = 1 | \theta > \theta_D\right] &= \Pr\left[\theta > \theta_M | \theta > \theta_D\right] \\ &= \Phi_{\theta > \theta_D}\left[\ln\theta + \ln\left(E^{\frac{1}{\varepsilon - 1}}\alpha P/w\right) - \frac{1}{\varepsilon - 1}\ln\left(\varepsilon c f_M\right) > 0\right]. \end{aligned} \tag{21}$$

In this equation, we estimate the probability of a multinational firm entering a host country $z_M(\theta) = 1$, conditional on being active in the home country market, as a function of firm ex-ante productivity θ, host country demand conditions E and P, wage rate w, and fixed investment cost cf_M. All host-country specific factors are controlled for using country-industry fixed effect FE_M. In addition, we control for bilateral factors including the distance between host and headquarters countries and whether the countries share common land border and language, all of which may affect the fixed cost of multinational production (as well as trade costs). The ex-ante headquarter productivity of multinational firms is expected to affect multinationals' decision to engage in foreign production, but is unlikely to be directly correlated with the future productivity of host-country firms, thereby serving as an exclusion condition in the second stage to identify the causal effects of multinational production. Based on estimates of the above equation, we obtain the predicted probability of entry for each multinational firm, i.e., $\widehat{\Pr}\left[\theta > \theta_M | \theta > \theta_D\right]$, the expected productivity of multinational firms in each host country, i.e., $\widehat{\widehat{\theta}}_M$, and the expected probability of new multinational production

in each host country, i.e., $\widehat{\ }_M$.

(2) The Selection of Domestic Firms After entry of multinational firms, a domestic firm will survive in the market if $\pi_D(\theta) > 0$ or equivalently $\theta > \theta_D$. Given equation (4), we consider the following empirical specification

$$\Pr\left[z_D(\theta) = 1\right] = \Pr\left[\theta > \theta_D\right], \tag{22}$$

where the dependent variable $z_D(\theta)$ denotes whether the domestic firm survives in the market. Based on the estimates, we obtain the predicted probability of survival for each domestic firm $\widehat{\Pr}\left[\theta < \theta_D\right]$, the expected productivity of surviving domestic firms in each host country $\widehat{\widetilde{\theta}}_D$, and the expected survival rate $\widehat{\ }_D$. Alternatively, we consider the cutoff productivity of domestic firms. Given equation (4), we obtain

$$\theta_D = \theta_A \left(\frac{c}{c_A}\right)^{\frac{1}{\varepsilon \square 1}} \frac{P_A}{P}, \tag{23}$$

where θ_A, c_A and P_A are, respectively, the cutoff productivity, capital price, and aggregate price prior to multinational entry.[12] Taking natural logs of the above equation yields:

$$\ln \theta_D \square \ln \theta_A = \frac{1}{\varepsilon \square 1} \ln \frac{c}{c_A} + \ln \frac{P_A}{P}. \tag{24}$$

Given the estimate of $\ln c/c_A$ below, we can obtain an estimate of $\ln P_A/P$.

(3) Labor Market Reallocation To evaluate the labor market reallocation effect of multinational production, we assess the distribution of domestic firm revenue. As described in Section 2.4, $r_D(\theta)/\tau_\theta^{z_M(\varepsilon \square 1)} < r_A(\theta)$ for all surviving domestic firms, i.e., $r_D(\theta) = \left(\frac{P}{P_A}\tau_\theta^{z_M}\right)^{\varepsilon \square 1} r_A(\theta)$. Foreign production hence would shift the domestic firms' revenue distribution either rightward or leftward depending on whether $P\tau_\theta^{z_M} > P_A$. We hence consider the following empirical specification:

$$r_D(q_A) = \left(\frac{P}{P_A}\tau_\theta^{z_M}\right)^{\varepsilon \square 1} r_A(q_A), \tag{25}$$

where q_A represents the qth (e.g., 25th, 50th and 75th) percentile of the ex-ante revenue distribution. Given the estimate of $\tau_\theta^{z_M}$ from equation (27) below, we can obtain an estimate of P/P_A by estimating the slope of the above equation.

[12] For notational simplicity, we normalize the aggregate price by the wage rate and refer P to the real aggregate price henceforth.

(4) Capital Market Reallocation Next, we explore the zero profit condition to estimate the effect of multinational production on domestic capital price. Given $r_D(\theta_D) = \varepsilon c f_D$ at the cutoff productivity θ_D, we consider

$$\ln r_D(\theta_D) = \ln \frac{c}{c_A} + \ln \varepsilon c_A f_D = \ln \frac{c}{c_A} + \ln r_D(\theta_A), \tag{26}$$

where c/c_A is expected to be greater than 1 and $r_D(\theta_A)$ is the cutoff revenue prior to the entry of multinational firms.

(5) Knowledge Spillover Finally, consider the knowledge spillover effect of foreign multinationals. Recall $\theta = \tau_\theta^{z_M} \cdot \theta_a$ where θ_a is drawn from the distribution function $G(\theta_a)$. Knowledge spillovers from foreign multinational firms would shift the productivity distribution of surviving domestic firms rightward by τ_θ. Let q_A denote the qth percentile of θ_a; we can estimate the knowledge spillover effect τ_θ by considering the following estimation:

$$\theta(q_A) = \tau_\theta^{z_M} \theta_a(q_A), \tag{27}$$

where q_A represents the qth (e.g., 25th, 50th and 75th) percentile of the ex-ante productivity distribution. In all the second-stage estimations, namely, equations (22)-(27), we account for the self-selection of foreign multinationals by instrumenting the entry of multinational firms with $\widehat{\ }_M$ obtained from equation (21).

Figures 1-3 illustrate the theoretical predictions, i.e., how multinational entry affects, via market reallocation and knowledge spillover, the cutoffs as well as the distributions of domestic productivity and revenue.

3 Cross-Country Firm Financial and Ownership Data

We employ a cross-country firm-level panel dataset, drawn from Orbis, that contains comprehensive financial, operation, and ownership information for public and private companies in 60 countries.[13] Orbis is published by Bureau van Dijk, a leading source of company information and business intelligence. Orbis combines information from around 100 sources and information providers. Over 99 percent of the companies included in Orbis are private. The

[13] Table A.1 provides a list of countries. We imposed a number of requirements in cleaning the data. First, we dropped all records that lack revenue, employment, asset, and industry information. Second, we focused on manufacturing industries only. Third, we excluded countries with fewer than 100 observations.

dataset reports for each company the following categories of information: a) detailed 10-year financial information including 26 balance sheet and 25 income sheet items; b) industries and activities including primary and secondary industry codes in both local and international classifications; c) corporate structure including board members and management; d) ownership information including shareholdings and subsidiaries, direct and indirect ownership, ultimate owner, independence indicator, corporate group, and all companies with the same ultimate owner as the subject company.

Orbis provides several distinct advantages that are central to our analysis. First, a notable strength of Orbis is its ownership information, which covers over 30 million shareholder/subsidiary links and is known for its scope and accuracy. The information is collected from a variety of sources including official registers, annual reports, research, and newswires. The data show full lists of direct and indirect subsidiaries and shareholders, a company's degree of independence, its ultimate owner, and other companies in the same corporate family. We explore the shareholder, ultimate owner, and subsidiary information to identify MNC activities across countries. Second, the financial data in Orbis consist of a rich array of time-series information enabling us to measure and compare firm total factor productivity over time. Third, Orbis provides a broad country coverage, including a wide range of industrial and emerging economies. This enables us to perform analysis of multinational production for a range of heterogeneous countries and investigate how its impact varies across nations.

Our analysis focuses on manufacturing industries and covers over 1 million companies in 60 countries. We use four categories of information for each firm: (i) industry information including the 4-digit NAICS code of the primary industry in which each establishment operates; (ii) ownership information including each firm's domestic and global parents and domestic and foreign subsidiaries; (iii) location information; (iv) financial information including revenue, employment, asset, investment, and export activities. A firm is considered foreign owned if it is majority owned by a foreign multinational firm. There are about 36,000 foreign owned subsidiaries in the final sample.[14]

We use revenue, employment, asset, and material cost information to estimate each firm's total factor productivity, a primary variable of the paper. In particular, we use firms' financial data in the 2002-2007 period to derive estimates of production function and productivity.[15]

[14]The subsidiary data employed in our paper do not distinguish between greenfield foreign investment and mergers and acquisitions. However, it is worth noting that our primary theoretical predictions and empirical approach are not dependent on the mode of multinational entry.

[15]Revenue, asset, and material cost are deflated in the data. We obtained industry-level revenue, asset, and material cost deflators from the EU KLEMS and OECD STAN databases. For countries without

The estimation methodology employed in the paper is the semiparametric estimator developed by Levinsohn and Petrin (2003).[16] Based on this approach, we estimate the production function for each country and each NAICS 4-digit industry and obtain the productivity of each firm based on the country-industry specific production function estimates. In the empirical analysis, we divide the 6-year period to two sub-periods: 2002-2004 and 2005-2007 and investigate how changes in multinational production between the two periods affect host-country domestic firms.[17]

To take a first glance at the data, Figures 4 and 5 plot the correlations between multinational production and average productivity. Countries and industries with greater multinational production are, on average, more productive, but also the productivity growth is positively and significantly correlated with the growth in multinational production. In the next section, we seek to disentangle the roles of firm selection and knowledge spillover in explaining the positive correlation.[18]

4 Empirical Evidence

In this section, we assess the self-selection of multinational firms and the effects of multinational production on domestic firm selection, factor market reallocation, and knowledge spillover taken as guidance the framework described in Section 2.5.

4.1 The Self-Selection of Multinational Firms

We begin our empirical analysis by examining first the entry of foreign multinational firms. To proceed, we estimate the following equation adopted from equation (21):

industry-level deflators, we used national income and capital deflators. See Section 6.1 for discussions on the implications of unobserved price information and the robustness analysis.

[16] We also considered a number of approaches to obtain estimates of TFP, including instrumental variables and semiparametric estimations. Van Biesebroeck (2008) provides a comparison of these methods and finds them to produce similar productivity estimates. Similar to Van Biesebroeck (2008), we did not find significant differences in the estimates of TFP obtained from either the IV or the semiparametric estimations. We report the results based on the semiparametric estimator introduced by Levinsohn and Petrin (2003). In Section 6.1, we further discuss measures of productivity and related issues.

[17] Compared to entry, we observe relatively few exits of multinational firms in the data. We hence focus on the effect of new entry in the empirical analysis.

[18] Table A.2 reports the summary statistics of the data.

$$\begin{aligned}\Pr\left[z_M(\theta)=1|\theta>\theta_D\right] &= \Phi_{\theta>\theta_D}\left[\ln\theta \square \ln\theta_M>0\right] \\ &= \Phi_{\theta>\theta_D}\left[\ln\theta + FE_M \square \frac{1}{\varepsilon \square 1}\ln d>0\right], \end{aligned} \tag{28}$$

where $z_M(\theta)$ represents foreign multinationals' binary decision to enter a given host country in 2005-2007, θ is the ex-ante productivity of multinational firms estimated based on headquarter activities in 2002-2004, FE_M is a vector of host country-industry dummies, and d represents bilateral country factors including distance, common border, and common language between headquarters and host countries.[19] As discussed earlier, the ex-ante headquarter productivity of multinational firms serves as an exclusion condition in the second-stage estimations to identify the causal effect of multinational production.

Table 1 reports the estimation results of equation (28).[20] We find that, as expected in Section 2, more productive firms exhibit a greater likelihood of entering foreign countries, a result consistent with Helpman et al. (2004), Yeaple (2009), and Chen and Moore (2010). Further, the probability of multinational production decreases in the distance between headquarter and host countries, in alignment with the existing empirical literature of multinational production. Multinationals are also more likely to enter host countries that have land borders and common languages with headquarter countries. These findings are robust to the inclusion of host country-industry and headquarter country-industry fixed effects, which control for all country-industry specific factors that could affect multinationals' entry decisions, and the use of firm-level clustering.

Based on the estimates, we then obtain the predicted probability of entry for each multinational firm $\widehat{\Pr}\left[\theta>\theta_M|\theta>\theta_D\right]$, the expected productivity of multinational firms in each host country $\widehat{\widetilde{\theta}}_M$, and the expected probability of new multinational production in each host country $\widehat{\ }_M$, the latter two of which are used in the following analysis.

Now we move on to evaluate the effect of multinational production on host-country domestic firms taking into account the self-selection of multinational firms.[21] Before examining the empirical framework described in Section 2.5, we first follow most of the existing literature and estimate the net effect of multinational production on the average productivity of

[19] See Yeaple (2009) and Chen and Moore (2010) for related empirical analysis.

[20] A linear probability model is used to avoid the incidental parameter problem that arises in fixed-effect maximum likelihood estimators.

[21] Given the MNC entry measure is obtained from a first-stage estimation, we bootstrap the standard errors in all the following estimations.

domestic firms. Table 2 shows that multinational production exerts, on average, a positive and significant effect on the average productivity of domestic firms, taking into account the endogeneity of multinational entry.

There are, however, two important considerations regarding selection, reallocation and spillover behind these estimates. First, comparing the OLS and the instrumented results, we find that failure to account for the self-selection of multinational firms can lead to an over-estimation of the effect of multinational production. According to column (2), a 100-percent increase in the probability of new multinational entry is associated with 2 percent increase in domestic productivity. Second, traditionally, the positive effect on domestic productivity has been interpreted as the effect of positive knowledge spillover from multinational to domestic firms. But as our theoretical framework shows, increases in domestic productivity can also arise from firm selection. Looking at the relationship between multinational production and average domestic productivity alone does not allow us to distinguish the sources of productivity gains. Productivity gains could be attributed to knowledge spillover, firm selection, or both. We next use the empirical framework in Section 2.5 to guide the identification of the relative importance of these sources.

4.2 The Selection of Domestic Firms

We start with the selection of domestic firms. We first examine the survival of individual domestic firms by estimating

$$\Pr\left[z_D(\theta)=1\right]=\Phi\left[\beta_0+\beta_1\ln\theta_A+\beta_Z z_M\right], \tag{29}$$

where $z_D(\theta)$ represents whether the domestic firm continues production in 2005-2007, θ_A is the lagged productivity of the domestic firm, and z_M is an indicator for new multinational entry. Because only the lagged productivity is observable for exiting firms, based on Section 2.5, $\beta_Z \equiv \ln\tau_\theta \,\square\, \left(\frac{1}{\varepsilon\square 1}\ln\frac{c}{c_A}+\ln\frac{P_A}{P}\right)$ represents the cumulative effect of new multinational entry on the survival probability of domestic firms, including the positive knowledge spillover effect and the effects of capital and aggregate prices. In addition, we include vectors of country and industry dummies to control for country and industry factors and country-industry clustering to allow for correlations within each cluster. To account for the endogeneity of z_M, we substitute $\widehat{\ }_M$ obtained from equation (28) into the above equation.

Table 3 reports the results. We find that a greater probability of new multinational

production exerts a negative and significant effect on the survival probability of domestic firms. Domestic firms are more likely to exit the market in the presence of new multinational entry. This result, robust to the control of firm characteristics including productivity and size, suggests that $\frac{1}{\varepsilon \square 1} \ln \frac{c}{c_A} + \ln \frac{P_A}{P} > \ln \tau_\theta$, i.e., the selection effect dominates the effect of knowledge spillovers. Based on the estimates, we obtain the predicted probability of survival for each domestic firm $\widehat{\Pr}\left[\theta > \theta_D\right]$, the expected productivity of surviving domestic firms in each host country $\widehat{\widehat{\theta}}_D$, and the expected survival rate $\widehat{\ }_D$.

Alternatively, we estimate directly the cutoff productivity of domestic firms following equation (24) in Section 2.5:

$$\ln \theta_D \square \ln \theta_A = \beta_D z_M. \tag{30}$$

Column (1) of Table 4 suggests that a higher probability of multinational entry leads to a significant increase in the cutoff productivity of domestic firms. In particular, we find $\beta_D \equiv \frac{1}{\varepsilon \square 1} \ln \frac{c}{c_A} + \ln \frac{P_A}{P} = 0.16$, implying a 100-percent increase in the probability of new multinational firms is associated with 16 percent increase in the cutoff productivity. Domestic firms whose productivity falls between the ex-ante and the new, higher productivity thresholds would be forced to exit the markets.[22]

4.3 Labor Market Reallocation

To evaluate the labor market reallocation effect of multinational production, we assess changes in the revenue distribution of domestic firms, based on equation (25), by tracking firms located in different percentiles of the ex-ante revenue distribution:

$$\ln r_D(q_A) \square \ln r_A(q_A) = (\varepsilon \square 1)\left(\beta_P + \beta_\theta\right) z_M, \tag{31}$$

where $\beta_P \equiv \ln\left(P/P_A\right)$ is expected to be negative and $\beta_\theta \equiv \ln \tau_\theta$ is expected to be positive. Given the estimate of β_θ from equation (33) below, we can obtain an estimate of β_P and subsequently P/P_A.

The lower panel of Table 5 suggests that a higher likelihood of multinational entry leads to a significant decrease in the level of revenue for firms at both the 25th and 50th percentiles.[23]

[22] To avoid potential noises in productivity estimates and hence the level of cutoff productivity, we also used alternative measures of cutoffs such as the bottom 5th percentile and the mean of the bottom 5 percentiles. The results are similar.

[23] Instead of individual percentiles, we also considered percentile ranges, such as 20-30 percentiles, 45-55 percentiles and so on, for both revenue and productivity distributions and found results to be robust.

The magnitude of decline is, however, smaller at the 50th percentile, suggesting that the relatively smaller domestic firms see a bigger contraction in their revenue.[24]

4.4 Capital Market Reallocation

Next, we estimate the effect of foreign multinational entry on domestic capital markets by examining the following equation adopted from equation (26) in Section 2.5:

$$\ln r_D(\theta_D) \square \ln r_D(\theta_A) = \beta_c z_M \tag{32}$$

where $\ln r_D(\theta_D) \square \ln r_D(\theta_A)$ is the change in the cutoff revenue of domestic firms and $\beta_c \equiv \ln(c/c_A)$, expected to be positive, captures the effect of foreign multinational production on capital price. Again, to address the self-selection of foreign multinationals, z_M is instrumented by $\widehat{\ }_M$ from equation (28).

As shown in column (2) of Table 4, we find a higher probability of multinational entry to lead to a significant increase in the cutoff revenue of domestic firms. In particular, $\beta_c \equiv \ln(c/c_A) = 0.06$, which implies that a 100-percent increase in the likelihood of new multinational firms is associated with 6 percent increase in the unit capital price. Given $\beta_c \equiv \ln(c/c_A) = 0.06$ and $\beta_D \equiv \frac{1}{\varepsilon \square 1} \ln \frac{c}{c_A} + \ln \frac{P_A}{P} = 0.16$ and assuming, for example, $\varepsilon = 2$, we obtain $\ln \frac{P_A}{P} = 0.1$ and $\frac{P}{P_A} = 0.9$, that is, 10 percent decrease in the aggregate price.[25]

4.5 Knowledge Spillover

Finally, we assess the extent of knowledge spillover by examining the productivity distribution of domestic firms following equation (27):

$$\ln \theta(q_A) \square \ln \theta_a(q_A) = \beta_0 + \beta_\theta z_M, \tag{33}$$

where $\beta_\theta \equiv \ln \tau_\theta$ captures the magnitude of knowledge spillovers and z_M is instrumented by $\widehat{\ }_M$ from equation (28).

[24] While the monopolistic competition model adopted in the paper abstracts from selections through product market competition (due to the CES specification), the latter is captured in our empirical analysis, specifically by the estimated effect of multinational entry on the revenue distribution of domestic firms. In Section 6.1, we further discuss the implications of variable markups and the robustness of our results.

[25] Here we adopt the median value of the demand elasticities reported for SITC 3-digit industries in Broda and Weinstein (2006).

The upper panel of Table 5 reports the results. The estimates suggest that a higher probability of new multinational firms leads to an increase in the productivity of domestic firms at both the 25th and 50th percentiles with $\beta_\theta = 0.03$ and 0.04, respectively. This implies $\tau_\theta = 1.03 \sim 1.04$, that is, 3-4 percent upward shift of the productivity in the lower range of the distribution. The productivity in the upper range is not found to be significantly affected.[26] Table 6 provides a summary of the estimated effects.

A possible concern here is that the shift in the productivity distribution might be driven by other factors such as increased export activity of domestic firms which leads to learning by exporting. Note, however, in that case increased export activity would imply not only a rightward shift of the productivity distribution but also a rightward shift of the revenue distribution. The latter is contrary to the evidence in our empirical analysis. Nevertheless, we adopted two strategies to address the concern. First, we accounted for the endogeneity of multinational entry in the first stage by instrumenting with multinationals' ex-ante headquarter productivity. Second, we explicitly controlled for export and import growth in host-country industries and found the results to remain largely similar.[27]

5 Quantifying Gains from Multinational Production

In this section, we perform counterfactual analysis and quantify the welfare and productivity gains from greater openness to multinational production.

5.1 Aggregate Productivity and Welfare Gains

First, we evaluate the aggregate welfare effect, ΔW. Given equation (10), we compute

$$\Delta W = \frac{N^{\frac{1}{\varepsilon \square 1}} \widetilde{\theta}}{N_A^{\frac{1}{\varepsilon \square 1}} \widetilde{\theta}_A} \square 1, \tag{34}$$

where N is the expected number of firms (and product varieties) following the entry of multinational firms and N_A is the total number of firms (and product varieties) prior to the

[26] The evidence on the effect of multinational production across heterogeneous firms is mixed. Aitken and Harrison (1999) find negative effects on firms less than 50 workers in Venezuela. Girma and Wakelin (2001) find positive effects on small- and medium-sized domestic firms and conclude that large and highly-skilled domestic firms may not benefit from foreign presence, as the latter firms, being nearest to foreign multinationals in terms of technology and market share, may already operate at the technological frontier.

[27] The results are suppressed in the paper and available upon request.

entry. Given $N = (1 + \ _M)N_D$, the above equation can be written as:

$$\Delta W = [(1 + \ _M) \ _D]^{\frac{1}{\varepsilon \square 1}} \frac{\widetilde{\theta}}{\widetilde{\theta}_A} \square 1. \tag{35}$$

where $\widehat{\ }_M$ and $\widehat{\ }_D$ can be used to proxy for $\ _M$ and $\ _D$, respectively.

The productivity effect, represented by $\widetilde{\theta}/\widetilde{\theta}_A$, can be computed as follows:

$$\Delta\widetilde{\theta} \equiv \frac{\widetilde{\theta}}{\widetilde{\theta}_A} \square 1 = \frac{\left\{\frac{1}{N}\left[N_D\widetilde{\theta}_D^{\varepsilon \square 1} + N_M\widetilde{\theta}_M^{\varepsilon \square 1}\right]\right\}^{\frac{1}{\varepsilon \square 1}}}{\widetilde{\theta}_A} \square 1, \tag{36}$$

where $\widetilde{\theta}$ is the expected aggregate productivity given the entry of multinational firms and $\widetilde{\theta}_A$ is the aggregate productivity prior to the entry. Given $N_M = \ _M N_D$ and $N = (1 + \ _M)N_D$, the above equation can be written as:

$$\Delta\widetilde{\theta} = \left\{\frac{\frac{1}{1+\ _M}\left[\widetilde{\theta}_D^{\varepsilon \square 1} + \ _M\widetilde{\theta}_M^{\varepsilon \square 1}\right]}{\widetilde{\theta}_A^{\varepsilon \square 1}}\right\}^{\frac{1}{\varepsilon \square 1}} \square 1. \tag{37}$$

where $\widehat{\widetilde{\theta}}_D/\widehat{\widetilde{\theta}}_A$, $\widehat{\widetilde{\theta}}_M/\widehat{\widetilde{\theta}}_A$, and $\widehat{\ }_M$ can be used to proxy for $\widetilde{\theta}_D/\ \widetilde{\theta}_A$, $\widetilde{\theta}_M/\ \widetilde{\theta}_A$, and $\ _M$, respectively.

When the foreign investment fixed cost is sufficiently low, the decrease in the number of domestic firms due to greater openness to multinational production will be dominated by the increase in the number of foreign firms, leading to an increase in total product variety.[28] This effect, together with increased aggregate productivity, contributes positively to welfare. Based on the estimates reported in Table 6, we find the aggregate productivity $\widetilde{\theta}$ to increase by 1.4 percent and the total product variety N to increase by 8 percent when the probability of entry by new multinational firms increases by 100 percent (Table 7). The two effects jointly lead to a 9.5 percent increase in aggregate welfare W.

5.2 Decomposing the Productivity Gain

As shown in Section 2, the productivity gain from multinational production arises from three sources: (1) the greater productivity of entering multinational firms (self-selection of multinational firms); (2) the higher average ex-ante productivity of surviving domestic firms

[28] It is possible when the foreign investment fixed cost is sufficiently high that foreign firms replace a larger number of domestic firms, leading to a decrease in total product variety and welfare. For other analysis of possible negative gains, see Rodríguez-Clare (1996) and Markusen and Venables (1999).

(selection of domestic firms); (3) knowledge spillover. To investigate their relative importance, we decompose the aggregate productivity gain next by considering one channel at a time.

The Self-Selection of Multinational Firms First, we estimate the direct productivity gain associated with the self-selection of multinational firms, i.e.,

$$\Delta\widetilde{\theta}_M = \frac{\widetilde{\theta}_M}{\widetilde{\theta}_A} \square 1. \tag{38}$$

The results suggest $\Delta\widetilde{\theta}_M = 0.049$, that is, entering multinationals are, on average, 4.9 percent more productive than domestic incumbents. Given the weight of multinational firms in the aggregate economy, i.e., 14 percent ($= \ _M/(1+\ _M)$), this productivity advantage leads to 0.68 percent increase in aggregate productivity.[29]

The Productivity Gain of Domestic Firms Next, we evaluate the productivity gain of domestic firms as a result of knowledge spillover and tougher selection captured by:

$$\Delta\widetilde{\theta}_D = \frac{\widetilde{\theta}_D}{\widetilde{\theta}_A} \square 1. \tag{39}$$

The results suggest that aggregate domestic productivity increases by 0.87 percent when the probability of multinational entry rises by 100 percent. Given the weight of domestic firms in the aggregate economy, i.e., 86 percent ($= 1/(1+\ _M)$), this is equivalent to 0.75 percent increase in aggregate productivity.

Next we further decompose the productivity gains of domestic firms to two parts: gains from knowledge spillover and gains from firm selection and market reallocation.

The Productivity Gain of Domestic Firms: Knowledge Spillover The productivity gain as a result of knowledge spillover can be estimated by assuming away the effects of domestic selection and market reallocation, i.e., by setting $\beta_P, \beta_c = 0$:

$$\Delta\widetilde{\theta}_D\Big|_{\beta_P,\beta_c=0} = \frac{\widetilde{\theta}_D}{\widetilde{\theta}_A}\Bigg|_{\beta_P,\beta_c=0} \square 1. \tag{40}$$

[29] Note that this estimate is derived by using multinationals' ex-ante headquarter productivity as a proxy for their subsidiary productivity to avoid endogeneity concerns. In our data, we find the two are highly correlated, suggesting the former serves as a reasonable proxy for evaluating the productivity advantage of multinational subsidiaries. An alternative interpretation for this source of productivity gain is the productivity upgrading of acquired plants after the acquisition by multinational firms. As shown in Arnold and Javorcik (2009) and Guadalupe et al. (2011), multinational firms tend to acquire the most productive domestic firms, which then, after acquisition, adopt foreign technologies and achieve higher productivity.

We find that knowledge spillovers alone lead to about 0.6 percent increase in domestic productivity (or equivalently 69 percent of the domestic productivity gain).

The Productivity Gain of Domestic Firms: Firm Selection The productivity gain as a result of the tougher selection of domestic firms and market reallocation (while assuming zero knowledge spillovers) is given by:

$$\Delta\widetilde{\theta}_D\Big|_{\beta_\theta=0} = \frac{\widetilde{\theta}_D}{\widetilde{\theta}_A}\Big|_{\beta_\theta=0} \square\, 1. \tag{41}$$

The estimates imply a 0.3 percent increase in domestic firm productivity (or equivalently 31 percent of the total domestic productivity gain) when domestic selection and market reallocation are the only operative channel. This result suggests that it is important to take into account the role of selection and market reallocation in determining the productivity gains from multinational production. Ignoring this source and attributing all the domestic productivity gains to knowledge spillover can over-estimate its importance by 50 percent, leading to significant bias in understanding the nature of gains from multinational production.

5.3 Country Heterogeneity of Productivity and Welfare Gains

In this sub-section, we explore how the estimated welfare and productivity gains may vary across countries. We find that country level results display important differences and wide variances, as documented in previous studies focusing on different countries. For example, countries such as Lithuania, Norway and France are shown to achieve the highest estimated productivity gains from increases in multinational production. Other countries with top productivity gains include Argentina, Bulgaria, Sweden, Hong Kong, Finland and Spain. Lithuania is also estimated to register the greatest domestic productivity gains (22.3 percent). This is similarly true for Norway, Bulgaria, and Finland, with the majority due to knowledge spillover. The distribution of productivity gains is different for France and Hong Kong. The productivity premium of multinational firms accounts for an important share in the aggregate productivity gain. The domestic productivity gain is about 0.78 percent in France, with knowledge spillover and market reallocation each accounting for about half.

Next we examine whether there exist systematic differences across rich and poor nations by dividing the sample to two groups: developed and developing countries. We re-estimate the empirical model and quantify the aggregate as well as the decomposed gains for the two

groups, respectively. The results are summarized in the last two columns of Tables 6 and 7.

We show in Table 6 that multinational entry leads to a significant increase in cutoff productivity and cutoff revenue in developed countries, suggesting tougher domestic market selection and reallocation. The increased multinational production raises the threshold productivity for domestic firms to survive. This is channeled through both the capital market, as implied by the increase in cutoff revenue (a proxy of capital cost), and the labor market, as indicated by the decrease in revenue for both 25th and 50th percentile domestic firms. The results also show the existence of knowledge spillover limited to low-productivity domestic firms. Domestic firms with medium or high productivity do not see a rightward shift. The results are drastically different in developing nations. Multinational entry does not increase the cutoff productivity nor the cutoff revenue. Only the medium-size domestic firms see a decrease in revenue. In contrast, there is greater evidence of knowledge spillover. The domestic productivity distribution's left and middle ranges shift significantly rightward.

When computing welfare and productivity gains based on these estimates, we find a 100-percent increase in the probability of new multinational entry leads to 9.92 percent aggregate welfare gain in developed nations. This consists of 1.22 percent aggregate productivity gain and 8.6 percent gain in product variety. Focusing on productivity gains, we find domestic productivity increases by 0.55 percent in developed countries and multinationals that enter developed countries exhibit 7.29 percent greater productivity than domestic competitors. Further, of the 0.55 percent domestic productivity gain, knowledge spillover and market reallocation account for 0.20 and 0.35 percentage points, respectively, suggesting that firm selection and market reallocation play a more important role in determining the productivity gains from multinational production. In comparison to developed nations, the estimated welfare gains are smaller, estimated around 8.85 percent, in developing countries. This is mainly due to a smaller gain in product variety. The magnitudes of aggregate and domestic productivity gains are greater in developing countries. In sharp contrast to the developed countries, the vast majority of the domestic productivity gain is associated with knowledge spillover with market reallocation playing little role.

6 Discussion and Robustness Analysis

6.1 Measures of Productivity

As in most empirical work that exploits productivity estimates, we do not observe firm-level physical output quantities and prices. This information is especially difficult to obtain for the large cross section of countries considered in this paper. Thus, we estimate firm productivity based on the output value (instead of physical output) produced by each firm given its inputs.[30]

It is important to note that the broader point we highlight, that ignoring the role of firm selection and market reallocation can lead to significant biases in understanding the gains from multinational production, does not depend on the availability of physical output data or productivity estimation methodologies. The traditional approach that attributes increases in average domestic productivity to knowledge spillover would overstate the role of spillover even when physical output or true productivity were observed.

Further, although using output value to estimate productivity may affect the magnitude of productivity estimates, it will not bias our primary estimates in the survival, cutoff revenue, and revenue distribution equations, i.e., $\beta_Z \equiv \beta_\theta \left(\frac{1}{\varepsilon - 1}\beta_c + \beta_P \right)$, $(\varepsilon - 1)(\beta_P + \beta_\theta)$, and β_c in equations (29), (31) and (32), respectively. Previously, we estimated the degree of knowledge spillover, $\beta_\theta \equiv \ln \tau_\theta$, directly from the shift of the productivity distribution, i.e., equation (33). Alternatively, we can identify β_θ by exploring the three moments given by equations (29), (31) and (32). Based on this identification strategy, we find $\beta_\theta \equiv \ln \tau_\theta \approx 0.1$ and $\tau_\theta \approx 1.01$ (given $\varepsilon = 2$), i.e., on average 1 percent increase in the productivity of domestic firms. This is in alignment with the previous result in Section 4.4 in which we show a 3-4 percent upward shift of the productivity in the lower range of the productivity distribution and insignificant effect in the upper range.

Next we discuss further the empirical implications when productivity is systematically correlated with firm prices and markups. Melitz and Ottaviano (2008) show that in a variable-markup setup increased competition should induce a downward shift in the distribution of markups across firms (even in the absence of labor reallocation). They find that although only

[30] Note that even if price or physical output information were observed, the relationship between prices and markups would still be unclear. Higher prices can reflect higher quality, instead of higher markups. De Loecker (2011) introduces a methodology that uses detailed product level information to recover the markups and the output based productivity of firms. However, this approach requires specific assumptions regarding the mechanisms through which demand shocks affect prices and productivity.

relatively more productive firms survive (with higher markups than the less productive firms that exit), the distributions of markups and prices of surviving firms should shift downward. This prediction suggests that the estimates of knowledge spillover in our paper, derived based on the shift of the productivity distribution, would be biased downward if the distribution of productivity partly reflects the distribution of markups.

Given the difficulty in obtaining the data required for output-based productivity, one of the solutions suggested by the literature is to focus on homogeneous goods. Thus, as an additional robustness check, we re-estimate equation (33) for industries with relatively homogeneous products. In such industries, the concern that revenue-based productivity is systematically correlated with prices or markups is mitigated. The shift of the productivity distribution is more likely to reflect changes in productivity. To proxy for the degree of product differentiation, we use information on country-industry specific import demand elasticities estimated by Broda, Greenfield and Weinstein (2006) who show industries with more homogeneous products are characterized by higher import demand elasticities. We re-estimate equation (33) for country-industry pairs whose elasticity is above the 75th percentile in each country. We find the results to remain qualitatively similar. The productivity distribution of domestic firms shifts rightward by about 3 percent at both the 25th and the 50th percentiles while seeing no significant changes at the 75th percentile. Moreover, we also find the productivity distribution becomes more left truncated, indicated by an increase in the cutoff productivity in equation (30), suggesting tougher selection in the domestic market.

6.2 Between-Industry Reallocations and Spillovers

Our main analysis has focused on quantifying within-industry gains from multinational production. In this sub-section, we explore how multinational production can lead to gains through between-industry factor reallocations and knowledge spillovers (vertical linkages).

We first consider how increased multinational production in one industry may cause increased demand for labor and capital and subsequently factor reallocations in other, related industries. This between-industry factor reallocation effect could influence the production costs of domestic firms in other industries, especially in industries that employ similar types of labor and capital goods.

To capture this potential factor market externality between industries, we construct two measures. First, we construct a measure of industry pair's similarity in occupational labor requirements, $Labor\ similarity_{ij}$. Industries with greater similarity in occupational labor

structure are expected to share greater externality in labor markets. We use the Bureau of Labor Statistics' 2006 National Industry-Occupation Employment Matrix (NIOEM) which reports industry-level employment across detailed occupations (e.g., Assemblers and Fabricators, Textile, Apparel, and Furnishings Workers, Business Operations Specialists, Financial Specialists, Computer Support Specialists, and Electrical and Electronics Engineers). As in Ellison et al. (2009), we convert occupational employment counts into occupational percentages for each industry and measure each industry pair i and j's correlation in occupational percentages. Second, we attempt to evaluate capital market externality by constructing a measure of industries' similarity in capital-good demand, $Capital\ similarity_{ij}$. This variable uses capital flow data from the Bureau of Economic Analysis (BEA), a supplement to the 1997 benchmark input-output (I-O) accounts, which shows detailed purchases of capital goods (e.g., motors and generators, textile machinery, mining machinery and equipment, wood containers and pallets, computer storage devices, wireless communications equipment) by using industry. We measure each using-industry pair i and j's similarity in capital-good demand by the correlation of investment flow vectors.

Constructing the industry relatedness measures using the U.S. industry account data is motivated by two considerations. First, the measures reflect standardized production technologies and are relatively stable over time. Second, the measures require detailed factor demand information and the U.S. industry account data are more disaggregated than most other countries.

We interact the two measures of industry relatedness with predicted multinational production in each industry j and compute the weighted sum of multinational production in industries that share similar labor and capital good demand. The results are reported in Table 8. We find that increased multinational production in industries with similar labor demand can lead to an increase in the domestic cutoff productivity. This suggests that an increase in labor demand can lead to labor reallocations between related industries, resulting in tougher domestic market selections. The analysis also shows evidence of capital reallocations between industries. As shown in column (4), increased multinational production in an industry will lead to an increase in cutoff revenue, a function of capital costs, in industries that share similar capital-good demand. The above findings suggest that the selection and market reallocation effect of multinational production can also occur between industries, further stressing the importance of this channel in determining the productivity gains from multinational production.

Next, we explore the possibility of knowledge spillovers across industries, through vertical production linkages. Considering spillovers via horizontal or vertical channels does not invalidate the main point that it is important to take into account the role of firm selection and reallocation when analyzing the gains of MNC. However, as mentioned in the introduction, there is important evidence on the role of spillovers from foreign firms to domestic firms through vertical production linkages. Thus to complement our analysis, we explore this effect and examine how multinational production in a given industry can affect the productivity distribution of domestic firms in related industries. Following Javorcik (2004), we construct two variables, $Backward\ linkage_{ij}$ and $Forward\ linkage_{ij}$, to measure the extent of the input-output relationships between each pair of industries. $Backward\ linkage_{ij}$ measures the share of a downstream industry j's inputs that come from an upstream industry i and $Forward\ linkage_{ij}$ the share of a downstream industry i's inputs that come from an upstream industry j. The shares are computed using the 2002 Benchmark Input-Output Accounts published by the Bureau of Economic Analysis. We interact the above variables with predicted multinational production in each industry j and compute the weighted sum of multinational production in downstream and upstream industries, respectively. Our results suggest significant knowledge spillovers via backward linkages, from downstream foreign multinational firms to upstream domestic firms, at the 25th percentile (Table 9). Overall, our findings are consistent with Javorcik (2004) who shows the existence of positive spillovers through backward linkages and negative spillovers through forward linkages.

Now we re-compute the welfare and productivity gains taking into account the between-industry factor reallocations and knowledge spillovers. As shown in Table 10, we find the aggregate welfare W and the aggregate productivity $\widetilde{\theta}$ to increase by 9.6 and 1.5 percent, respectively, when the probability of entry by new multinational firms increases by 100 percent. The domestic productivity $\widetilde{\theta}_D$ increases by 1.02 percent, compared to 0.87 percent previously, when the effects of factor reallocations and knowledge spillovers between industries are taken into consideration. Most of the additional productivity gain arises from between-industry factor reallocation, which now, together with within-industry factor reallocation, leads to 0.4 percent increase in domestic productivity. This further highlights the importance of accounting for firm selection and factor market reallocation in assessing the gains from multinational production even when considering alternative spillover channels.

7 Conclusion

Identifying gains from openness to multinational production has been a fundamental topic of economic research. A primary challenge in empirical investigations is to distinguish the sources of productivity gains, including gains from knowledge spillover and firm selection. In this paper, we disentangle the roles of knowledge spillover and firm selection in determining the aggregate impact of multinational production and quantify their relative importance.

We develop a standard model of monopolistic competition and heterogeneous firms to address simultaneously the selections of domestic and multinational firms and the knowledge spillover from multinational to domestic production. Our theoretical framework suggests that while both firm selection and knowledge spillover predict a positive relationship between openness to multinational production and aggregate productivity, the effects can be distinguished by exploring their distinct predictions for the productivity and revenue distributions of domestic firms. Knowledge spillover induces a rightward shift of the productivity distribution; firm selection, in contrast, causes a weaker, or even leftward, shift of the revenue distribution and an increase in the cutoff productivity and revenue.

These predictions are evaluated using a rich cross-country firm panel dataset that contains comprehensive financial, operation, and ownership information for over 1 million public and private manufacturing companies in 2002-2007. Our empirical evidence suggests that multinational production leads to not only knowledge spillover but also tougher firm selection and factor reallocation in domestic markets. Entry of multinational firms raises the cutoff productivity of domestic firms, pushing the least productive domestic firms to exit the markets. New multinational production also leads to an increase in the minimum revenue of continuing domestic firms, indicating an increase in fixed production cost and capital price. Further, the estimates show a significant decrease in the aggregate price, suggesting increased competition and market reallocation. Following the entry of multinational firms, the revenue distribution of domestic firms shifts leftward, at both the 25th and 50th percentiles. In contrast, the productivity distribution of domestic firms shifts rightward, while the distribution becomes more left truncated due to selection.

When quantifying the gains from multinational production, we find the aggregate welfare and productivity to increase, respectively, by 9.5 and 1.4 percent across countries, when the probability of entry by new multinational firms increases by 100 percent. The productivity of domestic firms increases by 0.9 percent, with knowledge spillover and domestic selection accounting for 69 and 31 percent, respectively. Further, the relative importance of each source

exhibits significant country heterogeneity. In particular, we find the gains to be driven by knowledge spillover in developing nations but by firm selection and market reallocation in developed countries. These results suggest that it is important to take into account the role of firm selection and market reallocation in assessing the gains from multinational production. Ignoring these alternative sources of gains can lead to an over-estimation of the importance of knowledge spillover with consequent biases in the design of policy aiming at increasing productivity gains and welfare.

A potential extension of our analysis worthy of particular attention is to further explore the heterogeneous gains from multinational production found across countries. For example, how domestic labor-market rigidities and firm credit constraints may affect the extent of factor market reallocation and subsequent productivity and welfare effects of multinational production? And how the different levels of domestic human capital and technology stock across host countries could influence the degree of gains from knowledge spillover? Such analysis on the role of economic and institutional characteristics in determining countries' gains from multinational production will provide additional research and policy insights.

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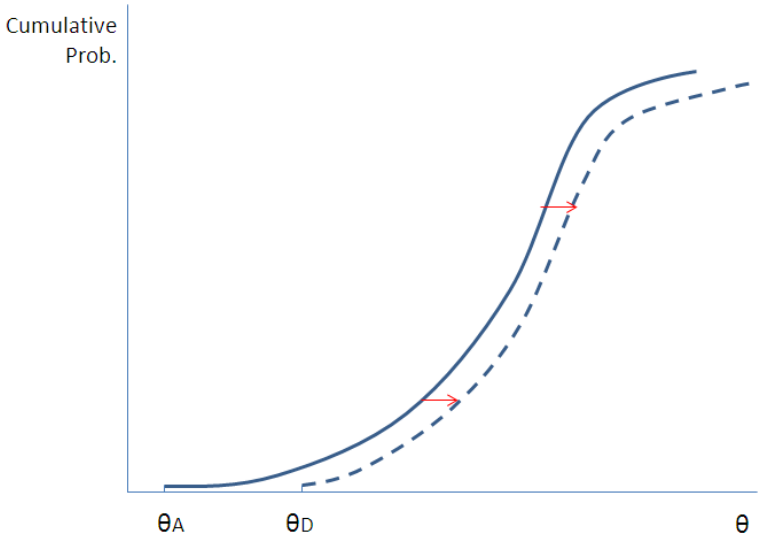

Figure 1: The productivity distribution before and after multinational entry

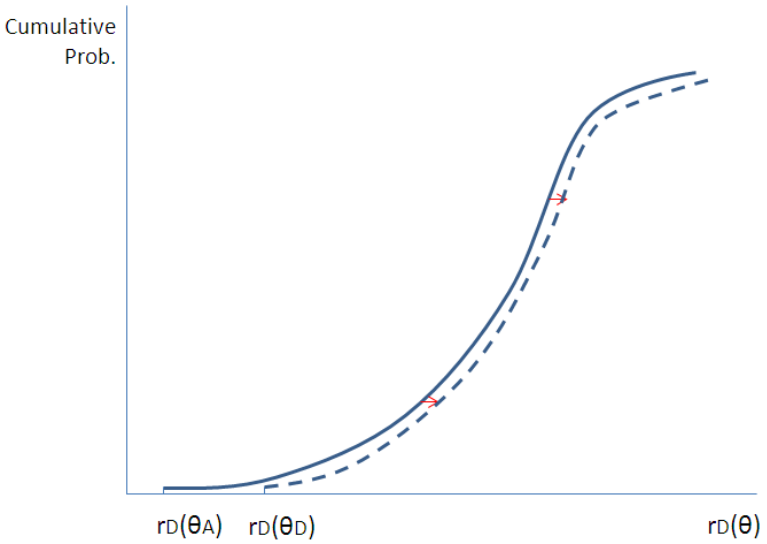

Figure 2: The revenue distribution before and after multinational entry (case I)

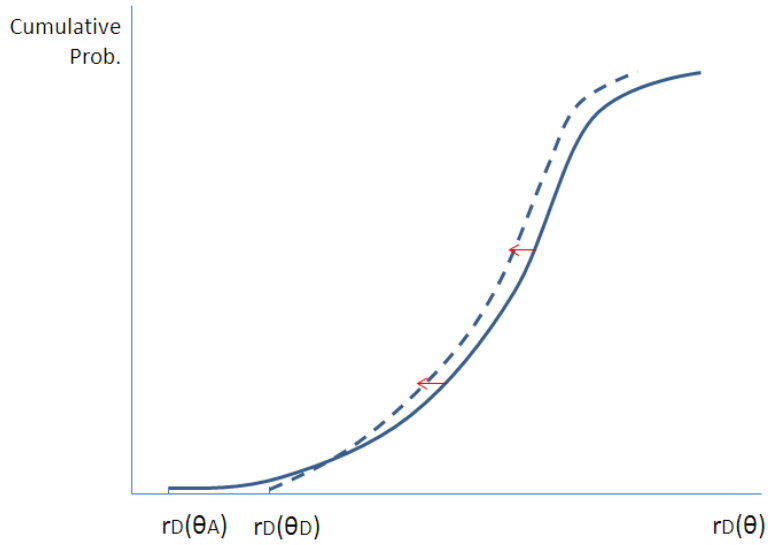

Figure 3: The revenue distribution before and after multinational entry (case II)

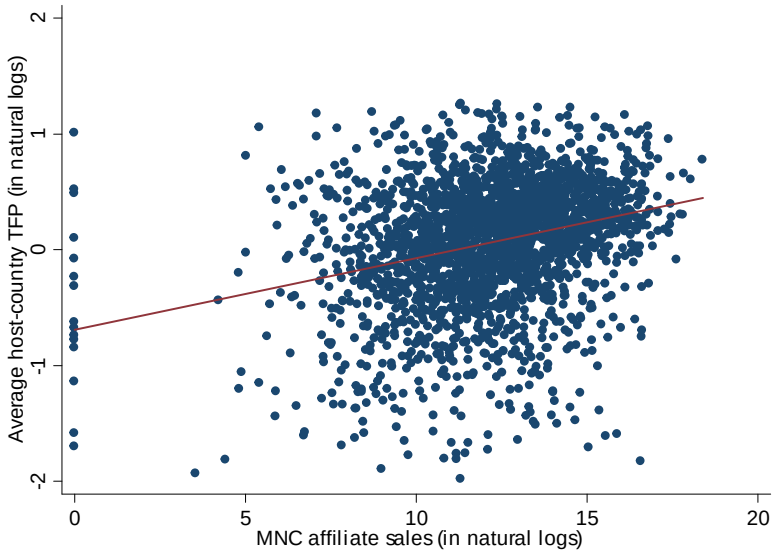

Figure 4: The correlation between multinational production and average productivity

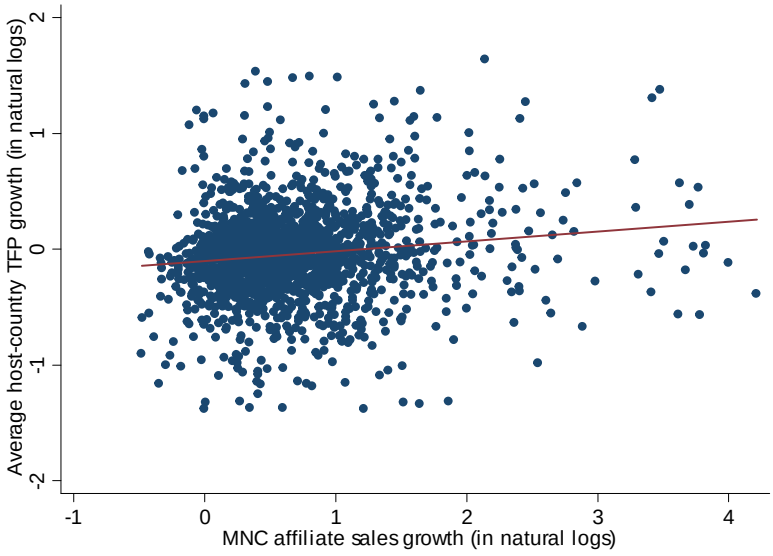

Figure 5: The correlation between increase in multinational production and average productivity growth

Table 1: The Self-Selection of Multinational Firms

Dependent var.: MNC entry	(1)	(2)
HQ TFP	0.004***	0.004***
	(0.001)	(0.001)
Distance	-0.003***	-0.007***
	(0.001)	(0.001)
Contiguity	0.06***	0.06***
	(0.004)	(0.007)
Language	0.03***	0.03***
	(0.003)	(0.004)
Host country-ind FE	Yes	Yes
HQ country-ind FE	No	Yes
Firm cluster	Yes	Yes
Obs	907,776	907,776
R square	0.08	0.08

Notes: (i) Linear probability (LP) estimates are reported; (ii) Standard errors clustered at the firm level are reported in the parentheses; (iii) ***, **, and * represent statistical significance at 1, 5, and 10 percent, respectively.

Table 2: Multinational Production and Average Productivity

Dependent var.: Change in —	(1) Average TFP	(2) Average TFP
MNC entry	0.14*	
	(0.08)	
MNC entry (predicted)		0.02**
		(0.01)
Host country FE	Yes	Yes
Industry FE	Yes	Yes
Obs	2,819	2,819
R square	0.39	0.43

Notes: (i) Columns (1) and (2) report country- and country-industry level OLS estimates, respectively; (ii) Bootstrapped standard errors are reported in the parentheses; (iii) ***, **, and * represent statistical significance at 1, 5, and 10 percent, respectively.

Table 3: The Selection of Domestic Firms

Dependent var.: Domestic firm survival	(1)	(2)
MNC entry (predicted)	-0.001***	-0.001***
	(0.000)	(0.000)
TFP (lagged)		0.002***
		(0.000)
Employment (lagged)		0.005***
		(0.000)
Host Country FE	Yes	Yes
Industry FE	Yes	Yes
Country-Industry cluster	Yes	Yes
Obs	548,249	548,249
R square	0.15	0.18

Notes: (i) Linear probability estimates are reported; (ii) Standard errors clustered at the country-industry level are reported in the parentheses; (iii) Bootstrapped standard errors are reported in the parentheses; (iv) ***, **, and * represent statistical significance at 1, 5, and 10 percent, respectively.

Table 4: Selection and Market Reallocation

Dependent var.: Change in —	(1) Cutoff TFP	(2) Cutoff revenue
MNC entry (predicted)	0.16*	0.06***
	(0.09)	(0.03)
Host country FE	Yes	Yes
Industry FE	Yes	Yes
Obs	2,819	3,408
R square	0.38	0.43

Notes: (i) Weighted least squre estimates are reported; (ii) Bootstrapped standard errors are reported in the parentheses; (iii) ***, **, and * represent statistical significance at 1, 5, and 10 percent, respectively.

Table 5: The Productivity and Revenue Distributions of Domestic Firms

	(1) 25th Percentile	(2) 50th Percentile	(3) 75th Percentile
Panel A: TFP of different percentiles			
MNC entry (predicted)	0.03*	0.04***	-0.00
	(0.02)	(0.01)	(0.01)
Host country FE	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes
Obs	2,313	2,313	2,313
R square	0.14	0.15	0.13
Panel B: Revenue of different percentiles			
MNC entry (predicted)	-0.05***	-0.03*	-0.002
	(0.01)	(0.02)	(0.02)
Host country FE	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes
Obs	3,773	3,773	3,773
R square	0.19	0.17	0.12

Notes: (i) The percentiles are taken from the distributions in 2002-2004; (ii) Bootstrapped standard errors are reported in the parentheses; (iii) ***, **, and * represent statistical significance at 1, 5, and 10 percent, respectively.

Table 6: Estimated Effects of Multinational Production

Parameters	Estimates		
	All	Developed	Developing
Cutoff productivity	0.16	0.35	0.00
Cutoff revenue/Financing cost	0.06	0.09	0.00
Aggregate real price	-0.10	-0.26	0.00
Revenue – 25th perc.	-0.05	-0.04	0.00
Revenue – 50th perc.	-0.03	-0.02	-0.04
Revenue – 75th perc.	0.00	0.00	0.00
Knowledge spillovers – 25th perc.	0.03	0.02	0.05
Knowledge spillovers – 50th perc.	0.04	0.00	0.11
Knowledge spillovers – 75th perc.	0.00	0.00	0.00

Notes: (i) The table reports the estimated effect of multinational production on variables listed in the first column, for all, developed and developing nations, respectively.

Table 7: Estimated Productivity and Welfare Gains

	Estimates (in percentage)		
	All	Developed	Developing
Welfare Gains	9.51	9.92	8.85
TFP Gains	1.40	1.22	2.11
TFP Gains (Decomposed)			
Multinational Firms	4.90	7.29	1.31
Domestic Firms	0.87	0.55	2.25
— Spillover	0.60	0.20	2.20
— Selection/Reallocation	0.27	0.35	0.05

Notes: (i) The table reports estimated productivity and welfare gains for all, developed and developing nations, respectively, when the probability of multinational entry increases by 100 percent.

Table 8: Within- and Between-Industry Reallocations

Dependent var.:	(1)	(2)	(3)	(4)
Change in —	Cutoff TFP		Cutoff Revenue	
MNC entry (predicted)				
in the same industry	0.09***	0.15***	0.07***	0.05***
	(0.04)	(0.04)	(0.03)	(0.02)
in related industries				
– Labor similarity	0.02***		-0.002	
	(0.003)		(0.002)	
– Capital similarity		0.004		0.005***
		(0.003)		(0.001)
Host country FE	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes
Obs	2,802	2,802	3,391	3,391
R square	0.37	0.36	0.33	0.33

Notes: (i) Weighted least squre estimates are reported; (ii) Bootstrapped standard errors are reported in the parentheses; (iii) ***, **, and * represent statistical significance at 1, 5, and 10 percent, respectively.

Table 9: Within- and Between-Industry Knowledge Spillovers

Dependent var.:	(1)	(2)	(3)
Change in TFP	25th Percentile	50th Percentile	75th Percentile
MNC entry (predicted)			
in the same industry	0.04*	0.04***	-0.002
	(0.02)	(0.02)	(0.01)
in related industries			
– Backward linkage	0.06**	0.02	0.07
	(0.03)	(0.05)	(0.05)
– Forward Linkage	-0.23**	-0.25	-0.02
	(0.11)	(0.16)	(0.13)
Host country FE	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes
Obs	2,291	2,291	2,291
R square	0.12	0.14	0.12

Notes: (i) The percentiles are taken from the productivity distributions in 2002-2004; (ii) Bootstrapped standard errors are reported in the parentheses; (iii) ***, **, and * represent statistical significance at 1, 5, and 10 percent, respectively.

Table 10: Estimated Productivity and Welfare Gains with Within- and Between-Industry Reallocations and Spillovers

	Est. (in percentage)
	All
Welfare Gains	9.62
TFP Gains	1.50
TFP Gains (Decomposed)	
Multinational Firms	4.90
Domestic Firms	1.02
— Spillover	0.62
— Selection/Reallocation	0.40

Notes: (i) The percentiles are taken from the productivity distributions in 2002-2004; (ii) Bootstrapped standard errors are reported in the parentheses; (iii) ***, **, and * represent statistical significance at 1, 5, and 10 percent, respectively.

Table A.1: List of Countries

Algeria	Germany	Norway
Argentina	Greece	Poland
Australia	Hong Kong	Portugal
Austria	Hungary	Republic of Korea
Belarus	Iceland	Romania
Belgium	India	Russian Federation
Bermuda	Indonesia	Serbia
Brazil	Ireland	Slovakia
Bulgaria	Israel	Slovenia
Canada	Italy	South Africa
Chile	Japan	Spain
China	Kazakhstan	Sweden
Colombia	Latvia	Switzerland
Croatia	Lithuania	Taiwan
Czech Republic	Macedonia	Tunisia
Denmark	Malaysia	Turkey
Egypt	Mexico	Ukraine
Estonia	Morocco	United Arab Emirates
Finland	Netherlands	United Kingdom
France	New Zealand	United States

Table A.2: Summary Statistics

Variable	Mean	Std. Dev.
Change in cutoff productivity	-0.83	2.07
Change in cutoff revenue	-0.61	2.08
Survival	0.96	0.18
Change in productivity – 25th perc.	0.0002	0.61
Change in productivity – 50th perc.	-0.07	0.50
Change in productivity – 75th perc.	-0.13	0.48
Change in revenue – 25th perc.	0.34	0.91
Change in revenue – 50th perc.	0.28	0.75
Change in revenue – 75th perc.	0.24	0.77