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Market Reallocation and Knowledge Spillover: The 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 emphasized explanation is market reallocation, whereby competition from multinationals leads to factor reallocation and the survival of only the most productive domestic firms. We develop a model that incorporates both aspects and quantify their relative importance in the gains from multinational production by exploring their distinct predictions for domestic distributions of productivity and revenue. We show that knowledge spillover shifts both distributions rightward while market reallocation raises the left truncation of the distributions and shifts revenue leftward. Using a rich firm-level panel dataset that spans 60 countries, we find that both market reallocation and knowledge spillover are significant sources of productivity gain. Ignoring the role of market reallocation can lead to significant bias in understanding the nature of gains from multinational production.

JEL Codes: F2, O1, O4

Key Words: Gains from Multinational Production, Market Reallocation, and Knowledge Spillover

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1 Introduction

Nations with greater openness to multinational production (MP) exhibit, on average, higher productivity and faster economic growth. This stylized fact—illustrated in Figure 1 which depicts a positive and significant relationship between multinational affiliate sales and host-country total factor productivity (TFP), in both absolute levels and growth rates—has been established in numerous macro-level studies (see, for example, Borensztein et al., 1998; Alfaro et al., 2004).[1] The positive relationship is often attributed to *knowledge spillover*, whereby foreign multinationals generate positive productivity externalities to domestic firms. Such externalities can arise from direct knowledge transfer through partnership, opportunities to observe and learn the technologies of foreign firms, sharing intermediate input suppliers, and interaction and movement in labor market.

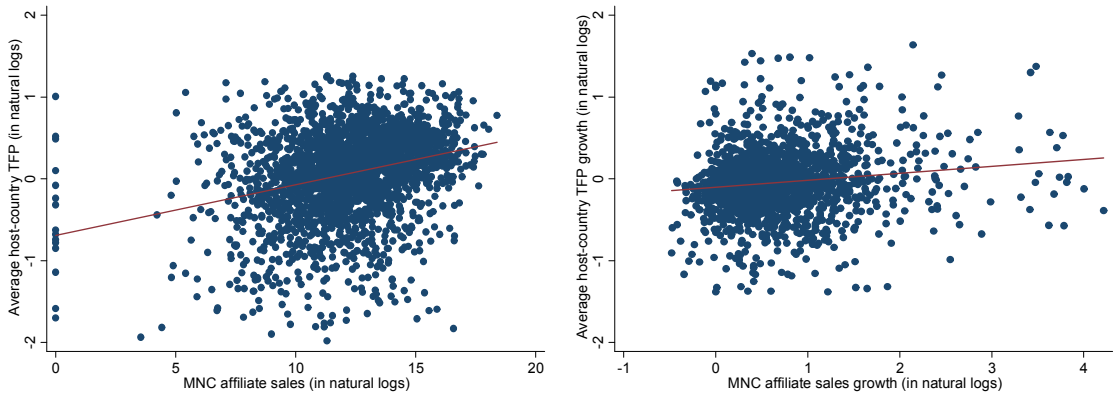

Figure 1: The relationship between multinational production and host-country TFP

There is, however, a less emphasized, alternative explanation, centering on *market reallocation*. Greater openness to multinational production leads to tougher competition in host-country product and factor markets, which results in a reallocation of resources from domestic to multinational and from less productive to more productive firms. This

[1] See Harrison and Rodríguez-Clare (2011) and Kose et al. (2011) for recent overviews of the literature on the relationship between multinational production, productivity, and economic growth. Evidence suggests that multinational production exerts a positive effect on economic growth conditional on local conditions, such as sufficient human capital stock and relatively developed financial markets. Figure 1 is plotted with country-industry multinational affiliate sales and TFP data computed using Orbis, a cross-country firm-level database used in the paper (see Section 3 for a detailed description of the data). 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 World Development Indicators and Penn World Tables; data: 1980-2005).

resource reallocation forces the least efficient domestic firms to exit the market, increasing the host country's average productivity.[2]

Although both knowledge spillover and market reallocation imply that multinational production positively affects domestic productivity, they represent two distinct margins at which this occurs. Knowledge spillover operates through an intensive margin whereby MP increases the within-firm productivity of continuing firms; market reallocation, in contrast, works at an extensive margin whereby MP leads to the exits of the least productive domestic firms. Their implications for domestic economies are also sharply different and even contrary. Positive externalities engendered by knowledge spillover cause an expansion of domestic industries and stimulate local technological development whereas market reallocation results in a contraction of domestic industries and may hinder the growth of domestic entrepreneurship.

Distinguishing between market reallocation and knowledge spillover is thus essential in improving our understanding of the mechanisms by which an economy responds to multinational production and crucial for evaluating the effect of foreign investment and setting corresponding economic policies. If knowledge spillover is the primary source of productivity gains, special treatment for foreign firms, often provided by host countries in the form of tax breaks and financial incentives, may be justified and sufficient. But if productivity increases arise also from market reallocation, it would be important to improve domestic market conditions, including labor mobility and credit access, to facilitate gains from competition and reallocation of resources. While an extensive body of research has been devoted to assessing the knowledge spillover effect of multinational firms, little analysis has investigated the role of market reallocation in the aggregate impact of multinational production and how market reallocation and knowledge spillover distinctively as well as jointly influence the potential gains from multinational competition.[3]

This paper disentangles the roles of market reallocation and knowledge spillover in de-

[2] The positive relationship between multinational production and host-country productivity might also reflect the possibility that multinationals are attracted to host countries with higher productivity. Our empirical strategy, as discussed below, will address this potential endogeneity to identify the causal effects of multinational production.

[3] Although the role of market reallocation is underemphasized in evaluating gains from multinational production, its role is well established in assessing the productivity gains from trade liberalization (see Melitz, 2003). An important empirical study in this area, Pavcnik (2002), finds that of the 19.3 percent manufacturing productivity growth from trade liberalization in Chile during 1979-1986, 12.7 percent is attributable to reallocation of resources from less to more efficient producers and 6.6 percent to increased productivity within plants. See Melitz and Redding (2013) for a recent overview.

termining the aggregate gains from multinational production and quantifies their relative importance. This cannot be accomplished by simply examining the relationship between multinational production and host-country average productivity, as both channels predict a positive relationship. We therefore develop an empirical framework based on a model of monopolistic competition and heterogeneous firms adapted from Melitz (2003) and Helpman, Melitz and Yeaple (2004) and augmented to incorporate the two aspects of multinational production. This framework, grounded in a standard model of firm heterogeneity but applying to a broader class of theoretical setups, addresses simultaneously the market reallocation and the knowledge spillover effects of multinational competition and accounts for the endogenous entry decision of multinational firms. It enables us to distinguish the different channels and establish their relative importance by exploring their different predictions for domestic distributions of productivity and revenue.

In particular, greater competition from multinational production is predicted to raise factor prices and reallocate labor and capital from domestic to multinational and from less productive to more productive firms. The reallocation in labor market erodes the revenue of individual domestic firms shifting the revenue distribution leftward, while the reallocation of capital results in greater cutoff revenue for domestic firms. Both effects cause an increase in the cutoff productivity and force the least efficient domestic firms to exit the market. Knowledge spillover from foreign multinational production, in contrast, induces a rightward shift of the productivity distribution of surviving domestic firms. The revenue distribution might shift either rightward or leftward depending on the extent to which 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 more than one million public and private manufacturing companies for the 2002-2007 period. The database exhibits several strengths central to our analysis. First, Orbis reports detailed ownership information that covers over 30 million shareholder-subsidiary links collected from a variety of sources including official registers, annual reports, research, and newswires. We explore the shareholder, ultimate owner, and subsidiary information to identify MNC activities across countries. Second, the dataset provides rich firm-level time-series financial and operation data, enabling us to compare firm TFP and other economic attributes over time. Third, Orbis offers a broad country

coverage that includes an extensive set of industrial and emerging economies.[4]

Our estimation proceeds in two steps. First, we account for the endogenous entry decision of multinational firms using the instrument and specification motivated by the theoretical framework. The entry decision of multinationals is examined as a function of not only all time-variant country-pair industry factors but also multinational headquarters' ex-ante productivity and idiosyncratic financial shock. Multinationals that draw a high productivity are more likely to enter new host countries. Similarly, multinationals that experience a financial shock at headquarters, due to, for example, high investment returns or an appreciation of headquarter-country currency, are expected to have less financial constraint in foreign investments and thus more likely to make new entry in the next period. But such idiosyncratic cash flow shocks, unlike other firm characteristics such as productivity, should not be directly correlated with the future productivity growth of host-country domestic firms, thereby offering a suitable exclusion restriction in the second stage to identify the causal effects of multinational production.

In the second step, we quantitatively assess the relative importance of market reallocation and knowledge spillover by estimating the effect of expected multinational entry on various distribution properties of domestic production, including the cutoffs and quantiles of the domestic firms' productivity and revenue distributions. The estimated impact on changes in cutoff productivity and revenue determines the reallocation effect, while the estimated effect on the shift of the overall productivity distribution quantifies the magnitude of knowledge spillover.

Our empirical analysis suggests that knowledge spillover and market reallocation are two significant but distinctly different sources of gains from multinational production. Entry of multinational firms raises the cutoff productivity and the cutoff revenue of domestic firms, pushing the least productive to exit the market. The revenue distribution of domestic firms shifts leftward, at all the percentile levels considered. These results imply an increase in factor prices and a decrease in aggregate price as a result of increased competition and reallocation in factor markets. In contrast, the productivity distribution of domestic firms shifts rightward, suggesting knowledge spillover from foreign multinational to domestic firms. In quantifying the productivity gains from multinational production, we find that, in our preferred estimations, when the probability of a new multinational en-

[4]Section 3 and the Data Appendix describe the dataset in detail. In Section 6, we use different subsamples and perform several robustness analyses regarding the data.

try increases by 100 percentage points, aggregate domestic productivity increases by 1.22 percent across countries. Market reallocation alone accounts for 1.04-percent productivity gains, while knowledge spillover by itself accounts for 0.43 percent. These results highlight that a substantial share of productivity gains are channeled through market reallocation. Ignoring the role of market reallocation could therefore lead to a biased understanding of the origin and magnitude of gains from multinational production.

We perform a series of robustness analysis, including assessing the employment distribution and wage effects of multinational entry to further explore labor market reallocation, re-estimating our parameters with different data samples such as industries with relatively homogeneous products (to address potential markup issues in productivity measure) and countries with better data coverage, introducing additional controls such as the role of trade, and exploring between-industry factor reallocation and knowledge spillover with measures of industry-pairs' relatedness in factor demand and technology. We find consistent evidence of knowledge spillover and market reallocation.

Our study is closely related to several strands of the literature. First, as mentioned above, we build on an extensive empirical literature that assesses the existence of productivity spillover from multinational to domestic firms. One of the earliest contributions to this literature is a study by Aitken and Harrison (1999) that finds evidence of negative spillover in a panel of Venezuelan manufacturing enterprises for the period 1975-1989. The authors attribute this result to a market-stealing effect whereby foreign multinational firms steal market share from domestic firms. That paper soon spawned a large series of empirical studies. Keller and Yeaple (2009), for example, find significant evidence of positive spillover from foreign multinational to domestic firms in the same industry in the United States. Similar results are found in Aghion et al. (2012) for a panel of medium-sized and large Chinese enterprises for the period 1998-2007. Javorcik (2004), exploring spillovers through vertical production linkages in Lithuania between 1996 and 2000, shows that multinational production generates positive externalities via backward production linkage from multinational affiliates to local intermediate input suppliers. Studies by Arnold and Javorcik (2009) and Guadalupe et al. (2012), which account for the endogenous acquisition decisions of foreign multinational firms, find that foreign ownership leads to significant productivity spillover in acquired plants even after addressing the acquisition decisions, while Fons-Rosen et al. (2013) find little evidence of spillover.

In contrast to the ample literature on productivity spillover, evidence for the market reallocation effect of multinational production is scarce. A number of studies offer related insights by evaluating the effects of multinational production on domestic wage rates and financial constraints. Aitken, Harrison, and Lipsey (1996) investigate the impact of foreign-owned plants on the wages of domestically owned establishments in Mexico and Venezuela and report an increase of industry wages due to foreign multinational production. Similarly, Feenstra and Hanson (1997) find a higher level of maquiladora activity to lead to a higher share of total wages going to skilled (nonproduction) workers in Mexico, interpreting their result 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 that domestic firms are more credit-constrained than foreign firms and that borrowing by foreign firms exacerbates domestic firms' credit constraints.[5] Ramondo (2009), using a panel of Chilean manufacturing plants, finds entry by foreign plants to be associated negatively with the market shares of domestic firms and positively with the productivity of domestic incumbents. Kosova (2012), analyzing exit and growth sales of domestic firms in the Czech Republic, finds evidence consistent with crowding out and technology spillovers.

Our paper contributes to the above literature by evaluating the distinct roles of market reallocation and knowledge spillover in determining the gains from multinational production. First, our micro theoretical foundation, based on a standard model of firm heterogeneity, addresses simultaneously the two aspects of multinational production. More important, it informs a novel empirical strategy for quantitatively assessing their relative importance that applies beyond the model's specific attributes. Second, our empirical analysis accounts for the endogenous entry decision of multinational firms and the potential reverse causality between host-country productivity and multinational production using specifications motivated by the theory. Third, our approach, by allowing both market reallocation and knowledge spillover to play a role instead of focusing on one channel at a time, enables us to perform counterfactual analysis and quantify the aggregate and decomposed gains from greater openness to multinational production. Our analysis

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

should thus be seen as a complement to previous work, as it connects previous studies of knowledge spillover and market reallocation to form a general analysis examining the various gains from multinational production.

The paper is also related to a recent strand of quantitative studies that evaluate the patterns and effects of multinational production with emphasis on interactions between trade and multinational production and the role of geography; see Ramondo and Rodriguez-Clare (2011), Irrarazabal, Moxnes, Opromolla (2011), and Arkolakis, Ramondo, Rodriguez-Clare, and Yeaple (2012). Albeit our model does not address the above features of multinational production, our paper complements these studies by quantifying the sources of productivity gains from multinational production, specifically via market reallocation and knowledge spillover, a distinction that has been previously under-stressed.

More broadly, understanding the role of spillovers, reallocation and more generally selection from tougher competition has been an important subject of inquiry in many fields of economics. In addition to trade (e.g. Pavnic, 2002; Melitz, 2003), Combes et al. (2012), for example, study the role of agglomeration forces (externalities) versus selection in explaining the productivity advantage of large cities,[6] and Bloom et al. (2012) analyze the effects of technology spillovers versus market rivalry in R&D. Our work also connects to the growing literature that emphasizes the productivity effect of resource allocation across establishments (see Hsieh and Klenow, 2009; Alfaro et al., 2009). Echoing these studies, our paper suggests that reallocation of capital and labor as a result of increased multinational production could lead to important productivity gains. Our findings thus have implications of interest to both policy and academic debates on FDI, as understanding the sources of potential gains from multinational production is critical to designing economic policies (Harrison and Rodríguez-Clare, 2011).

The rest of the paper is organized as follows. Section 2 presents the theoretical framework. Section 3 describes the data used in the empirical analysis. Sections 4 and 5 report

[6]Both Combes et al (2012) and our paper are motivated by stylized models in the firm heterogeneity literature. Incorporating Melitz and Ottaviano (2008) with urban economics models, Combes et al. (2012) develop a new quantile regression approach to compare the distribution of establishment productivity for each sector across French areas of different density. Our paper, built on Helpman, Melitz and Yeaple (2004) and Melitz (2003), examines the various gains from multinational production by exploring its effects on the productivity and revenue distributions of domestic firms. Our approach estimates directly the moments derived from the model to infer and decompose the effects of multinational production on various outcome variables including aggregate price, capital price, productivity spillover, and aggregate productivity.

the estimation results and productivity gain estimates, respectively. Section 6 discusses additional robustness analyses and results. Section 7 concludes.

2 Theoretical Framework

In this section, we employ a standard model of monopolistic competition and heterogeneous firms augmented to incorporate various aspects of multinational production. The model, adapted from the work of Melitz (2003) and Helpman, Melitz and Yeaple (2004), offers guidance for the empirical analysis and the quantification of the gains from multinational production.[7]

2.1 Environment

Suppose the world consists of two sectors, one homogeneous and one differentiated. The homogeneous good serves as the numeraire. In the differentiated sector, each firm produces a different variety and draws a productivity level θ. Given a CES utility function, the demand function for each variety 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.

There are $n+1$ countries and, as in Melitz (2003), countries are assumed to be symmetric.[8] Without loss of generality, we focus the analysis on one representative country. Domestic firms in this country must incur a marginal cost w/θ and a per-period fixed cost cf_D, where w is the common wage rate, c is the unit capital price, and f_D is the units of capital (such as machinery) required for production. The profit-maximizing strategy is to set $p(\theta) = w/(\alpha\theta)$, which yields the domestic revenue and profit functions, denoted

[7] In the robustness section, we discuss various considerations and empirical extensions to the model.

[8] As noted in Melitz (2003), this assumption ensures factor-price equalization so the analysis can examine market reallocation effects that are independent of wage differences. However, the assumption can be relaxed without altering our predictions and empirical strategy outlined later in the section, as they apply beyond the specific attributes.

as $r_D(\theta)$ and $\pi_D(\theta)$, respectively, below:

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

Foreign firms may also serve a country via either multinational production or exporting. We assume firms must pay a per-period fixed cost cf_M/φ for multinational production and cf_X/φ for exporting, where φ is a firm-specific fixed-cost shifter governed by a cumulative distribution function $H(\varphi)$. The fixed-cost shifter captures cross-firm variation in, for example, financial constraints and foreign business networks, factors that could potentially lead to heterogeneous levels of fixed costs for serving foreign markets.[9] Heterogeneity in the foreign-market fixed cost also allows the model to accommodate the possibility that two firms with identical productivity θ may differ in their choices of export and multinational production locations.

The revenue and profit earned by foreign multinational firms, denoted as $r_M(\theta)$ and $\pi_M(\theta)$, respectively, are given by:

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

The revenue and profit earned by foreign exporters, denoted as $r_X(\theta)$ and $\pi_X(\theta)$, respectively, are given by

$$r_X(\theta) = E\left(\frac{\alpha P\theta}{wd}\right)^{\varepsilon-1}; \quad \pi_X(\theta) = \frac{r_X(\theta)}{\varepsilon} - cf_X/\varphi, \tag{4}$$

where d (> 1) is per-unit iceberg trade cost.

Domestic firms will produce in the domestic market if $\pi_D(\theta) > 0$ or equivalently if the productivity exceeds the cutoff productivity given by:

$$\underline{\theta}_D = \left(\frac{\varepsilon cf_D}{E}\right)^{\frac{1}{\varepsilon-1}} \left(\frac{w}{\alpha P}\right). \tag{5}$$

Foreign firms will choose to invest and produce in the domestic market if $\pi_M(\theta) > \pi_X(\theta)$

[9] The fixed cost of serving domestic markets could also vary across firms. While we abstract from this possibility in the model for simplicity, allowing for firm-specific domestic fixed cost will not change the analytical predictions of the model.

or equivalently if the productivity exceeds, for any given value of φ, the cutoff level given by:

$$\underline{\theta}_M = \left[\frac{\varepsilon c(f_M - f_X)}{E\varphi(1-d^{1-\varepsilon})}\right]^{\frac{1}{\varepsilon-1}} \left(\frac{w}{\alpha P}\right). \tag{6}$$

In contrast, foreign firms whose productivity falls between θ_M and the cutoff productivity for exporting given by:

$$\underline{\theta}_X = \left(\frac{\varepsilon c f_X}{E\varphi}\right)^{\frac{1}{\varepsilon-1}} \left(\frac{wd}{\alpha P}\right) \tag{7}$$

will choose to export. Following Helpman, Melitz and Yeaple (2004), we assume $f_D < d^{\varepsilon-1} f_X < f_M$, which yields $\underline{\theta}_D < \underline{\theta}_X < \underline{\theta}_M$, that is, the cutoff productivity is highest for multinational firms, intermediate for exporters, and lowest for domestic producers.

When there is foreign multinational production, we allow for the possibility of productivity spillover from foreign multinational to domestic firms.[10] To capture this effect, the productivity of domestic firms is assumed to be a function of two components: an ex-ante productivity θ drawn from a distribution function $G(\theta)$ and a slope parameter $\tau_\theta(z_M)$ where z_M is a measure of new foreign multinational production (such as the number of new multinational firms). Specifically, we assume $\theta' \equiv \tau_\theta(z_M)\theta = \tau_\theta^{z_M} \cdot \theta$, where $\tau_\theta \geq 1$. In the empirical analysis, we allow the degree of spillover to be heterogeneous across both domestic and multinational firms and consider more general functional forms.

Let N_D denote the equilibrium mass of incumbent domestic firms in each country. The equilibrium masses of firms from each country that engage in multinational production and exports are given by $N_M = \gamma_M N_D$ and $N_X = \gamma_X N_D$, respectively, where $\gamma_M \equiv [1 - G(\underline{\theta}_M)] \,/\, [1 - G(\underline{\theta}_D)]$ and $\gamma_X \equiv [G(\underline{\theta}_M) - G(\underline{\theta}_X)] \,/\, [1 - G(\underline{\theta}_D)]$. The total mass of varieties available to consumers in each country and, equivalently, the total mass of firms competing in each country is hence $N = N_D + nN_M + nN_X$.

[10] It is worth noting that knowledge spillover can also occur in the reverse direction, from domestic firms to foreign multinationals. We do not consider that possibility here, 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.

2.2 Aggregate Outcomes

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

$$\begin{aligned}
\widetilde{\theta}_D &\equiv \widetilde{\theta}(\underline{\theta}_D) = \frac{1}{1-G(\underline{\theta}_D)}\left[\int_{\underline{\theta}_D}^{\infty}\theta^{\varepsilon-1}g(\theta)d\theta\right]^{\frac{1}{\varepsilon-1}}; \\
\widetilde{\theta}_M &\equiv \widetilde{\theta}(\underline{\theta}_M) = \frac{1}{1-G(\underline{\theta}_M)}\left[\int_{\underline{\theta}_M}^{\infty}\theta^{\varepsilon-1}g(\theta)d\theta\right]^{\frac{1}{\varepsilon-1}}; \\
\widetilde{\theta}_X &\equiv \widetilde{\theta}(\underline{\theta}_X) = \frac{1}{G(\underline{\theta}_M)-G(\underline{\theta}_X)}\left[\int_{\underline{\theta}_X}^{\underline{\theta}_M}\theta^{\varepsilon-1}g(\theta)d\theta\right]^{\frac{1}{\varepsilon-1}}.
\end{aligned} \tag{8}$$

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

$$\widetilde{\theta} = \left\{\frac{1}{N}\left[N_D\widetilde{\theta}_D^{\varepsilon-1} + nN_X\left(\widetilde{\theta}_X/d\right)^{\varepsilon-1} + nN_M\widetilde{\theta}_M^{\varepsilon-1}\right]\right\}^{\frac{1}{\varepsilon-1}}. \tag{9}$$

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 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:

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

2.3 Market Clearing 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. A firm that obtains a low productivity draw may decide to exit immediately and not produce. If a firm produces, it faces, in every period, a constant probability δ of a bad shock that would force it to exit. An entering firm with productivity θ would 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 forced to exit.

The zero cutoff profit condition implies that

$$r(\underline{\theta}_D) = \varepsilon c f_D. \tag{11}$$

Since the average productivity level is determined by the cutoff productivity level, the average profit and revenue levels are also tied to the cutoff levels:

$$\begin{aligned} \overline{r}_D &= r(\widetilde{\theta}_D) = \left[\frac{\widetilde{\theta}_D}{\underline{\theta}_D}\right]^{\varepsilon-1} r_D(\underline{\theta}_D) = \left[\frac{\widetilde{\theta}_D}{\underline{\theta}_D}\right]^{\varepsilon-1} \underline{r}_D; \\ \overline{\pi}_D &= \pi(\widetilde{\theta}_D) = \left[\frac{\widetilde{\theta}_D}{\underline{\theta}_D}\right]^{\varepsilon-1} \frac{\underline{r}_D}{\varepsilon} - c f_D. \end{aligned} \tag{12}$$

Given equations (2) and (3), the average profit of all domestic firms is given by:

$$\overline{\pi} = \overline{\pi}_D + n\gamma_M \overline{\pi}_M + n\gamma_X \overline{\pi}_X = c(\lambda_D f_D + n\gamma_M \lambda_M f_M/\varphi + n\gamma_X \lambda_X f_X/\varphi), \tag{13}$$

where $\overline{\pi}_M$ and $\overline{\pi}_X$ are similarly defined as $\overline{\pi}_D$ in equation (12) and $\lambda_l \equiv \left[\widetilde{\theta}(\underline{\theta}_l)/\underline{\theta}_l\right]^{\varepsilon-1} - 1$ for $l = D, M, X$.

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

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

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

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

$$v_E = \frac{1}{\delta}\left[1 - G(\underline{\theta}_D)\right]\overline{\pi} - c f_E. \tag{16}$$

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

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

where $\gamma_D \equiv 1 - G(\underline{\theta}_D)$ is the ex-ante probability of survival after entry. The above equation, together with equations (11) and (12), determine $\overline{\pi}$, $\underline{\theta}_D$, $\underline{\theta}_M$, and $\underline{\theta}_X$.

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, that is, $N_D\left(\overline{r}_D + n\gamma_X\overline{r}_X + n\gamma_M\overline{r}_M\right)/\alpha^{\varepsilon-1} = N_D\overline{r}/\alpha^{\varepsilon-1} = L$ where $N_D\left(\overline{r}_D + n\gamma_X\overline{r}_X\right)/\alpha^{\varepsilon-1}$ is the domestic (exporting and non-exporting) firms' demand for domestic labor and $N_D n\gamma_M\overline{r}_M/\alpha^{\varepsilon-1}$ is foreign multinational firms' demand for domestic labor. This, in turn, determines the equilibrium mass of incumbent domestic firms producing in each country:

$$N_D = \frac{\alpha^{\varepsilon-1}L}{\overline{r}}, \tag{18}$$

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

In the capital market, we assume that firms employ a constant share of the capital needed in fixed foreign investment cost at home and the rest in host countries.[11] The total demand for capital by domestic and foreign multinationals in each country is then given by $N_D n\gamma_M f_M$. The capital-market clearing condition requires that $N_D\left(f_D + n\gamma_X f_X + n\gamma_M f_M + \delta f_E/\gamma_D\right) = K$, where $N_D\left(f_D + n\gamma_X f_X\right)$, $N_D\gamma_M f_M$, and $N_D\delta f_E/\gamma_D$ represent the demand for capital in the domestic market by domestic (exporting and non-exporting) producers, by domestic and foreign multinationals, and by domestic entrants, respectively, and where K is the aggregate supply of capital.[12] The above equation, in conjunction with equations (17) and (18), determines unit capital price c.

[11] In terms of capital accumulation, Graham and Krugman (1991), Lipsey (2002), and Harrison 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 rather than bringing capital from abroad, they may exacerbate domestic firms' financing constraints by crowding them out of domestic capital markets.

[12] We abstract from considerations regarding international capital flows in the theoretical framework. The international trade literature suggests that firms engage in MP not because of differences in the cost of capital but because certain assets are worth more under foreign than under local control. If a lower cost of capital were the only advantage a foreign firm had over domestic firms, it would 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. See Antras and Yeaple (2013) for related discussion.

2.4 The Impact of Multinational Production

We now use the present framework to examine the impact of greater multinational production, due to, for example, a decrease in the fixed cost of multinational production. We ask: What happens to the productivity and revenue distributions of domestic firms? And how are aggregate productivity and welfare affected?

The Productivity Distribution Greater multinational production affects the productivity distribution of domestic firms in two ways. First, knowledge spillover from additional multinational entry enhances the productivity level of domestic firms, inducing a rightward shift of the productivity distribution. Second, inspection of the zero cutoff profit conditions reveals that increased multinational production will lead to an increase in the domestic cutoff productivity level $\underline{\theta}_D$. Assuming that the effect of knowledge spillover is inadequate to offset the negative competition effect, the least productive domestic firms with productivity levels between the ex-ante and ex-post cutoffs can no longer earn positive profits and will exit. We label the second effect as the market reallocation effect. As in Melitz (2003), the market reallocation effect operates through a reallocation in domestic factor markets. The increased factor demand by foreign multinational firms bids up the real wage and capital price, allocating greater resources to foreign multinationals and forcing the least productive domestic firms to exit.[13]

The Revenue Distribution Now consider the revenue of domestic firms, $r_D(\theta)$. As above, the effect of greater foreign multinational production is twofold. On the one hand, knowledge spillover from foreign multinationals exerts a positive effect on firm productivity and revenue. On the other hand, market reallocation induces an increase in average productivity and consequently a decrease in the aggregate price P, which in turn exerts a negative effect on domestic firm revenue. The two effects imply that, in the absence

[13] As noted in Melitz (2003), an alternative channel of the market reallocation effect is through the increase in product market competition. 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, that is, 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 trade literature is to introduce variable markups, as in Melitz and Ottaviano (2008). However, since factor market competition is the primary aspect that distinguishes multinational production from foreign imports, we focus on factor market reallocations in our theoretical analysis. Our empirical strategy, on the other hand, accounts for both product and factor market reallocation by exploring the effect of multinational entry on the revenue distribution of domestic firms. In Section 6.2, we present further discussion on the implications and robustness of our results.

of knowledge spillover (that is, with $\tau_\theta = 1$) or when the degree of knowledge spillover is relatively small, domestic firms will incur a loss in domestic sales and the revenue distribution of surviving firms will shift leftward. When the degree of knowledge spillover is sufficiently large to offset the market reallocation effect, the revenue distribution of surviving domestic firms could shift rightward. But the magnitude of the revenue shift will be smaller than the shift of $\theta^{\varepsilon-1}$. Moreover, inspection of equation (11) suggests that the cutoff revenue level increases with greater foreign multinational production, due to the rising capital cost.

Aggregate Productivity Next we examine the effect of greater foreign multinational production on aggregate productivity. Equation (8) suggests that increased 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 market reallocation effect, greater multinational production can also increase the aggregate productivity of domestic firms through 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 then leads to an increase in the country's aggregate productivity.

Welfare The welfare effect of greater multinational production is determined by two components: aggregate productivity and total product variety. When the decrease in total product variety is sufficiently small, the increase in aggregate productivity will lead to an increase in welfare as indicated by equation (10).[14]

2.5 Empirical Strategy

In this sub-section, we describe our empirical strategy for disentangling the effects of multinational production on market reallocation and knowledge spillover. First, we examine multinational firms' endogenous decision to enter a host country, based on conditions described in Section 2.1, to address the possibility that multinationals are likely to be attracted to host countries with high productivity growth. Then, accounting for the endogeneity of multinational entry, we explore the properties of the productivity and revenue

[14] See Melitz and Redding (2013) for more discussion.

distributions, as discussed in Section 2.4, to identify the effects of greater multinational production on market reallocation and knowledge spillover.

It is worth noting that despite the assumption used to derive function forms, our empirical approach explores predictions of the model that hold in more general settings. Specifically, spillovers from increased multinational production should lead to a rightward shift of the distribution of domestic firm's productivity even though the degree of spillovers could be conditional on the productivities of domestic and foreign multinational firms. Market reallocation due to greater multinational production should result in exits of the least productive domestic firms even in models with variable markups as shown in Melitz-Ottaviano (2008) (see more discussion in Section 6.2). Our empirical analysis exploits these generalizable predictions to quantify the gains from multinational production. We proceed by first examining the endogenous entry decision of multinational firms.

Stage 1: The Entry of Multinational Firms As described in Section 2.1, a foreign firm will invest in a host country if $\theta > \underline{\theta}_M \equiv \left[\frac{\varepsilon c(f_M - f_X)}{E\varphi(1-d^{1-\varepsilon})}\right]^{\frac{1}{\varepsilon-1}} \left(\frac{w}{\alpha P}\right)$. This leads us to consider the following empirical specification

$$\begin{aligned} & \Pr\left[entry_{kij} = 1\right] \\ = \; & \Phi\left[\ln\theta_{ki} + \left(\frac{1}{\varepsilon-1}\right)\ln\varphi_{kij} - \ln\left\{\left[\frac{\varepsilon c_j(f_{Mj} - f_{Xj})}{E_j(1-d_{ij}^{1-\varepsilon})}\right]^{\frac{1}{\varepsilon-1}}\left(\frac{w_j}{\alpha P_j}\right)\right\} > 0\right], \quad (19) \end{aligned}$$

where $entry_{kij}$ is an indicator variable that represents whether a multinational firm k headquartered in country i will enter a host country j in a given period.

The above equation suggests that, as predicted in Helpman, Melitz and Yeaple (2004), firms with a large productivity draw θ_{ki} are more likely to enter new host countries. Moreover, the firm- (and potentially firm-market-) specific fixed-cost shifter φ_{kij} reflecting, for example, multinational headquarters' financial constraints or business networks is also expected to affect multinationals' decisions to enter a host country. In the empirical analysis, we consider changes in multinational headquarters' cash flow (deflated by real exchange rates between headquarter and host countries) as a proxy for changes in multinationals' financial constraints. Multinationals that experience an idiosyncratic cash flow shock at headquarters, due to, for example, high investment returns or an appreciation of headquarter-country currency, see a decrease of financial constraints in foreign invest-

ments and are thus more likely to enter new host countries (see also Froot and Stein, 1991). But such idiosyncratic cash flow shocks, unlike other firm characteristics such as productivity and size, should not be directly correlated with the future productivity growth of host-country domestic firms, thereby serving as a suitable exclusion restriction in the second stage to identify the causal effects of multinational production.

We also use country-pair-industry-time fixed effect to control for all time-variant host-country, headquarter-country, and country-pair industry specific factors including not only E_j, c_j, P_j, w_j, f_{Mj}, f_{Xj}, and d_{ij} but also all other potential determinants of multinational entry such as host-country institutional characteristics, sectoral FDI and trade policies, and domestic industry characteristics. Furthermore, as mentioned earlier, since multinational firms are likely to be attracted to host countries with faster productivity growth, the use of the country–pair-industry-time fixed effect accounts for this possibility by controlling for host-country current and future productivity growth.

Based on estimates of the above equation, we obtain the predicted probability of entry for each multinational firm in each host country, that is, $\widehat{\Pr}\left[entry_{kij}=1\right]$, and the expected number of multinational entries in each host country, that is, $\widehat{z}_{Mj} \equiv \sum_{k,i} \widehat{\Pr}\left[entry_{kij}=1\right]$.

Stage 2: The Effects of Multinational Entry In the second stage, we assess the market reallocation and knowledge spillover effects of multinational entry accounting for the endogenous entry.

(1) Market Reallocation After the entry of new multinational firms, a domestic firm will survive if $\theta > \underline{\theta}_D$. This leads to the following empirical specification

$$\Pr\left[survival_{kj}=1\right] = \Pr\left[\ln\theta_{kj} - \ln\underline{\theta}_{Dj} > 0\right], \tag{20}$$

where the dependent variable $survival_{kj}$ denotes whether a domestic firm k survives in the domestic market j, and $\underline{\theta}_{Dj}$ is the domestic cutoff productivity in country j which is a function of multinational entry. In the above and all the following estimating equations, we account for the endogeneity of z_{Mj} by substituting it with the expected number of multinational entry $\widehat{z}_{Mj}$ obtained from the first stage.

Alternatively, we examine different properties of the productivity and revenue distributions of domestic firms. First, consider the domestic cutoff productivity $\underline{\theta}_D = \left(\frac{\varepsilon c f_D}{E}\right)^{\frac{1}{\varepsilon-1}}\left(\frac{w}{\alpha P}\right)$. Comparing the ex-post and ex-ante domestic cutoff productivities, we

obtain

$$\frac{\underline{\theta}'_{Dj}}{\underline{\theta}_{Dj}} = \left(\frac{c'_j}{c_j}\right)^{\frac{1}{\varepsilon-1}} \frac{P_j}{P'_j}, \tag{21}$$

where $\underline{\theta}'_D/\underline{\theta}_D$ measures the change in domestic cutoff productivity after multinational entry and c'/c and P/P' capture, respectively, the effects of new multinational entry on capital price and aggregate real price.[15] Taking natural logs of the above equation yields:

$$\ln \underline{\theta}'_{Dj} - \ln \underline{\theta}_{Dj} = \frac{1}{\varepsilon - 1} \ln \frac{c'_j}{c_j} + \ln \frac{P_j}{P'_j}. \tag{22}$$

Note that, by essentially taking the first difference of the cutoff productivity equation (as well as the equations of the other distribution variables below), we control for all time-invariant country-industry factors that might affect the productivity (and revenue) distributions of domestic firms. In addition, we include separate fixed effects in the first-differenced equations to control for all time-variant country and industry characteristics that might affect changes of the distributions.

Similarly, we assess the change in the cutoff revenue $\underline{r}_D = \varepsilon c f_D$ after new multinational entry given by:

$$\ln \underline{r}'_{Dj} - \ln \underline{r}_{Dj} = \ln \frac{c'_j}{c_j}, \tag{23}$$

where $\ln \underline{r}'_{Dj} - \ln \underline{r}_{Dj}$ is the log change of domestic cutoff revenue. Estimating equation (23) provides us with estimates of c'_j/c_j, the effect of new multinational entry on capital price.

We can also evaluate the overall revenue distribution. As shown in Section 2.4, $r_D(\theta) = E\left(\frac{\alpha P \theta}{w}\right)^{\varepsilon-1}$. We therefore consider the following specification:

$$\ln r'_{Dj}(q) - \ln r_{Dj}(q) = (\varepsilon - 1)\left[\ln\left(\frac{P'_j}{P_j}\right) + \ln \tau_{\theta j}\right], \tag{24}$$

where $\ln r'_{Dj}(q) - \ln r_{Dj}(q)$ is the log revenue change of the qth (for example, the 25th, 50th and 75th) percentile firm of the ex-ante revenue distribution. Because the new productivity and revenue cutoffs would change the percentile rank of each domestic firm, quantile regressions are not appropriate here. Instead, we look at within-firm changes by

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

tracking firms at a given percentile of the ex-ante distributions. Evaluating revenue at different percentiles also enables us to examine empirically how the market reallocation effect might vary with the size of domestic firms.

(2) Knowledge Spillover Next, consider the knowledge spillover effect of foreign multinationals. Knowledge spillovers from foreign multinational firms would shift the productivity distribution of surviving domestic firms rightward by τ_θ. Let q denote the qth percentile of the ex-ante productivity distribution; we can estimate the knowledge spillover effect τ_θ by considering the following estimation:

$$\ln \theta'(q) - \ln \theta(q) = \ln \tau_\theta, \tag{25}$$

where $\ln \theta'(q) - \ln \theta(q)$ is the log productivity change of the qth (for example, the 25th, 50th and 75th) percentile firm of the ex-ante productivity distribution. As above, by exploring shifts of the distribution, we control for all time-invariant country-industry factors that might affect the productivity distribution.

Figures 2-4 summarize the theoretical predictions, that is, how new multinational entry affects, via market reallocation and knowledge spillover, the cutoffs as well as the overall distributions of domestic productivity and revenue.

3 Cross-Country Firm Financial and Ownership Data

We use 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.[16]

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. Primary sources include Tax Authorities, Ministry of Statistics, Provincial Bureau of Legal Entities, Securities and Investments Commissions, National Banks, Municipal Chambers of Commerce, and State Register of Accounts. Over 99 percent of the

[16] 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. The Data Appendix presents detailed description of the data set.

companies included in Orbis are private. For each company, the dataset reports: 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, and d) ownership information, including shareholders 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 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. 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 (majority- and wholly owned) 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 a firm's total factor productivity over time. Third, Orbis provides a broad country coverage, including a wide range of both industrial and emerging economies.

Our analysis focuses on manufacturing industries and covers over 1.2 million companies in 60 countries. We use four categories of information for each firm: (a) industry information including the 4-digit NAICS code of the primary industry in which each establishment operates, (b) ownership information including each firm's domestic and global parents and domestic and foreign subsidiaries, (c) location information, and (d) non-consolidated financial information including revenue, employment, assets, investment, and material cost. A firm is considered foreign-owned if it is majority- or wholly owned by a foreign multinational firm. There are about 36,000 foreign-owned subsidiaries in the final sample.[17]

While we believe that Orbis is a very informative and useful data source for answering the question raised in our paper, we are aware of its limitations. Like most other datasets that rely on public registries and proprietary sources, Orbis does not cover the population

[17] The subsidiary data used in our paper do not distinguish between greenfield foreign investment and mergers and acquisitions. However, our primary theoretical predictions and empirical approach are not dependent on the mode of multinational entry.

of businesses across countries. An ideal alternative would be national census data that include the entire population of firms. However, such census data are hard to obtain (usually subject to location and nationality restrictions and requirements) and inexistent in many developing countries. The reason for the lack of data is simple: high costs and institutional restrictions prevent frequent collections of economic census for all the businesses existing in a country.

To assess the extent of coverage, in particular, with respect to small businesses, we compare the data against several benchmarks including, for example, the Structural and Demographic Business Statistics (SDBS) from the OECD and the U.S. Census. We find Orbis provides satisfactory coverage in most of the countries considered. For France, for example, the SDBS dataset reports that 84 and 91 percent of the enterprises have fewer than 10 and 20 employees, respectively, in 2007. Orbis reports 80 and 86 percent. The coverage for some countries seems highly satisfactory. For Norway and Sweden, SDBS reports close to 88 and 93 percent, respectively, of the enterprises have fewer than 20 employees, while Orbis shows 85 and 95 percent. For some other countries, Orbis tends to have a lower percentage of small firms. For Spain and Portugal, for example, the percentage of enterprises with fewer than 20 employees in SDBS is 91 and 89 percent, respectively. In our data, it is 80 and 77 percent. For the U.S., the SDBS reports close to 77 percent of the enterprises have fewer than 20 employees in 2006 (no data for 2007) and the U.S. Census Bureau reports 89 percent in 2008.[18] Orbis shows close to 89 percent for 2007. The SDBS data does not include data for developing countries, but the numbers in Orbis seem comparable for some of the countries. For Argentina, for example, the share of enterprises with fewer than 20 employees was close to 90 percent (with INDEC showing 82 percent for Buenos Aires). For Latvia, it was close to 78 percent in Orbis while Eurostat reports 85 percent.

In Section 6.3, we further address potential issues with the data and data sampling in a number of ways, including, in particular, redoing our analysis for subsamples of countries with better data coverage and performing falsification exercises.

Productivity: Estimation Methodology 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

[18] http://www.census.gov/econ/smallbus.html

to derive estimates of production function and productivity.[19]

A key challenge in the measurement and identification of productivity relates to the endogeneity of the firm's optimal choice of inputs. Different estimation measures exhibit different advantages and limitations. As shown by Ackerberg, Caves, and Frazer (2006), the use of instruments based on lagged input decisions as the source of identification in structural estimation methods such as Olley and Pakes (1996) and Levinsohn and Petrin (2003) may be associated with collinearity problems.[20]

We considered a variety of productivity estimation methodologies, including Olley and Pakes (1991), Levinsohn and Petrin (2003), Ackerberg, Caves, and Frazer (2006), and Gandhi et al. (2012).[21] Gandhi et al. (2012) use a transformation of the firm's first order condition for flexible inputs that does not require finding instrument for the flexible inputs or subtracting them from output. The transformation enables a nonparametric regression of the flexible input revenue share against all observed inputs to non-parametrically identify the flexible input's production elasticity and the ex-post shocks. We report our primary results based on productivity estimates obtained using Ghandi et al.'s (2012) technique, but confirm that the findings are qualitatively similar when other estimation methods are used.

We estimate the production function for each NAICS 4-digit industry and obtain the productivity of each firm based on industry-specific production function estimates. In the empirical analysis, we divide the 6-year period into two sub-periods—2002-2004 and 2005-2007—and investigate how multinational entry affects host-country domestic firms.[22]

[19] Revenue, asset, and material cost are deflated in the data. We obtained industry-level revenue, asset, and material cost deflators from the EU KLEMS, the OECD STAN database, and some other national data sources. For countries without industry-level deflators, we used national income and capital deflators. See Section 6.2 for discussions on the implications of unobserved price information and the robustness analysis.

[20] Gandhi et al (2012) show that the methods suggested by Ackerberg, Caves, and Frazer (2006), and Wooldrige (2009), which are based on a quasi-fixed assumption on the inputs included in the production function, mantain the same identification problems.

[21] Van Biesebroeck (2008) and Syverson (2011) provide a comparison of several different productivity estimation methods and show them to produce similar productivity estimates.

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

4 Econometric Evidence

In this section, guided by the framework described in Section 2.5, we assess the entry of multinational firms and its effects on domestic market reallocation and knowledge spillover.

4.1 The Entry Decision of Multinational Firms

We begin our empirical analysis by examining the entry of foreign multinational firms. To proceed, we estimate the following equation adopted from equation (19):

$$\Pr\left[entry_{kijs}=1\right]=\Phi\left[\ln\theta_{ki}+\left(\frac{1}{\varepsilon-1}\right)\ln\varphi_{kijs}+FE_{ijs}>0\right], \tag{26}$$

where $entry_{kijs}$ represents the binary decision of a multinational firm k (headquartered in country i) to invest in a given host country j and industry s in 2005-2007, θ_{ki} is the lagged productivity of multinational firms estimated on the basis of headquarters activities in 2002-2004, φ_{kijs} is the change in firm k headquarters' cash flow (deflated by industry real exchange rates between headquarters and host countries), and FE_{ijs} is a vector of country-pair-industry dummies. Because we examine the entry decision in a single period, the time dimension is suppressed in the fixed effect. As discussed earlier, the change in multinationals' financial constraints, a factor that could influence multinationals' fixed cost of foreign investment, serves as an exclusion restriction in the second-stage estimations to identify the causal effect of multinational production.

Table 1 reports the estimation results of equation (27).[23] We find that, as expected in Section 2, more productive firms exhibit a greater likelihood of entering foreign countries, a result consistent with Helpman, Melitz and Yeaple (2004), Yeaple (2009), and Chen and Moore (2010). Further, firms whose headquarters experience a greater positive cash flow shock are more likely to enter new host countries, suggesting that a decrease in financial constraints could prompt new entries. These findings are robust to the inclusion of either host-country-industry or country-pair-industry fixed effects, which control for all (time-variant and time-invariant) country-industry and country-pair-industry factors that could affect multinationals' entry decisions, including the possibility that multinationals

[23] We use a linear probability model to avoid the incidental parameter problem that arises in fixed-effect maximum likelihood estimators.

are attracted to host countries with higher productivity growth. In addition, firm-level clustering is used to allow for correlations of errors within each firm.

Based on the estimates, we then obtain the predicted probability of entry for each multinational firm $\widehat{\Pr}\left[entry_{kijs}=1\right]$ and the expected number of new multinational firms in each host country $\widehat{z}_{Mjs} \equiv \sum_{k,i} \widehat{\Pr}\left[entry_{kijs}=1\right]$, the latter to be 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 endogenous entry of multinational firms.[24] Before examining the empirical framework described in Section 2.5, we first estimate the net effect of new multinational entry on the average productivity of 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 behind these estimates. First, comparing the OLS and the instrumented results, we find that failure to account for the endogenous entry of multinational firms can lead to an over-estimation of the effect of multinational production. According to column (2), a one-standard-deviation increase in the probability of new multinational entry is associated with a 0.02-standard-deviation increase in average domestic productivity, as opposed to a 0.05-standard-deviation increase according to the OLS results. The lower estimate in the instrumented equation suggests that there indeed exists potential reverse causality between multinational entry and host-country TFP growth and our first-stage estimation helps to address the issue. Second, as our theoretical framework shows, increases in average domestic productivity can arise from both knowledge spillover and market reallocation. Looking at the relationship between multinational production and average domestic productivity alone does not allow us to distinguish between the two sources of productivity gains. We therefore next use the empirical framework in Section 2.5 to help identify the relative importance of market reallocation and knowledge spillover.

[24] Given that firm productivity and MNC entry are both obtained from first-stage estimations, we bootstrap the standard errors in all the estimations.

4.2 Market Reallocation

We first examine the survival of individual domestic firms by estimating

$$\Pr\left[survival_{kjs}=1\right]=\Phi\left[\beta_0+\beta_1\ln\theta_{kjs}+\beta_2\ln\underline{\theta}_{Djs}+\beta_Z\widehat{z}_{Mjs}+FE_j+FE_s\right], \quad (27)$$

where $survival_{kjs}$ represents whether a domestic firm k operating in industry s and country j continues production in 2005-2007, θ_{kjs} is the lagged productivity of the domestic firm, $\underline{\theta}_{Djs}$ is the lagged cutoff domestic productivity in country j and industry s, $\widehat{z}_{Mjs}$ is the predicted number of new multinational entries obtained from the first-stage equation (26), and FE_j and FE_s are vectors of country and industry dummies, respectively, controlling for all (time-variant and time-invariant) country and industry factors. Because only the lagged productivity is observable for exiting firms, β_Z represents the cumulative effect of new multinational entry on the survival probability of domestic firms, including the positive knowledge spillover effect and the effects on capital and aggregate prices. In addition, we include country-industry clustering to allow for correlations of errors within each cluster.

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 the market reallocation effect dominates the knowledge spillover effect in explaining the aggregate impact of multinational entry on domestic firms' survival.

Alternatively, we estimate directly changes in the cutoff productivity of domestic firms in each country and industry following equation (22) in Section 2.5:

$$\ln\underline{\theta}'_{Djs}-\ln\underline{\theta}_{Djs}=\beta_D\widehat{z}_{Mjs}. \quad (28)$$

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 $\beta_D\equiv\frac{1}{\varepsilon-1}\ln\frac{c'}{c}+\ln\frac{P}{P'}=0.83$, implying that a 100-percentage-point increase in the probability of a new multinational entry is associated with a 83-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 market.[25]

4.2.1 Labor Market Reallocation

To evaluate the labor market reallocation effect of multinational production, we assess changes in the revenue distribution of surviving domestic firms, based on equation (24), by tracking firms in different percentiles of the ex-ante revenue distribution:

$$\ln r'_{Djs}(q) - \ln r_{Djs}(q) = (\varepsilon - 1)(\beta_P + \beta_\theta)\widehat{z}_{Mjs}, \tag{29}$$

where $\beta_P \equiv \ln(P'/P)$ and $\beta_\theta \equiv \ln \tau_\theta$.

The lower panel of Table 5 suggests that a higher likelihood of multinational entry leads to a significant decrease in revenue for firms at all percentiles.[26] The magnitude of the decline is, however, the greatest at the 50th percentile, suggesting that the medium-size domestic firms see the greatest contraction in their revenue.[27]

4.2.2 Capital Market Reallocation

Next we estimate the effect of foreign multinational entry on domestic capital markets by examining the following equation adopted from equation (23) in Section 2.5:

$$\ln \underline{r}'_{Djs} - \ln \underline{r}_{Djs} = \beta_c \widehat{z}_{Mjs} \tag{30}$$

where $\ln \underline{r}'_{Djs} - \ln \underline{r}_{Djs}$ is the change in the cutoff revenue of domestic firms in each country j and industry s and $\beta_c \equiv \ln(c'/c)$, expected to be positive, captures the effect of foreign multinational production on capital price. Again, to address the endogenous entry of foreign multinationals, z_{Mjs} is replaced with $\widehat{z}_{Mjs}$ from equation (26).

[25] To address potential noise in the level of cutoff productivity, we also used alternative measures of cutoffs such as the bottom 10th percentile and the mean of the bottom 10 percentiles. In Section 6, we further explore different moments of the theoretical framework that are not dependent on productivity estimates and focus on countries with comprehensive coverage. The results are qualitatively similar.

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

[27] While the monopolistic competition model adopted in the paper abstracts from reallocation through product market competition (due to the CES specification), the latter is captured by the estimated effect of multinational entry on the revenue distribution of domestic firms. In Section 6.2, we further discuss the implications of variable markups and the robustness of our results.

As shown in column (2) of Table 4, we find that a higher probability of multinational entry significantly increases the cutoff revenue of domestic firms. In particular, $\beta_c \equiv \ln(c/c_A) = 0.49$, which implies that a 100-percentage-point increase in the likelihood of a new multinational entry is associated with a 49-percent increase in the unit capital price.

4.3 Knowledge Spillover

Finally, we assess the extent of knowledge spillover by examining the productivity distribution of domestic firms following equation (25):

$$\ln \theta'_{js}(q) - \ln \theta_{js}(q) = \beta_\theta \widehat{z}_{Mjs}, \tag{31}$$

where $\beta_\theta \equiv \ln \tau_\theta$ captures the magnitude of knowledge spillover.

The upper panel of Table 5 reports the results. The estimates suggest that a higher probability of new multinational firms increases the productivity of domestic firms at both the 25th and 75th percentiles with β_θ around 0.05. This implies $\tau_\theta = 1.05$, that is, a 5-percent upward shift in those ranges of the productivity distribution. The productivity in the middle range is not found to be significantly affected.

Given the estimates of equations (28)-(31), we can now obtain estimates of $\beta_P \equiv \ln(P'/P)$, $\beta_c \equiv \ln(c'/c)$, $\beta_\theta \equiv \ln \tau_\theta$ and ε. Table 6 provides a summary of the estimated parameters.

5 Quantifying the Gains from Greater Multinational Production

In this section, we perform counterfactual analysis and quantify the aggregate as well as the decomposed productivity gains from greater multinational production.

The aggregate productivity gains of domestic firms are given by:

$$\Delta\widetilde{\theta}_D = \frac{\widetilde{\theta}'_D}{\widetilde{\theta}_D} - 1, \tag{32}$$

$$\text{where } \widetilde{\theta}'_D = \frac{1}{1-G(\underline{\theta}'_D)}\left[\int_{\underline{\theta}'_D}^{\infty}(\tau_\theta\theta)^{\varepsilon-1}g(\theta)d\theta\right]^{\frac{1}{\varepsilon-1}}$$

represents the expected aggregate domestic productivity given new multinational entry and $\widetilde{\theta}_D$ is the actual aggregate productivity prior to the entry. Using the estimates of β_P, β_c, and τ_θ from Section 4, we obtain the predicted cutoff productivity for each host country and industry, i.e., $\widehat{\underline{\theta}}'_D$, the expected fraction of surviving domestic firms, $1-G(\widehat{\underline{\theta}}'_D)$, and the expected productivity of surviving domestic firms in each host country, $\widehat{\widetilde{\theta}}'_D$.

The results, summarized in the lower panel of Table 6, suggest that aggregate domestic productivity increases by 1.22 percent when the probability of a new multinational entry rises by 100 percentage points. Next we decompose the productivity gains of domestic firms into two parts: gains from knowledge spillover and gains from market reallocation.

Productivity Gains from Knowledge Spillover The productivity gains as a result of knowledge spillover can be estimated by assuming away the effects of market reallocation, that is, by setting $\beta_P, \beta_c = 0$:

$$\Delta\widetilde{\theta}_D\Big|_{\beta_P,\beta_c=0} = \frac{\widetilde{\theta}'_D}{\widetilde{\theta}_D}\Big|_{\beta_P,\beta_c=0} - 1. \tag{33}$$

We find that knowledge spillover alone leads to about a 0.43-percent increase in domestic productivity (or equivalently 35 percent of the domestic productivity gain).

Productivity Gains from Market Reallocation The productivity gain as a result of market reallocation alone (while assuming zero knowledge spillover) is given by:

$$\Delta\widetilde{\theta}_D\Big|_{\beta_\theta=0} = \frac{\widetilde{\theta}'_D}{\widetilde{\theta}_D}\Big|_{\beta_\theta=0} - 1. \tag{34}$$

The estimates imply a 1.04-percent increase in domestic firm productivity (or equivalently 85 percent of the total domestic productivity gain) when market reallocation is the

only operative channel.[28] This result suggests that it is important to take into account the role of market reallocation in determining the productivity gains from multinational production. Ignoring this source can substantially underestimate the productivity increases, leading to significant bias in understanding the nature and magnitude of gains from multinational production.

6 Discussion and Robustness Analysis

6.1 Labor Market Reallocation: Additional Evidence

In this subsection, we offer additional evidence of labor market reallocation by looking directly at labor employment measures. First, we examine the employment distribution of domestic firms. Section 2 predicts a reallocation of labor from domestic to multinational firms and from less efficient to more efficient domestic firms. This motivates us to assess shifts of the employment distribution at different percentiles. As expected, we find new multinational entry leads to a decrease in employment at the 25th percentile but to no significant changes at the 50th and 75th percentiles (Table 7). This result suggests that the relatively smaller domestic firms are crowded out in the labor market by the new multinational firms, lending support to the prediction of labor market reallocation.[29]

Second, we consider the average wage rate of domestic firms. Section 2 predicts an increase in wage rate as a result of increased labor demand by foreign multinational firms. To examine this hypothesis, we compute the average unit labor cost for domestic firms in each country and industry. As shown in Table 8, we find that a 100-percent increase in the probability of new multinational entry leads to a 2-percent increase in average wage rate.

6.2 Measure of Productivity

In our main analysis, we estimate firm productivity using a new methodology developed by Ghandi et al. (2012). We have also compared our results using productivity estimates

[28] Note that given our decomposition approach, the decomposed gains from the two sources are not additive here in obtaining the total gains.

[29] Note that the estimates here capture only labor reallocation from (small) surviving domestic firms to multinationals. In the meantime, labor has also been reallocated from domestic firms that exited the market due to multinational entry shown in Section 4.2.

obtained based on Levinsohn and Petrin (2003), Ackerberg, Caves, and Frazer (2006), and simple labor productivity, and found the results to be qualitatively similar, all suggesting market reallocation to constitute an important source of gains from multinational production.

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. We therefore 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 market reallocation should be an important source of gains from multinational production—should not depend on the availability of physical output data or on productivity estimation methodologies. Considering knowledge spillover as the only mechanism by which countries realize productivity gains from multinational production would lead to a biased understanding of both the nature and the magnitude of the gains, even if physical output or true productivity were observed. Further, as shown in the previous section 6.1, direct analysis of the employment distribution provides additional evidence.

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

Given the difficulty of obtaining the data required for measuring output-based productivity, one of the solutions suggested in the literature is to focus on homogeneous goods. Therefore, as an additional robustness check, we re-estimate equation (31) for industries

[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.

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 that industries with more homogeneous products have higher import demand elasticities. We re-estimate equation (31) 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 4 percent at both the 25th and the 75th percentiles while there is no significant change at the 50th percentile. Moreover, we find that the productivity distribution becomes more left truncated, indicated by an increase in the cutoff productivity in equation (28), suggesting market reallocation in the domestic market.[31]

6.3 Data Coverage

The dataset used in our empirical analysis spans 60 countries. While this enables us to evaluate the productivity gains from multinational production based on a broad set of countries, the estimates can be affected by the data coverage across countries. For example, national public registries, an important source of our data, vary in their data reporting criteria. Some registries impose certain minimum-size criteria on, for example, revenue, censoring the data on the left tail. Such data censoring issues are likely to make it difficult to identify the market reallocation effect through exploring changes in the left truncations of the productivity and the revenue distributions, as the left truncations of these distributions should have little change over time.

In this subsection, we take several measures to address possible data sampling issues, including focusing on countries with arguably relatively better data coverage and no restrictions on data reporting, performing falsification tests by manually truncating the data in all countries, and considering stratified sampling.

[31] In industries with heterogeneous products, another factor that could lead to the shift of the productivity distribution is that domestic firms might engage in productivity self-upgrading in response to foreign multinational competition. In a recent study, Bao and Chen (2013) examine the issue by constructing a database of foreign investment news and investigating the responses of domestic firms to the threat of new multinational entry.

First, we restrict the analysis to countries with the largest number of domestic firms. Our earlier results remain qualitatively robust. For example, a 100-percentage-point increase in the probability of a multinational entry is associated with a 53-percent increase in cutoff productivity and a 33-percent increase in cutoff revenue. The analysis also shows the existence of knowledge spillover, but limited to low-productivity domestic firms. Domestic firms with medium or high productivity do not see a rightward shift.

[Additional robustness results to be added]

6.4 The Role of Trade

Our empirical analysis so far controls for all time-invariant country-industry factors by taking first differences of the key outcome equations (for example, cutoff productivity and revenue) between the two sub-periods and all time-variant country factors as well as time-variant industry characteristics through the use of fixed effects. Still, a possible concern that could arise is that observed changes in domestic productivity and revenue distributions might be driven by other factors such as export and import growth. For example, greater import competition could similarly lead to increases in cutoff productivity and a leftward shift of the revenue distribution. Increases in export activity, on the other hand, could shift both productivity and revenue distributions rightward when there is significant learning by exporting.

We adopted two strategies to address this concern. First, we accounted for the endogeneity of multinational entry in the first stage by instrumenting with multinationals' ex-ante cash flow shock. Our analysis shows that foreign multinational entry exerts significant market reallocation and knowledge spillover effects even when we take into account the potential endogeneity issue. Second, we explicitly controlled for export and import growth in host-country industries. We obtained cross-country industry-level export and import data from the UN COMTRADE and computed the export and import growth rates between 2002-2004 and 2005-2007. We found that controlling for the role of trade slightly lowers the estimated effect of multinational entry on cutoff productivity and on the productivity distribution.

Alternatively, one may consider that differences across horizontal, vertical, and export-platform FDI might affect the gains from multinational production through the role of trade. In this paper and, in particular, in our theoretical analysis, we focus on real-

location effects stemming from increased factor (labor and capital) demand by foreign multinational firms. As these effects apply to all types of FDI, our main qualitative point—that market reallocation constitutes an important source of gains from multinational production—remains valid.[32]

6.5 Between-Industry Factor Reallocation and Knowledge Spillover

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.

We first consider how increased multinational production in one industry may cause increased demand for labor and capital and subsequently factor reallocations in 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 an industry-pair's similarity in occupational labor requirements, $Labor\ similarity_{ss'}$. 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 (for example, 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. (2010), we convert occupational employment counts into occupational percentages for each industry and measure the correlation of each industry pair s and s'in occupational percentages. Second, we attempt to evaluate capital-good market externality by constructing a measure of industries' sim-

[32]Product market competition, the extent of relationships to domestic upstream and downstream industries, and the degree of knowledge spillover might, however, depend on the final market of foreign multinationals (see, among others, Markusen and Venables, 1999; Markusen, 2002, for related theoretical work). As in the case of most cross-country firm-level datasets, Orbis does not report intra-firm trade data to differentiate between the different types of FDI. One alternative is to use input-output tables and industry codes to identify potential production linkages between MNC headquarters and subsidiaries (as in Alfaro and Charlton, 2009). However, this would not be able to distinguish export-platform FDI from the rest. Assessing the gains from different types of FDI thus remains an important topic of research that could be advanced by availability of cross-country intra-firm trade data.

ilarity in demand for capital goods, $Capital - good\ similarity_{ss'}$. 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 (for example, motors and generators, textile machinery, mining machinery and equipment, wood containers and pallets, computer storage devices, and wireless communications equipment) by using industry. We measure the similarity of each using-industry pair s and s' in capital-good demand by the correlation of investment flow vectors.

Constructing the industry-relatedness measures using 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 those of most other countries.

We interact the two measures of industry-relatedness with predicted multinational production in each industry s' and compute the weighted sum of multinational production in industries with similar labor and capital-good demand.

We also explore the possibility of knowledge spillover 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 market reallocation when analyzing the gains from multinational production. However, as mentioned in the introduction, there is important evidence for knowledge spillover from foreign firms to domestic firms through vertical production linkages. Therefore, 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, $Backward\ linkage_{ss'}$ and $Forward\ linkage_{ss'}$, to measure the extent of the input-output relationships between each pair of industries. $Backward\ linkage_{ss'}$ measures the share of a downstream industry s' inputs that come from an upstream industry s and $Forward\ linkage_{ss'}$ the share of a downstream industry s inputs that come from an upstream industry s'. 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 s' and compute the weighted sum of multinational production in downstream and upstream industries, respectively.

[Results to be added]

7 Conclusion

Identifying gains from greater 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 from market reallocation. However, this task cannot be accomplished by simply examining the relationship between multinational production and host-country average productivity, as both channels predict a positive relationship. We thus develop a standard model of monopolistic competition and heterogeneous firms to address simultaneously the endogenous entry of multinational firms and the knowledge spillover and market reallocation effects of multinational production.

Our theoretical framework suggests that, while both market reallocation and knowledge spillover predict a positive relationship between openness to multinational production and aggregate domestic 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 and revenue distributions; market reallocation, in contrast, causes a 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 1.2 million public and private manufacturing companies in 2002-2007. Our empirical evidence suggests that multinational production leads to not only knowledge spillover but also factor reallocation in domestic markets. Entry of multinational firms raises the cutoff productivity of domestic firms, pushing the least productive 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 all the percentiles considered. In contrast, the productivity distribution of domestic firms shifts rightward, while the distribution becomes

more left truncated.

When quantifying the gains from multinational production, we find that, when the probability of a new multinational entry increases by 100 percentage points, the aggregate domestic productivity increases by 1.22 percent, with market reallocation alone accounting for 1.04 percent. These results suggest that it is critical to take the role of market reallocation into account when assessing the gains from multinational production. Ignoring this source can lead to a biased understanding of the nature and the magnitude of the productivity gains, with consequent biases in the design of FDI and industrial policies.

Two potential extensions of our analysis are worthy of particular attention. First, knowledge spillover and market reallocation might take a longer term to fully realize in domestic economies. Our estimates thus capture the lower bound of the total gains from multinational production due to the time length of the available data. It would be useful to investigate the long-run impact of multinational competition when longer time-series data are available. Second, future work would explore the heterogeneous gains from multinational production across countries. For example, how might domestic labor-market rigidities and financial markets affect the extent of factor market reallocation and the subsequent productivity effects of multinational production? How might the different levels of domestic human capital and technology stock across host countries 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.

8 Data Appendix

[TO BE COMPLETED].

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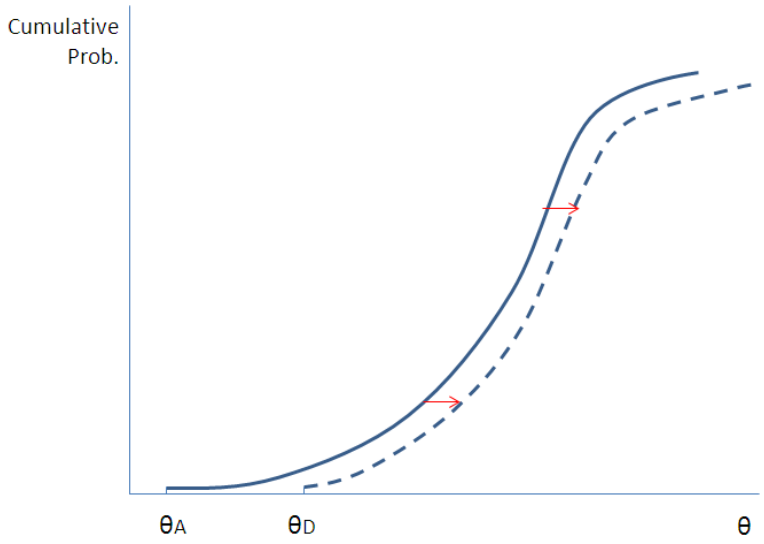

Figure 2: The productivity distribution before and after multinational entry

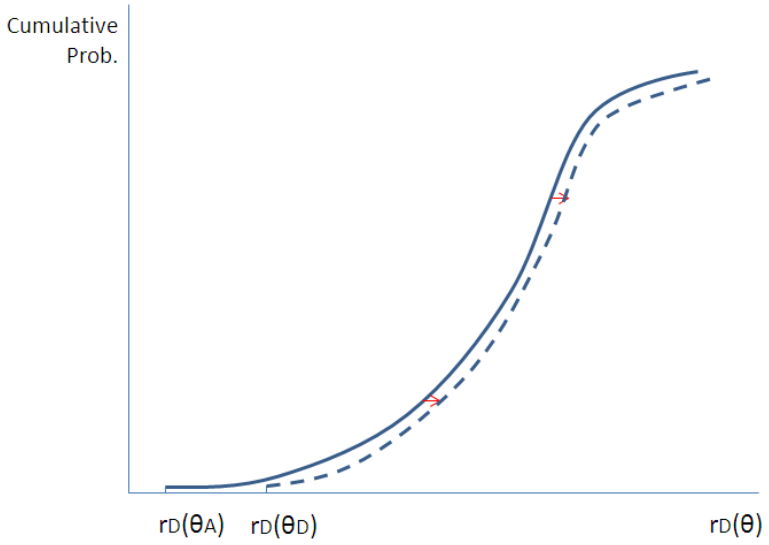

Figure 3: The revenue distribution before and after multinational entry (case I)

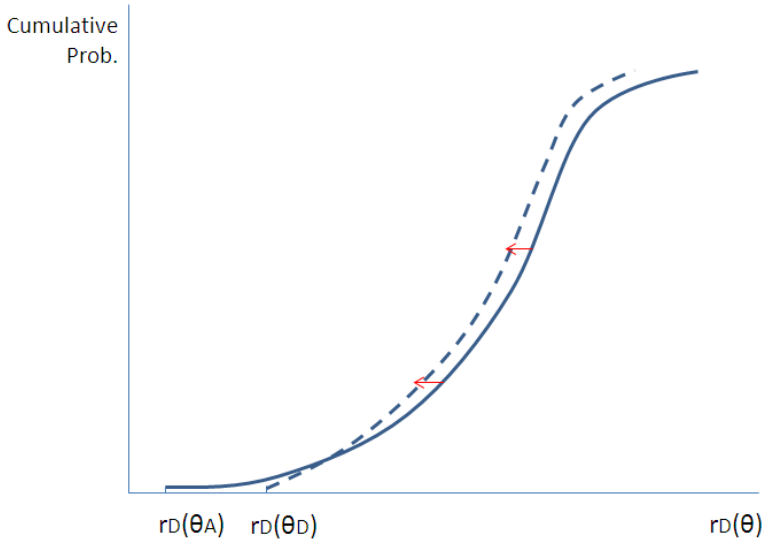

Figure 4: The revenue distribution before and after multinational entry (case II)

Table 1: The Entry Decision of Multinational Firms (Firm-Country Level)

Dependent variable:	(1) MNC entry	(2) MNC entry
HQ TFP	0.002***	0.001*
	(0.001)	(0.000)
Financial shock	0.002***	0.003***
	(0.001)	(0.001)
Host-country-ind FE	Yes	Yes
Country-pair-ind FE	No	Yes
Firm cluster	Yes	Yes
Obs	405,728	405,728
R square	0.04	0.33

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 Entry and Change in Average Productivity

Dependent variable:	(1) Change in ave TFP	(2) Change in ave TFP
MNC entry	0.01***	
	(0.004)	
MNC entry (predicted)		0.02**
		(0.01)
Beta coefficients	0.05	0.02
Host country FE	Yes	Yes
Industry FE	Yes	Yes
Obs	3,730	3,730
R square	0.52	0.52

Notes: (i) Columns (1) and (2) report OLS and instrumented 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: Survival of Domestic Firms

Dependent variable:	(1) Survival	(2) Survival
MNC entry (predicted)	-0.0004***	-0.001***
	(0.0001)	(0.0003)
Cutoff TFP (lagged)	-0.0001***	-0.0001***
	(0.0000)	(0.0000)
Firm TFP (lagged)	0.001***	
	(0.0001)	
Firm Revenue (lagged)		0.003***
		(0.0001)
Host country FE	Yes	Yes
Industry FE	Yes	Yes
Obs	407,975	616,270
R square	0.06	0.10

Notes: (i) Linear probability 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 4: Changes in Cutoff TFP and Revenue

Dependent variable:	(1) Change in cutoff TFP	(2) Change in cutoff revenue
MNC entry (predicted)	0.83***	0.49***
	(0.09)	(0.07)
Host country FE	Yes	Yes
Industry FE	Yes	Yes
Obs	3,730	5,300
R square	0.37	0.36

Notes: (i) Weighted least square 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: Shifts of Domestic Productivity and Revenue Distributions

	(1)	(2)	(3)
	25th Percentile	50th Percentile	75th Percentile
Panel A: Change in TFP			
MNC entry (predicted)	0.047**	-0.012	0.054**
	(0.025)	(0.029)	(0.024)
Host country FE	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes
Obs	2,673	2,673	2,673
R square	0.06	0.10	0.07
Panel B: Change in revenue			
MNC entry (predicted)	-0.031*	-0.062***	-0.045***
	(0.020)	(0.021)	(0.019)
Host country FE	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes
Obs	5,969	5,969	5,969
R square	0.06	0.06	0.06

Notes: (i) 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: Parameters and Estimated Productivity Gains

Parameters	Estimates
Cutoff productivity	0.83
Cutoff revenue/Capital price	0.49
Aggregate real price	-0.12
Revenue – 25th perc.	-0.03
Revenue – 50th perc.	-0.06
Revenue – 75th perc.	-0.04
Knowledge spillovers – 25th perc.	0.05
Knowledge spillovers – 50th perc.	0
Knowledge spillovers – 75th perc.	0.05
TFP Gains (in percentage)	Estimates
Aggregate Domestic TFP	1.22
Market Reallocation	1.04
Knowledge Spillover	0.43

Notes: The table summarizes the parameter estimates and the predicted productivity gains when the probability of a new multinational entry increases by 100 percentage points.

Table 7: Robustness: Shift of Domestic Employment Distribution

Dependent variable:	(1) 25th Percentile	(2) 50th Percentile	(3) 75th Percentile
	Change in employment		
MNC entry (predicted)	-0.01*	-0.001	0.001
	(0.00)	(0.01)	(0.01)
Host country FE	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes
Obs	4,052	4,052	4,052
R square	0.09	0.09	0.09

Notes: (i) 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 8: Robustness: Change in Average Wage Rate of Domestic Firms

Dependent variable:	(1) Change in ave wage
MNC entry (predicted)	0.033***
	(0.003)
Host country FE	Yes
Industry FE	Yes
Obs	3,407
R square	0.33

Notes: (i) Weighted least square 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 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