

# Foreign Ownership, Selection, and Productivity\*

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## Abstract

Using a unique firm level panel data set from several advanced countries, we show that both financial foreign investors (e.g., private equity, banks, and hedge funds) and industrial foreign investors select high productivity manufacturing firms. Foreign firms endogenously select firms based on their expected future productivity growth, which likely depends on many features of the target firms beyond those observable from the balance sheets. We construct a measure of exogenous changes in FDI which allows us to investigate the causal effect of foreign direct investment (FDI) on the productivity of target firms. Our measure is motivated by the similarity of financial and industrial investors in their selection of target firms. We find that exogenous changes in FDI lead to increased productivity although the effect is relatively small (compared to some previous estimates) and realized with a lag of several years.

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# 1 Introduction

The biggest shareholder in large companies such as Apple, Nestle, and McDonald's is the private equity firm BlackRock. It owns a stake in almost every listed company not just in America but globally—with over 4 trillion USD worth of directly controlled assets, it is the single biggest investor in the world.<sup>1</sup> Recent UNCTAD data shows that nearly 40% of private equity M&A deals in the last five years involved manufacturing firms (See Figure 1).

We examine how productivity of manufacturing firms relates to acquisitions by foreign financial investors, such as BlackRock, and to acquisitions by industrial investors. We show that both foreign financial investors (private equity, banks, hedge funds) and industrial foreign investors hold assets in firms with above average productivity; however, firms owned by foreign industrial owners are more productive than firms owned by foreign financial owners. Under the assumption that this observed difference reflects the impact of more intense management by industrial owners, we control for endogenous selection on time-varying characteristics that are unobservable by researchers and quantify the productivity improvements resulting from foreign investment.

Our data comes from the ORBIS database which is compiled by Bureau van Dijk Electronic Publishing (BvD). It covers 60 countries worldwide, including both developed and emerging countries; however, this study uses only data from 9 advanced countries which have comprehensive data both on industrial and financial FDI. ORBIS has financial accounting information from detailed harmonized balance sheets and profit and loss accounts of all companies. In terms of coverage, the database is crucially different from the other data sets that are commonly used in the literature, such as Compustat (for the United States), Compustat Global, and Worldscope databases in that 99 percent of the companies in ORBIS are private, whereas the data sets mentioned contain information mainly on large listed compa-

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<sup>1</sup>Economist, December 2013.

nies.<sup>2</sup> A fundamental advantage of our data is the detailed ownership information, encompassing over 30 million “links” between companies and their shareholders. For each target/affiliate/subsidiary company we know the amount of foreign investment in company stock, together with the country of origin of the investor and the type of foreign investor, whether financial or industrial, with ownership shares that vary over time. In the following, we for brevity refer to investment by these different types of investors as “financial FDI” and “industrial FDI.”

Two well known findings in the literature are that multinational subsidiaries generally outperform domestic firms,<sup>3</sup> and the most prevalent form of multinational entry is through acquisition, rather than greenfield investment.<sup>4</sup> These facts suggest that the superior performance of companies receiving FDI could be due to multinationals selecting domestic firms which *a priori* were better performing. It is not straightforward then to gauge how much of the correlation between ownership and productivity is due to selection and how much to active improvements caused by, say, transfers of superior technologies and organizational practices to foreign subsidiaries. In an influential paper, Guadalupe, Kuzmina, and Thomas (2012) investigate FDI and productivity, using a unique dataset from Spanish firms with information about how newly acquired subsidiaries increase productivity by investing and introducing new technologies. In order to control for selection, they implement a propensity score reweighting estimator, which controls for selection on observable factors, and obtain estimates of the average treatment effect of foreign acquisition on innovation. They find an important effect of FDI in terms of innovation and a 16 percent increase in total factor productivity (TFP) after a year (see Guadalupe, Kuzmina, and Thomas (2010)). Using a similar estimator, Arnold and Javorcik (2009) estimate

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<sup>2</sup>ORBIS’ firm coverage is similar to the Dun & Bradstreet and Compnet databases because they, like BvD, use official registers as the main source of information. However, ORBIS has an advantage over these databases for our purposes due to having full balance sheet variables and detailed international ownership links.

<sup>3</sup>See Caves (1974), Helpman, Melitz, and Yeaple (2004), Baldwin and Gu (2003), Ramondo (2009), Criscuolo and Martin (2009), and Arnold and Javorcik (2009).

<sup>4</sup>See Barba-Navaretti and Venables (2004).

the productivity effects of FDI for Indonesian firms, finding a 13 percent increase in TFP after three years.

Foreign owners may increase productivity of target firms through increased scale of production or through other means such as better management practices in addition to introducing new technologies (see Bloom and Van Reenen (2007)). For example, Aghion, Van Reenen, and Zingales (2013) look at the effects of institutional ownership on innovation and find a significant positive effect, regardless of whether such owners are foreigners or not. We argue that allowing for selection on firm-level time varying unobservable characteristics is important to understand all the mechanisms through which foreigners can impact productivity. We try to understand such mechanisms by using a novel source of exogenous variation to account for time-varying selection: both financial and industrial investors equally target firms with (unobserved by us) future growth potential, which allows us to difference out selection on unobservable factors.

We find a small significant (lagged) productivity effect of FDI once we account for time varying unobservable firm heterogeneity. Large changes in foreign ownership (from 50 to 100 percent) have a bigger effect than smaller changes. A large change in foreign ownership increases TFP by 3.7 percent over a four year span. Note that the effect of changes in foreign ownership on TFP is much larger in OLS/GLS regressions which do not account for selection on unobservables. Our IV-strategy is rather unique and can account for such selection. Foreign ownership is not normally distributed but rather clustered around shares of 0, 51, and 100 percent. This makes it unattractive to use standard IV estimation for continuous variables. We therefore suggest a discrete analog of IV, where we fit discrete categories of ownership change in a first stage and then, in a second stage, regress productivity changes on the predicted foreign ownership changes.

Another interesting finding is that negative changes in foreign ownership, where foreigners decrease their ownership shares while domestic owners increase theirs,

are also associated with positive TFP improvements. This result is consistent with productivity improvements coming from a change in ownership per se, which will typically be associated with restructuring and better management practices, rather than having the new owner (or owners) being a foreigner who brings a new technology. In fact, our preliminary results on the channels through which a change in foreign ownership affects TFP suggest that out of three possible mechanisms—innovation/hard technology transfer, scale economies, soft technology transfer—the most likely channel is soft technology transfer. This is because employment changes very little and capital/labor ratio goes down (or moves little) as foreign ownership increases.

Most papers in the empirical FDI literature find a positive correlation between target’s productivity and foreign ownership: Conyon (2002) and Harris and Robinson (2003) for the UK; Fukao, Ito, Kwon, and Takizawa (2008) for Japan; Arnold and Javorcik (2009) for Indonesia; Criscuolo and Martin (2009) for the United States and Guadalupe, Kuzmina, and Thomas (2012) for Spain. This correlation is partly due to foreign investors choosing to invest in more productive firms and this selection has been labeled “cherry picking.” The theoretical and empirical finance literature typically focuses on the opposite case where financial investors target low productivity firms with growth potential and buy these firms at fire-sale prices. This literature asserts that underperforming firms are the most likely to be acquired (Lichtenberg and Siegel (1987)). Using a sample of recent EU member countries, Damijan, Kostevcz, and Rojec (2012) find that the selection criteria of target firms differ significantly across countries. In some countries, better firms are chosen as targets for acquisition while in others “lemons” with growth potential were selected. We can shed light on this literature in the sense that we can examine if different types of FDI—financial vs industrial—target different firms as conjectured by the theoretical literature.

The paper proceeds as follows. In Section 2, we describe the data. Section 3

investigates selection by financial and industrial investors while Section 4 estimates the productivity effects of FDI without accounting for endogeneity. Section 5 outlines our thought experiment that provides the exogenous variation in FDI and our IV strategy. Section 6 re-estimates the productivity effects controlling for selection on unobservable characteristics. Section 7 studies the balance sheets of acquired firms to understand the channels for the productivity effects of FDI and Section 8 concludes.

## 2 Data

We focus on a sample of advanced European countries during 1999–2008 for which we have comprehensive data on foreign financial investors; namely, Belgium, Germany, Spain, Finland, France, Italy, Norway, Portugal and Sweden. We focus only on manufacturing where we have 400,000+ firm-year observations.

### 2.1 Foreign Ownership: Industrial and Financial Investors

The ownership section of ORBIS contains detailed information on owners of both listed and private firms, including name, country of residence, and type (e.g., bank, industrial company, private equity, individual). The database refers to each record of ownership as an “ownership link.” An ownership link indicating that an entity A owns a certain percentage of firm B is referred to as a “direct” ownership link. BvD traces a direct link between two entities even when the ownership percentage is very small (sometimes less than one percent). For listed companies, very small stock holders are typically unknown.<sup>5</sup> We compute *Foreign Ownership* (FO) as the sum of

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<sup>5</sup>Countries have different rules for when the identity of a minority owner needs to be disclosed; for example, France, Germany, the Netherlands, and Sweden demand that listed firms disclose all owners with more than a five percent stake, while disclosure is required at three percent in the UK, and at two percent in Italy. Information regarding US companies taken from the SEC Edgar Filings and the NASDAQ, however, stops at one percent. BvD collects its ownership data from the official registers (including SEC filings and stock exchanges), annual reports, private correspondence, telephone research, company websites, and news wires.

all percentages of *direct* ownership by foreigners.<sup>6</sup> We define a firm to be “domestic” only if it never had *any* type of foreign owner during the sample period.

We define a *financial owner* as either a bank, financial company, insurance company, mutual or pension fund, other financial institution, or private equity firm while an *industrial owner* operates in the industrial sector, which can be the same or different to the target firm’s sector.  $FO_{i,s,c,t}^I$  (*Industrial FO*) and  $FO_{i,s,c,t}^F$  (*Financial FO*) are the shares owned by foreign industrial and financial investors, in firm  $i$ , sector  $s$ , country  $c$  and time  $t$ , respectively.

Table 1 displays the fraction of firms with foreign ownership. Focusing on firms with positive industrial or financial FO in at least one year, we observe that industrial FO clearly dominates financial FO. The share of output produced by foreign owned firms is around 15 percent. Figure 2 shows asset weighted shares of foreign ownership by type of investor and sector depicting great variation.

Foreign investment is not usually in the form of 100 percent ownership, but rather heterogenous. Given the possibility that such heterogeneity may interact with the wide range of heterogeneity in total factor productivity, documented by Syverson (2011), it is important to know the exact amount of investment. Due to data availability, the literature most often uses a dummy variable which indicates whether the firm is owned by an “overseas” entity in the amount of more than a certain percent, or use only 100 percent foreign-owned subsidiaries of multinationals.<sup>7</sup>

Figure 3 plots the total distribution of foreign ownership shares and, in Panels (b) and (c), separated by financial and industrial owners. The distributions are different for industrial and financial owners: industrial FO is clearly bi-modal. There is a spike in the number of firms with an ownership share around 50 percent, likely reflecting a desire to control the firm but the largest spikes are around full ownership (with more than 35 percent of cases involving full foreign ownership) and the second largest

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<sup>6</sup>For example, if a company has three foreign owners with stakes of 10, 15, and 35 percent, FO for this company is 60 percent.

<sup>7</sup>Exceptions are Javorcik (2004), Aitken and Harrison (1999), and Arnold and Javorcik (2009). Their samples are limited to firms from single countries.

spike (about 30 percent) is for ownership shares under 20 percent. The distribution of shares among foreign financial investors is completely different, with almost 65 percent of financial owners preferring to hold less than 20 percent of the firm equity. The distributions suggest that a majority of industrial owners desire control while a majority of financial owners may be looking for income diversification.

## 2.2 Variables and descriptive statistics

The main *financial variables* used are total assets, operating revenue, tangible fixed assets, and expenditure on materials. We convert financial variables to “PPP US dollars with 2005 base,” using country GDP deflators (2005 base) and converting to dollars using the end-of-year 2005 exchange rate. The distribution of these (logged) variables does not change much over time and is very close to normal. Employment is in persons, and the distribution of employment is skewed with many firms having 15 employees (our chosen minimum).

*Firm productivity.* We construct TFP as the residual from a Cobb-Douglas production function with capital and labor:  $\log(\text{TFP}_{i,t}) = \log(Y_{i,t} - M_{i,t}) - \alpha_1 \log(L_{i,t}) - \alpha_2 \log(K_{i,t})$ , where the coefficients are estimated by the method of Wooldridge (2009) that improved upon Levinsohn and Petrin (2003) (WLP), as explained in Appendix.  $Y$  is output (operating revenue or sales),  $M$  is materials,  $K$  is capital (fixed tangible assets) and  $L$  is labor. We estimate TFP by country and sector and winsorize the resulting distribution at the 1 and 99 percentiles by country. However, similar results are obtained if TFP is estimated by country, rather than by country-sector, or if TFP is estimated by the method of Levinsohn and Petrin (2003). The results are also robust to the level of winsorizing chosen (we tried winsorizing the total sample at the 1 and 99 percentiles, winsorizing by country at the 5 and 95 percentiles, and by sector at the 1 and 99 percentiles, and at the 5 and 95 percentiles).

Table 2 displays descriptive statistics.  $\ln$  TFP has a mean of 11.7 with a standard deviation of 0.7 indicating large variation. A one standard deviation change

corresponds to roughly a doubling of TFP ( $2 \approx \exp 0.7$ ). On average, firms have 4.92 percent foreign ownership, with 4.71 percent industrial foreign ownership and 0.13 percent industrial ownership. There is a large spread in size, as measured by assets, and the average age is 20 years with a range from 0 to 319 years.

### **3 Do Foreign Firms Target More Productive Domestic Firms?**

Figure 4 plots the density distribution of *initial* TFP for domestic and foreign-owned companies. We focus on the sample of firms that were originally domestic (i.e., the percentage of foreign ownership is zero the first time we observe the firm in the sample) and plot the distribution according to whether the firm was foreign owned or not by the fourth year.

Panel (a) in Figure 4 shows that foreign owned firms by the fourth year had initially higher productivity compared to firms that remained domestic. We are not aware of any other study that distinguishes between industrial and financial foreign investors in the manufacturing sector and it is a priori not clear whether financial foreign owners target more productive local firms. On the one hand, financial investors seeking to diversify risk will select high performing firms, on the other hand, there is evidence that activist hedge funds target financially distressed firms and contribute to an efficient restructuring of economically viable firms (Brav, Jiang, and Kim (2009) and Lim (2013)). Panel (b) in Figure 4 shows that in the manufacturing sector both industrial and financial owners select initially more productive firms. It is clear that both foreign financial investors and industrial foreign investors hold assets in firms with above average productivity.

## 4 Do Foreign-Owned Firms Become More Productive After Ownership Change?

We now ask whether foreign-owned firms become more productive with increased foreign ownership; that is, we estimate dynamic relations with foreign ownership growth and productivity growth (for brevity: “difference regressions”).

We follow the approach of Javorcik (2004) and estimate the growth in TFP on the change in FO, experimenting with the length of the growth interval. We estimate the following equation:

$$\Delta^k \log(\text{TFP}_{i,s,c,t}) = \beta \Delta^k \text{FO}_{i,s,c,t} + \delta_{c,s,t} + \epsilon_{i,s,c,t}, \quad (1)$$

where  $\text{TFP}_{i,s,c,t}$  refers to total factor productivity of firm  $i$ , in sector  $s$ , in country  $c$ , at time  $t$ , and  $\text{FO}_{i,s,c,t}$  is the percentage of firm  $i$ 's capital owned by foreign investors at time  $t$ .  $\delta_{c,s,t}$  represents country-sector-year dummies. The lag-length  $k$  takes values between one and four; i.e.,  $\Delta^k x_t$  is  $x_t - x_{t-k}$ .

The parameter of interest is the “within” coefficient,  $\beta$ : a positive  $\beta$  implies that changes in foreign ownership are associated with increasing productivity relative to firms that stay domestically owned.

Table 3 examines the relationship between growth in foreign ownership and growth in firm total factor productivity in the manufacturing sector. As we have been emphasizing, accounting for firm selection is crucial and after differencing, all specifications in Table 3 are free of firm-specific time invariant effects. An additional factor, that we have not stressed so far, but is equally important is the role of country and sector selection. Foreigners may invest in growing countries or sectors resulting in reverse causality; consequently, we examine robustness to country and sector fixed effects (controlling for different trends in levels).

Columns (1) to (4) of Table 3 show the results for different time horizons without country and sector fixed effects. An increase in foreign ownership does not have an

immediate impact on productivity—only after three years is there a positive and statistically significant relationship between foreign ownership and firm productivity but the effect is larger at 0.017 after four years. The point estimate for the four-year differencing is significant at the 1 percent level and implies that a hundred percent increase in foreign ownership is associated with a 1.7 percent increase in firm productivity. This coefficient is robust to the inclusion of country and sector fixed-effects (see column (5)).

All these regressions are estimated by feasible Generalized Least Squares (GLS). There is a large difference in the variance of the error terms across firms, so GLS is more efficient. We do this in two steps: first OLS estimation, and then we use residuals from the OLS estimation to calculate firm-specific standard errors which we then use to weight observations in the second step.<sup>8</sup>

Figure 5 shows the distribution of the change in foreign ownership at different time horizons. The distribution is near discrete with a large pile-up of observations at zero change—even at the four-year horizon. Other spikes are centered around plus/minus 100 percent and plus/minus 50 percent and because investors choose these particular investment points, it is quite possible that continuous regressions, such as those displayed so far, miss potentially important non-linear effects at these discontinuity points. In order to explore this, we discretize foreign ownership changes and estimate the following regression (at different lengths of the differencing interval):

$$\Delta^k \log(\text{TFP}_{i,s,c,t}) = \sum_{j=1}^4 \beta^j \Delta^k \text{FO}(j)_{i,s,c,t} + \delta_{c,s,t} + \epsilon_{i,s,c,t}, \quad (2)$$

where  $\text{TFP}_{i,s,c,t}$  refers to total factor productivity of firm  $i$ , in sector  $s$ , in country  $c$ , at time  $t$ , and  $\Delta^k \text{FO}(j)_{i,s,c,t}$ ,  $j = 1, \dots, 4$  are indicator variables depending on whether the  $k$ -period change in foreign ownership falls into each of the following categories:  $[-100\%, -50\%]$  for  $j = 1$ ,  $(-50\%, 0\%)$  for  $j = 2$ ,  $(0\%, 50\%)$  for  $j = 3$ , and

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<sup>8</sup>For comparison, OLS results are reported in Tables (A.1) and (A.2).

[50%,100%] for  $j = 4$ . A negative change in foreign ownership implies that foreigners are decreasing their share of ownership by selling to domestic owners. The left-out base category, labeled  $j = 0$ , refers to firm-years that did not experience any change in foreign ownership.  $\delta_{c,s,t}$  represents country  $\times$  sector  $\times$  year fixed effects and  $k$  is the length of the differencing interval.

Table 4 shows the results from estimating equation (2). Again, we see higher correlations for large differencing intervals. Likely, the changes introduced by foreign owned companies take time to be implemented. The correlation of foreign ownership changes with productivity changes increases, the larger the change in foreign ownership. Column (4) shows that after four years positive changes in foreign ownership are associated with higher productivity, such that a change to foreign majority ownership is associated with an increase in productivity of 3.1 percent, but interestingly big negative changes in foreign ownership have a similar impact on firm productivity. Large dis-investment by foreign owned companies are necessarily associated with large domestic investment (recall that ownership is measured in terms of fraction owned) and change of ownership from foreign to domestic owner could have a similar effect to that of foreign investment. In other words, target firms might benefit from large changes in ownership regardless of whether the majority owner is foreign or domestic.<sup>9</sup> This might be due to managerial or other forms of new practices (See Bloom, Sadun, and Van Reenen (2012)). Columns (5)-(7) verify that the results are robust to the inclusion of sector-year, country-year, and even country-sector-year fixed effects.

The positive correlation between foreign ownership and TFP found in Table 3, where we use continuous ownership changes and a linear specification, can be driven mainly by firms with increasing foreign ownership shares and increasing productivity or by firms with decreasing foreign ownership shares and decreasing productivity. Once we estimate the same regression with discrete ownership changes in Table 4,

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<sup>9</sup>A recent paper by Javorcik and Poelhekke (2014) also investigates negative changes in foreign ownership.

allowing for non-linearity, we find that both positive and negative changes in foreign ownership are associated with productivity improvements. Mechanically, this discrepancy occurs because the frequency of negative changes happening is much lower than the frequency of positive changes in our data as shown in Table 5, so the linear specification will be driven by positive changes in foreign ownership. The first two columns provide information on one year changes. As expected, the large majority of observations, above 97 percent, do not experience any change in ownership. Jointly, about 1 percent of firms experience a reduction in the share of foreign ownership and approximately 1.5 percent experience an increase in the share of foreign owners. In both cases, small changes of up to a share of 50 percent are slightly more likely to occur than large changes. In the last two columns, we look at four year lags. The number of observations with no changes in ownership is less than 92 percent at this time frame. Domestic owners increase their share in about 3 percent of the cases, equally distributed between small and large changes. Interestingly, the number of cases with an increase in the share of foreign owners rises to more than 5 percent.

Early studies (see Aitken and Harrison (1999) or Javorcik (2004)) find a positive and significant correlation between foreign ownership and firm productivity which turns insignificant once firm fixed effects are included. Therefore, these early studies find a positive correlation between foreign ownership and productivity levels but not between foreign ownership growth and productivity growth. Our set of control dummy variables guarantees that the results in Table 4 are not driven by foreign investors targeting growing countries, growing sectors, or firms with constant higher productivity. However, it is likely that forward looking foreign investors target firms whose productivity would be increasing even in the absence of foreign investment. We, therefore, still need to verify that our result can be given a causal interpretation. We analyze this in the next section starting with a description of the instrumental variable methodology in what follows.

## 5 Exogenous Changes in Foreign Ownership

Foreign ownership is a function of current and expected future productivity and a function of firm-level variables. We split current and expected future productivity into an “inherent” component,  $\text{TFP}^{\text{P}}$ , which reflects productivity that would materialize whether the firm received FDI or not (organic productivity), and an “active” component,  $\text{TFP}^{\text{A}}$ , which reflects productivity that materialize from active foreign ownership. The inherent component is the source of reverse causality and we aim to eliminate it. We assume that the functional forms linking these two components and amount invested are identical for industrial and financial owners, with the exception that industrial firms, which invest  $\text{FO}^{\text{I}}$ , expect larger future productivity gains from active ownership than do financial firms, which invest  $\text{FO}^{\text{F}}$ . Some financial investors change management practices in take-over targets (Brav, Jiang, and Kim (2009); Kaplan and Stromberg (2009)) but industrial owners can be expected to further bring blue-prints and operating experience (Guadalupe, Kuzmina, and Thomas (2012)); see also Aghion, Van Reenen, and Zingales (2013), who show that firms owned by “active” institutional investors are relatively more likely to innovate. We assume

$$\text{FO}_{i,t}^{\text{I}} = \alpha_i + \sum_{l=0}^L \gamma_l E_t \{ \text{TFP}^{\text{P}}_{i,t+l} \} + \sum_{l=0}^L \delta_l^{\text{I}} E_t \{ \text{TFP}^{\text{A}}_{i,t+l} \} + g(X_{it}, \phi) + e_{i,t} ,$$

where  $e_{i,t}$  is a noise term, and

$$\text{FO}_{i,t}^{\text{F}} = \alpha_i + \sum_{l=0}^L \gamma_l E_t \{ \text{TFP}^{\text{P}}_{i,t+l} \} + \sum_{l=0}^L \delta_l^{\text{F}} E_t \{ \text{TFP}^{\text{A}}_{i,t+l} \} + g(X_{it}, \phi) + e_{i,t} .$$

The error terms are orthogonal to current and future expected productivity shocks by construction (assuming  $L$ , i.e., the number of future periods is large enough). In order to control for the component of foreign investment that is endogenous to productivity, we would like to subtract financial foreign ownership from industrial foreign ownership at the firm level, expecting to remove the endogenous component

( $\text{TFP}_{i,t+l}^P$ ) from the foreign investment decision. In other words, both industrial and financial foreign owners are expected to target highly productive firms, including firms with high expected productivity growth, and the effect of this selection is captured by the  $\gamma_l$  coefficients which are common to both types of investors. The identifying assumption underlying the exogeneity of our instruments is that the  $\gamma_l$  coefficients are identical for industrial and financial owners.

Subtracting  $\text{FO}_{i,t}^F$  from  $\text{FO}_{i,t}^I$  would leave us with the expected productivity change after acquisition due to ownership changes. However, the majority of firms do not simultaneously have foreign industrial and financial owners. Our strategy is therefore to aggregate FDI to the sector level and take the contrast there, using sectoral FDI as an instrument for firm-level FDI. We do this by country and weigh FO by the size of the firm measured by operating revenue in the initial year we observe the firm  $Y_{i,0}$ , where we use the initial year in order to use weights that are not a function of foreign investment since year 0. We construct sectoral industrial investment,

$$\text{FO}_{s,c,t}^I = \frac{\sum_{i \in c,t,s} \text{FO}_{i,t}^I Y_{i,0}}{\sum_{i \in c,s,t} Y_{i,0}} ; \quad (3)$$

and sectoral financial investment,

$$\text{FO}_{s,c,t}^F = \frac{\sum_{i \in c,t,s} \text{FO}_{i,t}^F Y_{i,0}}{\sum_{i \in c,s,t} Y_{i,0}} . \quad (4)$$

Now,  $\text{FO}_{s,c,t}^D = \text{FO}_{s,c,t}^I - \text{FO}_{s,c,t}^F$ , satisfies

$$\text{FO}_{s,t}^D = \alpha_s + \sum_{l=0}^L \kappa_l E_t \{ \text{TFP}_{s,t+l}^A \} + e_{s,t} , \quad (5)$$

where country indices have been suppressed for readability.  $\kappa_l = \delta_l^I - \delta_l^F$ , which will be positive if industrial owners invest more for the purpose of increasing productivity through active management than do financial investors. This is not a maintained assumption. If the  $\kappa_l$  terms are near zero the exogenous regressor (“instrument”) we

construct in the following will have little explanatory power. Under our assumptions, industrial foreign ownership will correlate more than financial foreign ownership with productivity and this prediction we can test using sectoral data.

Table 6 shows the correlations between firm level productivity and industrial and financial investment at the aggregated country-sector level. The OLS-coefficient capturing the relation between foreign industrial investment and productivity, for four year differencing, is four times the size of the corresponding coefficient for foreign financial investment. This is consistent with our assumptions regarding the differential response of productivity to industrial and financial foreign ownership. The sectoral regression results imply that, on average, firms owned by foreign industrial owners are more productive than firms owned by foreign financial owners.

We next construct instruments for foreign investment. We take initial values of firm-level variables to be predetermined, while time variation in our instruments is derived from the country and sector-level variable  $FO_{s,c,t}^D$ . Such variation makes our instruments immune to many potential endogeneity problems. For example, some sectors (or countries) have high inherent productivity growth and are, therefore targeted by foreign industrial and financial investors. We construct our instruments such that all time variation are a function of the *difference* in investment patterns by financial and industrial investors.

Considering the patterns of FDI in Figure 3, it is clear that foreign investment clusters around 0 percent and 100 percent and any instrument that does not reflect this is unlikely to work well. Standard first stage regressions fit such a clustered distribution badly and we proceed by constructing discrete exogenous variables which reflect the clustering in the foreign ownership numbers.

We use the discrete categories of changes in foreign ownership we defined earlier. We have a total of five different categories ( $j = 0, 1, 2, 3, 4$ ), including the zero-change category ( $j = 0$ ), and we use a multinomial logit model to estimate the probability  $P(\Delta^k FO_{i,s,c,t} \in j)$  as a function of exogenous variables. Our specification

assumes the probability of outcome  $j = 1, \dots, 4$ , for differencing interval of length  $k$ , is proportional to

$$\begin{aligned}
P(\Delta^k \text{FO}_{i,s,c,t} \in j) &\simeq \exp\{\gamma_1^j \Delta^k \text{FO}_{c,s,t}^D + \gamma_2^j \Delta^k \text{FO}_{c,s,t}^D \times \delta_c & (6) \\
&+ \gamma_3^j \Delta^k \text{FO}_{c,s,t}^D \times \delta_s + \\
&\gamma_4^j \Delta^k \text{FO}_{c,s,t}^D \times \ln(\text{Assets}_{i0}) + \\
&X'_{i0} \phi^j + \delta_c + \delta_s + \delta_t\}
\end{aligned}$$

where  $\text{FO}_{c,s,t}^D$  is the contrast between industrial and financial investment at the country-sector level and the remaining right-hand side firm-level variables are predetermined:  $X_{i0}$  is vector of firm predetermined characteristics,  $\delta_s$ ,  $\delta_c$  and  $\delta_t$  refer to the sector, country, and year fixed effects. Outcome  $j = 0$  is normalized to have all coefficients equal to 0. Referring to all exogenous and predetermined variables as  $Z_{it}$  so we have

$$P(j) \equiv P(\Delta^k \text{FO}_{i,s,c,t} \in j) = \frac{\exp\{Z'_{it} \psi_j\}}{1 + \sum_{q=1}^4 \exp\{Z'_{it} \psi_q\}},$$

for 4 vectors of parameters  $\psi_q$ ,  $q = 1, \dots, 4$ .

From the multinomial logit estimation, we obtain the predicted probability ( $\hat{P}(j) = \exp\{Z'_{it} \hat{\psi}_j\} / (1 + \sum_{q=1}^4 \exp\{Z'_{it} \hat{\psi}_q\})$ ) that an observation falls into each of the five different categories  $j$  previously defined (note that for the zero-change category,  $\psi_0$  is normalized to zero.) Table 7 displays the estimated coefficients of selected regressors from the multivariate regression. (The full set of regressors is available from the authors.) The table demonstrates the important role of the country-sector level contrast ( $\Delta \text{FO}^D$ ) in financial and industrial FDI in predicting firm level FDI.

We next use the estimated probabilities to construct predicted changes in foreign ownership. For most firm-periods, the most likely outcome is zero change in foreign ownership and in order to roughly match the actual frequency of zero change we

assign firms to the zero-change category if the estimated probability of zero change is greater than 0.8. The 0.8 cut-off is chosen such that the predicted number of zero changes roughly match the actual number of zero changes in Table 5.<sup>10</sup> The remaining the firm-years, where the predicted probability of no-change in ownership below 0.8, are assigned to that category of the remaining four which has the highest predicted probability according to the rule:

$$\hat{\mathbf{j}}_{it} = \arg \max_j \hat{P}(j)_{it}; j \neq 0 .$$

We then construct indicator variables,  $\Delta^k \hat{\text{FO}}(j)_{i,s,c,t}$  taking the value of 1 if for observation  $it$  the predicted change in ownership falls in the category  $j$ , and 0 if the change falls in other categories. These indicator variables are the instruments that we propose to study the effect of foreign ownership on firm productivity.

## 6 The Effect of Exogenous Changes in Foreign Ownership on Firm Productivity

### 6.1 IV Results

Our main results can be found in Table 8 where the change in productivity is regressed on indicator variables for the changes in foreign ownership falling into categories  $\hat{\mathbf{j}}_{it}$ . The estimated regressions take the form (using the predicted change in FO,  $\Delta^k \hat{\text{FO}}(j)$ , from previous section):

$$\Delta^k \log(\text{TFP}_{i,s,c,t}) = \sum_{j=1}^4 \beta^j \Delta^k \hat{\text{FO}}(j)_{i,s,c,t} + \epsilon_{i,s,c,t} . \quad (7)$$

Columns (1)-(4) illustrate how the results change with the differencing interval. As in the earlier regressions, the effect is largest for the four year differencing and

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<sup>10</sup>The 0.8 cut-off results in the prediction that there is no change in foreign ownership for 88 percent of the firm-years, which compares to the 92 percent zero changes in Table 5.

we focus on those. We find that productivity increases significantly with foreign ownership, in particular for increases over 50 percent. The effect of large positive foreign ownership changes (i.e., changes of over 50 percent ownership) on productivity are 50 percent larger than the effect of small changes (i.e., changes of less than 50 percent). The effect of such large changes on TFP is 3.7 percent increase after four years.

We find a positive effect of small negative changes in foreign ownership. Compared to the results shown in Table 4 large negative changes in foreign ownership are no longer systematically associated with productivity increases. A potential reason for this finding is the fact that the time variation in our instrument is coming from country-sector data and not from firm-level and because the changes in foreign ownership at the sector level are mainly positive, the instrument will not capture increases in domestic ownership well (i.e., negative changes in foreign ownership). Overall, the coefficients in the IV estimation are somewhat smaller than those of the OLS/GLS regressions, which highlights importance of the accounting of the selection bias.

It is hard to properly adjust standard errors for the autocorrelation induced by overlapping intervals. We therefore, in column (5), show results for non-overlapping differences.<sup>11</sup> We observe that the estimates for large foreign ownership changes still are significant at the one percent level. We further worried that our standard errors might be biased due “generated regressors”—our predicted changes in foreign ownership are, as any predicted variable, predicted with noise. We therefore also estimated the standard errors in the non-overlapping regression using a parametric Monte Carlo procedure as explained in Appendix B. Using this method, we found standard errors of 0.005, 0.003, 0.002, and 0.003 for the regressors in the top four rows of column (5). For the effect of large changes in FDI, these standard errors

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<sup>11</sup>Non-overlapping differences result in a smaller sample size. We have an unbalanced panel and observed firms for a maximum number of 10 years. Therefore, for each firm there is a maximum number of two observations per firm.

are quite similar to the ones reported in the table and the coefficients still have extremely large t-statistics when calculated from this way.

*Majority foreign ownership.* In Table 9, we provide instrumental variable results for regressions that estimate the change in TFP following a change from minority (including nil) foreign ownership to majority foreign ownership.<sup>12</sup> As before, changes in foreign ownership takes time to materialize and the results of interest are those of the column (4), which shows results for changes of 4 years. If foreigners acquire majority interest, productivity increases 4.5 percent (estimated with extremely high statistical significance). If foreign ownership sinks below 50 percent (implying that domestic owners are in the majority) this is likewise followed by a productivity increase, with a point estimate of 3.1 percent (with extremely high statistical significance). These results indicate that it is not the amount of change in foreign ownership, but rather the change in control that is important. Looking at the coefficients and standard errors, it is apparent that the effect is larger with statistical significance if the movement is in the direction of more foreign control, but in economic terms the difference between changes to foreign or to domestic majority ownership is not significant.

## 6.2 Differences-in-Differences Matching Estimator

We also follow Arnold and Javorcik (2009) and Guadalupe, Kuzmina, and Thomas (2012) and employ a difference-in-difference approach in combination with propensity score matching on a set of companies that switched from domestic to foreign-owned. The difference-in-difference approach allows us to control for the influence of all observable and unobservable non-random elements of the acquisition decision that are constant or strongly persistent over time while propensity score matching addresses concerns related to non-random selection of FDI targets—although the

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<sup>12</sup>Predicted values are obtained after re-estimating the multinomial model with three outcomes: no change in foreign ownership, change from above 50 percent to less than 50 percent, and change from below 50 percent to above 50 percent.

method, obviously, can only control for selection on variables in our dataset.

“Treated firms” are firms which were acquired by foreigners and the “control group” includes companies which had similar characteristics in the pre-acquisition year but remained domestic throughout the entire period. We carefully match acquired firms to several domestic companies in the same country-sector-year cell and also match with firm that have similar lagged values of labor productivity, capital intensity, assets, assets squared, age, and age squared.<sup>13</sup> The similarities between treated and control companies along these dimensions are summarized in so-called propensity scores which measure the probabilities of being acquired given observed characteristics. We use a one-to-many caliper matching algorithm to obtain a better control group compared to when a single “nearest neighbor” (in terms of propensity score) is used.<sup>14</sup>

The results of the estimation are presented in Table 10. Each column reports the result of a separate matching procedure with a different outcome  $\Delta_k \log(\text{TFP})$   $k = 1, \dots, 5$ . “ATT” stands for average treatment effect on the treated, or the difference in  $\Delta_k \log(\text{TFP})$  between acquired and matched non-acquired companies over  $k$  years. In this one-to-many algorithm, for each treated company a weighted average of controls is constructed where each control has propensity scores within the set radius distance; the number of treated and controls is reported in the last line. As seen from the reported t-statistics, starting from the first year after the acquisition year (column (2)), we observe a statistically significant effect of foreign acquisition on company productivity, measured by TFP, and this effect lasts for at least 5 years. The results indicate that, controlling for initial observable differences between the two groups of companies, the acquired companies have 1.3% higher TFP after 1 year

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<sup>13</sup>These variables are used for the “outcome”  $\text{TFP}$ . We do not include lagged labor productivity in the set of matching variables when we estimate the treatment effect for the outcome labor productivity.

<sup>14</sup>Caliper or radius matching uses all comparison observations within a predefined distance around the propensity score of the respective treated. This allows for higher precision than the nearest neighbor matching in regions in which many similar comparison observations are available.

following the acquisition and after 4 years following the acquisition the difference in TFP is close to 3 percent.

## 7 How Do Acquired Firms Adjust Their Balance Sheets?

Acquired firms increase productivity, even if the effect is minor. Is this due to higher investment in capital or due to transfer of soft technology such as better management practices? Table 11 provides some evidence on this issue—we report the results of regressions of revenue, revenue per worker, value added per worker, capital, employment, and capital per worker on dummies for predicted ownership, controlling for age and size (initial assets). We use predicted ownership for the regressor of interest.

In the first column, the effect on operating revenue is explored: an increase in foreign ownership in excess of 50 percent increases operating revenue by about 5 percent with a slightly smaller increase in operating revenue for smaller increases in foreign ownership. A small contraction in foreign ownership is also associated with a 5 percent change in revenue, whereas a large contraction in foreign ownership has no effect on revenue. The second column explores the effect on revenue per worker and the effect here is also about 5 percent for large increases in foreign ownership indicating, in view of the similar coefficient in the first column, that revenue increases are not a reflection of an expanded work force. A similar result is there for smaller foreign ownership changes. For small contractions in foreign ownership the effect is 2.3 percent, almost half of the effect on revenue, indicating that the revenue increases in this situation partly reflect the hiring of more workers. Column (3) investigates the effect of ownership changes on value added per worker, finding results that are similar to those for revenue per worker.

Column (4) shows an interesting contrast between increases in foreign ownership and increases in domestic ownership: increased foreign ownership has little or no effect on the amount of physical capital, whereas a small contraction in foreign

ownership is associated with a 7.5 percent increase in capital. For labor, as shown in column (5), positive changes in foreign ownership do not lead to economically significant changes in employment while a small contraction is associated with an increase of 3.4 percent. As a result, when we look at the capital-labor ratio in column (6), we observe no change, or a decrease, in the case of increased foreign ownership but some increase for domestic ownership increase.

These results likely reflect that foreign industrial investors bring in process and management innovation, consistent with the literature cited, rather than bringing in capital. While this pattern is likely to be different in emerging markets where capital is scarce (see Kalemli-Ozcan and Sørensen (2012)), it highlights that productivity effects from multinational ownership are not due to easing of credit constraints leading to an increased scale of production. Rather, it appears that the increase in TFP due to infusions of knowledge, whether in terms of process management or in terms of marketing or management practices more generally.

## 8 Conclusion

We estimate the productivity effects of FDI, accounting for selection due to time-varying unobserved firm-level heterogeneity, using a unique firm level data from 9 advanced countries. To investigate the causal effect of FDI on the productivity of target firms, we construct instruments that are exogenous to changes in productivity under the assumption that financial and industrial investors select firms in a similar manner.

We find that exogenous changes in FDI lead to increased productivity although the effect we find is relatively small compared to previous results. Our IV-estimates imply an increase of an (at most) 3.7 percent in TFP over four years following a large increase in FDI (between 50 and 100 percent). Using a differences-in-differences matching estimator, which has been applied in the literature, we find a similar 3 percent effect. We explore potential channels from FDI to productivity and we find

that FDI does not lead to capital deepening but rather points to a role for soft technology transfers; for example, better management practices.

Our estimates are based on advanced countries where the technology gap between investor and receiving countries is small. This might explain the difference in magnitudes between our estimates and results in the recent literature.

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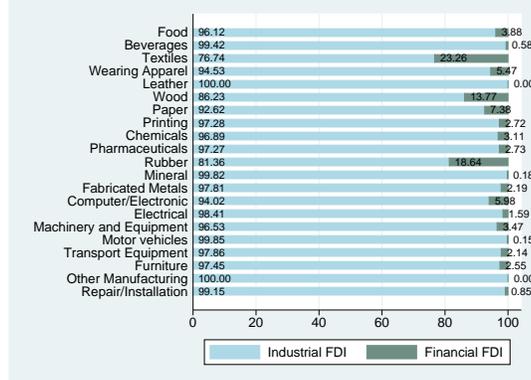
Figure 1: Cross-border M&As by private equity firms, by sector and main industry, 2005–2012.



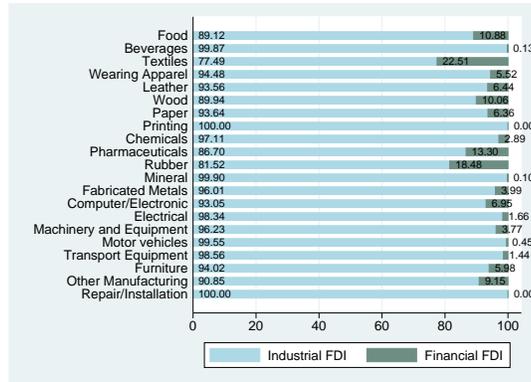
Source: UNCTAD FDI-TNC-GVC Information System, cross-border M&A database ([www.unctad.org/fdistatistics](http://www.unctad.org/fdistatistics)).  
 Note: Not adjusted to exclude FDI by SWFs.

Figure 2: Share of Industrial and Financial Foreign Investment by Sector

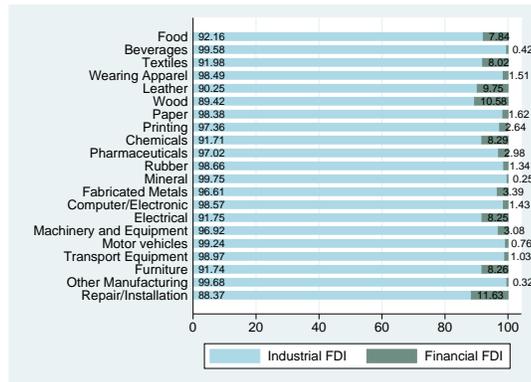
(a) 2002



(b) 2004

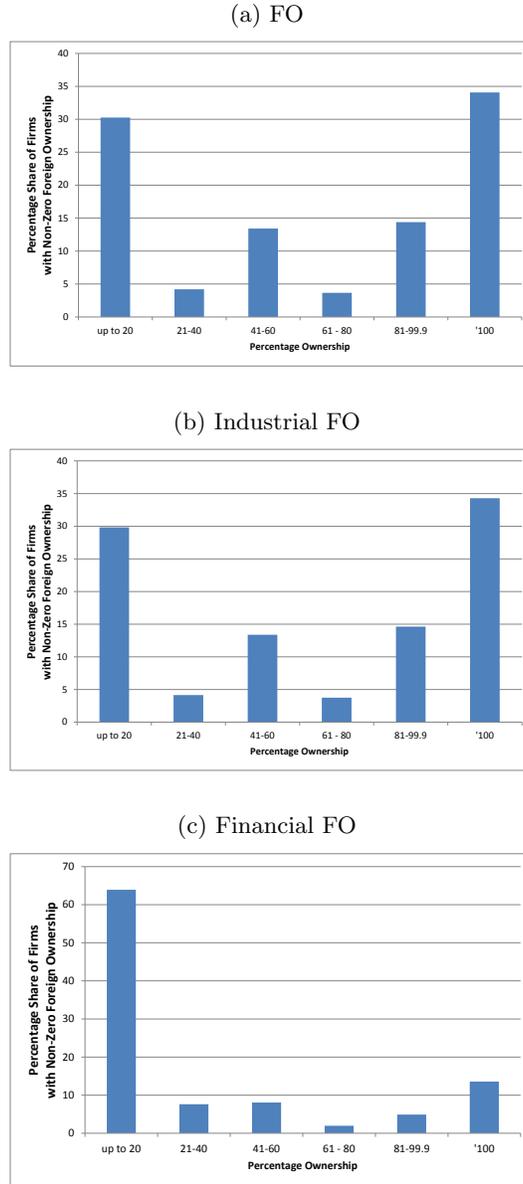


(c) 2006



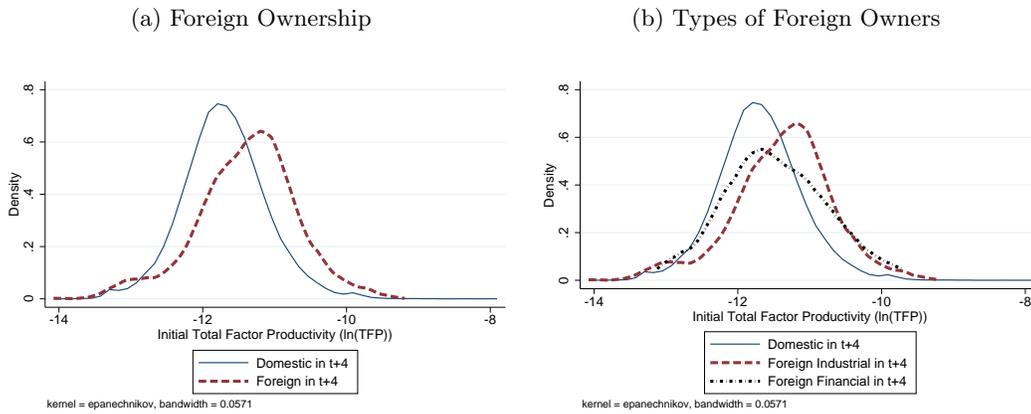
Notes: Share of Industrial and Financial Foreign Owned Assets in Total Foreign-Owned Assets.

Figure 3: Distribution of Industry-FO and Financial-FO Among Foreign Owned Firms



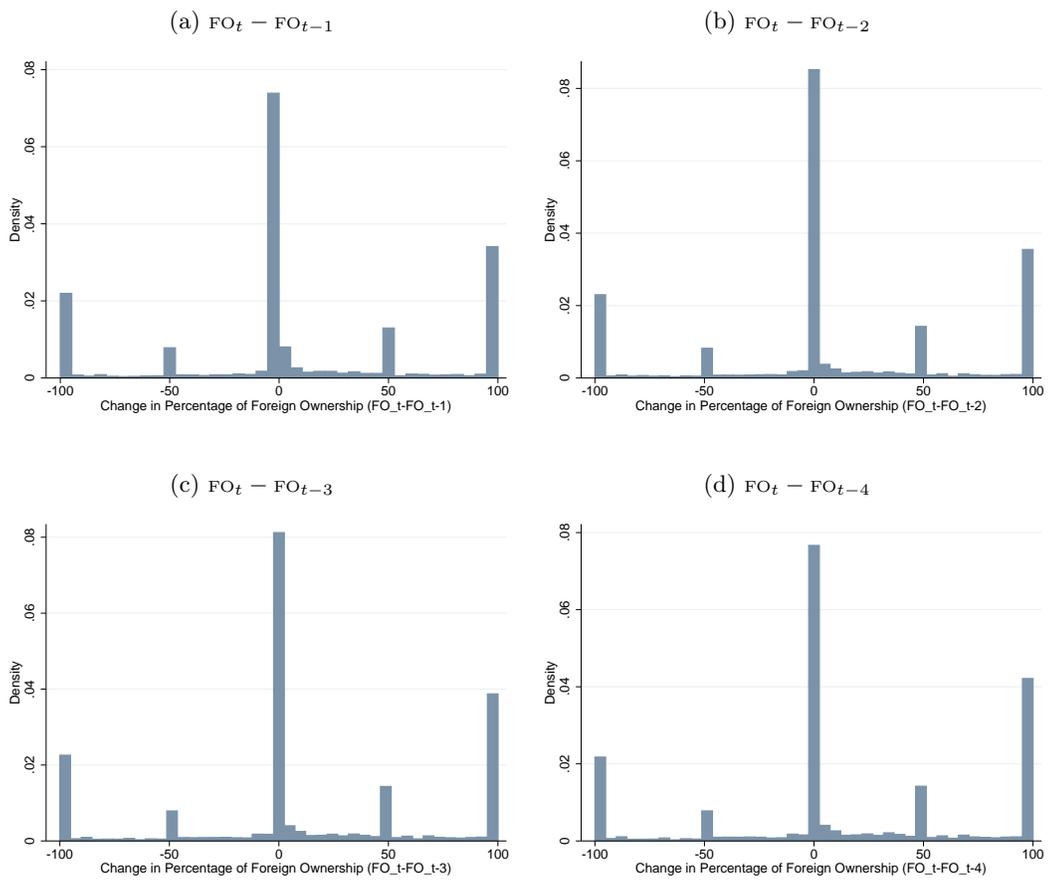
*Notes:* The figure shows the distribution of foreign ownership using all manufacturing firms in all available years. Firms are drawn from the regression samples of firms in the manufacturing sector with available data for the main regressions (see Data Appendix). Each graph defines foreign-owned firms as firms with foreign ownership of a given type (industrial, financial, or both) positive in at least one year. The percentage of observations in each ownership bin are computed relative to the total number of foreign-owned firms.

Figure 4: Distribution of Initial Productivity (TFP) for Acquired and Non-acquired Firms.



*Notes:* Initial productivity at the firm level is measured by total factor productivity ( $\ln(\text{TFP})$ ) in the first year the firm appears in the sample, demeaned by sector and country over the sample period. The solid line represents ( $\ln(\text{TFP})$ ) of domestic firms (firms that originally do not have any foreign ownership and remain non-acquired after four years ( $t+4$ )). In panel (a), the dashed line refers to foreign owned firms (those that are originally domestic but were acquired at some point during the next four years ( $t+4$ )). In panel (b), the dashed line refers to foreign industrial firms (those that are originally domestic but were acquired by a foreign industrial investor at some point during the next four years ( $t+4$ )); the dotted-dashed line refers to foreign financial firms (those that are originally domestic but were acquired by a foreign financial investor at some point during the next four years ( $t+4$ )).

Figure 5: Distribution of the Change in Foreign Ownership



Notes: Notes:

Table 1: Summary Statistics: Foreign Ownership

Panel A: Percentage of Observations in Total Sample		
	Percentage	Observations
FO	8.45%	418,736
FO – Industrial	8.00%	418,736
FO – Financial	0.49%	418,736

Panel B: Percentage of Observations in Foreign-Owned Sample		
	Percentage	Observations
FO-Industrial	94.67%	35,373
FO-Financial	5.74%	35,373
FO- <i>Majority</i>	63.30%	35,373
FO- <i>Majority</i> -Industrial	60.74%	35,373
FO- <i>Majority</i> -Financial	1.49%	35,373

*Notes:* FO is a dummy that takes the value of one in the year when foreign ownership is greater than zero. FO-Industrial is a dummy that takes the value of one in the year when foreign industrial ownership is greater than zero. FO-Financial is a dummy that takes the value of one in the year when foreign financial ownership is greater than zero. FO-*Majority* is a dummy that takes the value of one in the year when foreign ownership is greater than fifty percent. FO-*Majority*-Industrial and FO-*Majority*-Financial are constructed in a similar fashion. In Panel (B) the sum of FO-Industrial and FO-*Majority*-Financial does not add up to 100 percent because total foreign ownership is defined as the sum of industrial, financial, government, and other foreign ownership.

Table 2: Summary Statistics

Variable	Observations	Mean	SD	Median	Min	Max
TFP	396,647	11.7	0.7	11.67	6.69	15.48
FO	396,647	4.92	20.46	0	0	100.07
FO-Industrial	396,647	4.71	20.09	0	0	100
FO-Financial	396,647	0.13	3.17	0	0	100
$\ln(K/L)_0$	396,647	9.97	1.22	10.08	-4.1	15.08
$\ln(\text{ASSETS})_0$	396,647	15.64	1.34	15.5	9.95	24.92
AGE <sub>0</sub>	392,027	20.66	17.1	17	0	319
Share FO-Industrial country-sector	396,647	12.81	11.14	10.17	0	69.77
Share FO-Financial country-sector	396,647	0.53	1.57	0.04	0	29.49

*Notes:* TFP refers to Total Factor Productivity. FO is a dummy that takes the value of one in years where foreign ownership is greater than zero. FO-Industrial is a dummy that takes the value of one in years where foreign industrial ownership is greater than zero. FO-Financial is a dummy that takes the value of one in years where foreign financial ownership is greater than zero.  $\ln(K/L)_0$  is the log of capital to labor ratio the first time we observe the firm in the sample.  $\ln(\text{ASSETS})_0$  is the log of total assets the first time we observe the firm in the sample. AGE<sub>0</sub> is firm age the first time we observe the firm in the sample. Share FO-Industrial country-sector refers to sectoral industrial foreign ownership as specified in equation (3). Share FO-Financial country-sector refers to sectoral financial foreign ownership as specified in equation (4).

Table 3: Foreign Ownership and Firm Productivity

	(1)	(2)	(3)	(4)	(5)
	$\Delta \ln(\text{TFP})$	$\Delta^2 \ln(\text{TFP})$	$\Delta^3 \ln(\text{TFP})$	$\Delta^4 \ln(\text{TFP})$	$\Delta^4 \ln(\text{TFP})$
$\Delta \ln(\text{FO})$	0.002 (0.003)				
$\Delta^2 \ln(\text{FO})$		0.003 (0.003)			
$\Delta^3 \ln(\text{FO})$			0.009** (0.003)		
$\Delta^4 \ln(\text{FO})$				0.017*** (0.003)	0.013*** (0.003)
$\ln(\text{K/L})_0$	0.001*** (0.000)	0.002*** (0.000)	0.004*** (0.000)	0.006*** (0.000)	0.006*** (0.000)
$\ln(\text{ASSETS})_0$	-0.002*** (0.000)	-0.004*** (0.000)	-0.007*** (0.000)	-0.009*** (0.000)	-0.010*** (0.000)
Observations	324,606	271,760	228,038	188,138	188,138
Year Fixed Effects	yes	yes	yes	yes	yes
Country Trend	no	no	no	no	yes
Sector Trend	no	no	no	no	yes

*Notes:* The regressions are estimated by GLS. TFP is total factor productivity, computed using the Wooldridge-Levinsohn-Petrin methodology (WLP). FO is transformed as  $(\text{FO}/100) + 1$ . FO is the share of foreign-owned equity.  $\Delta^k$  indicates the change between year  $t$  and year  $t - k$  where  $k = 1, \dots, 4$ .  $\ln(\text{K/L})_0$  is the log of capital to labor ratio the first time we observe the firm in the sample.  $\ln(\text{ASSETS})_0$  is the log of total assets the first time we observe the firm in the sample. Standard errors clustered at the firm level are in parenthesis. \*\*\*, \*\*, \*, denote significance at 1%, 5%, and 10% levels.

Table 4: Categories of Foreign Ownership Change and Firm Productivity

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	$\Delta \ln(\text{TFP})$	$\Delta^2 \ln(\text{TFP})$	$\Delta^3 \ln(\text{TFP})$	$\Delta^4 \ln(\text{TFP})$	$\Delta^4 \ln(\text{TFP})$	$\Delta^4 \ln(\text{TFP})$	$\Delta^4 \ln(\text{TFP})$
$\Delta^k_{\text{FO}}(-100, -50)$	0.004 (0.003)	0.008** (0.003)	0.014*** (0.003)	0.028*** (0.004)	0.023*** (0.004)	0.022*** (0.004)	0.022*** (0.004)
$\Delta^k_{\text{FO}}(-50, 0)$	0.004* (0.002)	0.002 (0.002)	0.002 (0.003)	0.009** (0.003)	0.004 (0.003)	0.006* (0.003)	0.008** (0.003)
$\Delta^k_{\text{FO}}(0, 50)$	0.005** (0.002)	0.006** (0.002)	0.015*** (0.002)	0.023*** (0.002)	0.019*** (0.002)	0.018*** (0.002)	0.020*** (0.002)
$\Delta^k_{\text{FO}}(50, 100)$	0.007** (0.002)	0.011*** (0.002)	0.019*** (0.003)	0.031*** (0.003)	0.024*** (0.003)	0.022*** (0.003)	0.020*** (0.003)
$\ln(\text{K/L})_0$	0.001*** (0.000)	0.002*** (0.000)	0.005*** (0.000)	0.007*** (0.000)	0.007*** (0.000)	0.007*** (0.000)	0.007*** (0.000)
$\ln(\text{ASSETS})_0$	-0.002*** (0.000)	-0.004*** (0.000)	-0.008*** (0.000)	-0.011*** (0.000)	-0.012*** (0.000)	-0.012*** (0.000)	-0.012*** (0.000)
Observations	324,606	271,760	228,038	188,138	188,138	188,138	188,138
Year Fixed Effects	yes	yes	yes	yes	yes	yes	yes
Country Trend	no	no	no	no	yes	n/a	n/a
Sector Trend	no	no	no	no	yes	n/a	n/a
Country-Year Fixed Effect	no	no	no	no	n/a	yes	yes
Sector-Year Fixed Effect	no	no	no	no	n/a	yes	yes
Country-Sector-Year FE	no	no	no	no	no	no	yes

*Notes:* The regressions are estimated by GLS. TFP is total factor productivity, computed using the Wooldridge-Levinsohn-Petrin methodology (WLP).  $\Delta^k$  indicates the change between year  $t$  and year  $t - k$  where  $k = 1, \dots, 4$ . FO is the share of foreign-owned equity.  $\Delta^k_{\text{FO}}(-100, -50)$  is an indicator variable that takes the value of one if  $\Delta^k$  percent change in foreign ownership is between  $-100$  and  $-50$ .  $\Delta^k_{\text{FO}}(-50, 0)$  is an indicator variable that takes the value of one if  $\Delta^k$  percent change in foreign ownership is between  $-50$  and  $0$ .  $\Delta^k_{\text{FO}}(0, 50)$  is an indicator variable that takes the value of one if  $\Delta^k$  change in foreign ownership is between  $0$  and  $50$ .  $\Delta^k_{\text{FO}}(50, 100)$  is an indicator variable that takes the value of one if  $\Delta^k$  change in foreign ownership is greater than  $50$  percent.  $\ln(\text{K/L})_0$  is the log of capital to labor ratio the first time we observe the firm in the sample.  $\ln(\text{ASSETS})_0$  is the log of total assets the first time we observe the firm in the sample. Standard errors clustered at the firm level are in parenthesis. \*\*\*, \*\*, \*, denote significance at 1%, 5%, and 10% levels.

Table 5: Distribution of Foreign Ownership Changes

	$\Delta$		$\Delta^2$		$\Delta^3$		$\Delta^4$	
	freq	percent	freq	percent	freq	percent	freq	percent
$\Delta^k_{\text{FO}}(0)$	309,179	97.66	248,717	94.84	203,132	93.26	163,103	91.95
$\Delta^k_{\text{FO}}(-100, -50)$	1,239	0.39	2,228	0.85	2,390	1.1	2,292	1.29
$\Delta^k_{\text{FO}}(-50, 0)$	1,766	0.56	3,234	1.23	3,031	1.39	2,980	1.45
$\Delta^k_{\text{FO}}(0, 50)$	2,570	0.81	4,759	1.81	5,375	2.47	5,336	3.01
$\Delta^k_{\text{FO}}(50, 100)$	1,841	0.58	3,321	1.27	3,875	1.78	4,073	2.3

*Notes:*  $\Delta^k$  indicates the change between year  $t$  and year  $t - k$  where  $k = 1, \dots, 4$ . FO is the share of foreign-owned equity.  $\Delta^k_{\text{FO}}(-100, -50)$  is an indicator variable that takes the value of one if  $\Delta^k$  change in foreign ownership is between -100 and -50.  $\Delta^k_{\text{FO}}(-50, 0)$  is an indicator variable that takes the value of one if  $\Delta^k$  change in foreign ownership is between -50 and 0.  $\Delta^k_{\text{FO}}(0, 50)$  is an indicator variable that takes the value of one if  $\Delta^k$  change in foreign ownership is between 0 and 50.  $\Delta^k_{\text{FO}}(50, 100)$  is an indicator variable that takes the value of one if  $\Delta^k$  change in foreign ownership is greater than 50.

Table 6: Productivity and Sector Level Foreign Ownership by Type

	(1)	(2)	(3)	(4)
	$\Delta \ln(\text{TFP})$	$\Delta^2 \ln(\text{TFP})$	$\Delta^3 \ln(\text{TFP})$	$\Delta^4 \ln(\text{TFP})$
$\Delta \ln(\text{FO}_{s,c,t}^I)$	0.005** (0.002)			
$\Delta \ln(\text{FO}_{s,c,t}^F)$	0.002 (0.001)			
$\Delta^2 \ln(\text{FO}_{s,c,t}^I)$		0.015*** (0.003)		
$\Delta^2 \ln(\text{FO}_{s,c,t}^F)$		0.005* (0.002)		
$\Delta^3 \ln(\text{FO}_{s,c,t}^I)$			0.021*** (0.003)	
$\Delta^3 \ln(\text{FO}_{s,c,t}^F)$			0.007** (0.002)	
$\Delta^4 \ln(\text{FO}_{s,c,t}^I)$				0.022*** (0.003)
$\Delta^4 \ln(\text{FO}_{s,c,t}^F)$				0.006** (0.002)
Observations	320,382	265,336	220,320	179,425

*Notes:* The regressions are estimated by GLS. TFP is total factor productivity, computed using the Wooldridge-Levinsohn-Petrin methodology (WLP).  $\text{FO}_{s,c,t}^I$  is the share of industrial foreign ownership at the country-sector-year level weighted by initial output as specified in equation (3).  $\text{FO}_{s,c,t}^F$  is the share of industrial foreign ownership at the country-sector-year level weighted by initial output as specified in equation (3).  $\Delta^k$  indicates the change between year  $t$  and year  $t - k$  where  $k = 1, \dots, 4$ . Year fixed effects are included in all specifications. Standard errors clustered at the country-sector level are in parenthesis. \*\*\*, \*\*, \*, denote significance at 1%, 5%, and 10% levels.

Table 7: Multinomial (Selected Regressors)

	(1)	(2)	(3)	(4)
	$\Delta(\text{FO})$	$\Delta^2(\text{FO})$	$\Delta^3(\text{FO})$	$\Delta^4(\text{FO})$
<i>Category<sub>j</sub> = 2</i>				
$\Delta^k_{\text{FO}^{\text{D}}}$	0.199** (0.061)	0.176** (0.068)	0.188*** (0.045)	0.173*** (0.044)
$\Delta^k_{\text{FO}^{\text{D}}} \times \ln(\text{ASSETS})_0$	-0.016*** (0.003)	-0.016*** (0.003)	-0.013*** (0.002)	-0.011*** (0.002)
<i>Category<sub>j</sub> = 3</i>				
$\Delta^k_{\text{FO}^{\text{D}}}$	0.142** (0.047)	0.161*** (0.043)	0.132** (0.043)	0.131** (0.043)
$\Delta^k_{\text{FO}^{\text{D}}} \times \ln(\text{ASSETS})_0$	-0.008** (0.002)	-0.008*** (0.002)	-0.008*** (0.002)	-0.008*** (0.002)
<i>Category<sub>j</sub> = 4</i>				
$\Delta^k_{\text{FO}^{\text{D}}}$	0.093** (0.040)	0.061* (0.036)	0.026 (0.032)	0.021 (0.032)
$\Delta^k_{\text{FO}^{\text{D}}} \times \ln(\text{ASSETS})_0$	-0.006** (0.002)	-0.004* (0.002)	-0.002 (0.002)	-0.001 (0.002)
<i>Category<sub>j</sub> = 5</i>				
$\Delta^k_{\text{FO}^{\text{D}}}$	-0.154*** (0.045)	-0.136*** (0.039)	-0.088** (0.036)	-0.062* (0.034)
$\Delta^k_{\text{FO}^{\text{D}}} \times \ln(\text{ASSETS})_0$	0.012*** (0.003)	0.011*** (0.002)	0.007*** (0.002)	0.005** (0.002)
Observations.	316595	262259	217803	177384
R <sup>2</sup>	.29	.21	.21	.2
Year Fixed Effects	yes	yes	yes	yes
Country Fixed Effects	yes	yes	yes	yes
Sector Fixed Effects	yes	yes	yes	yes
FO <sup>D</sup> × sector	yes	yes	yes	yes
FO <sup>D</sup> × country	yes	yes	yes	yes
ln(VA/L) <sub>0</sub> × sector	yes	yes	yes	yes
ln(VA/L) <sub>0</sub> × country	yes	yes	yes	yes
ln(K/L) <sub>0</sub> × sector	yes	yes	yes	yes
ln(K/L) <sub>0</sub> × country	yes	yes	yes	yes
ln(ASSETS) <sub>0</sub> × sector	yes	yes	yes	yes
ln(ASSETS) <sub>0</sub> × country	yes	yes	yes	yes

*Notes:* The regressions are estimated by GLS.  $\Delta^k$  indicates the change between year  $t$  and year  $t-k$  where  $k = 1, \dots, 4$ .  $\text{FO}^{\text{D}}$  is the difference between industrial and financial country-sector level foreign ownership:  $\text{FO}^{\text{D}}_{s,c,t} = \text{FO}^{\text{I}}_{s,c,t} - \text{FO}^{\text{F}}_{s,c,t}$  where  $\text{FO}^{\text{I}}_{s,c,t}$  is the share of industrial foreign ownership at the country-sector-year level weighted by initial output as specified in equation (3) and  $\text{FO}^{\text{F}}_{s,c,t}$  is the share of financial foreign ownership at the country-sector-year level weighted by initial output as specified in equation (3).  $\ln(\text{VA}/\text{L})_0$  is the log of value added to total employment the first year we observe the firm.  $\ln(\text{K}/\text{L})_0$  is the log of capital to labor ratio the first time we observe the firm in the sample.  $\ln(\text{ASSETS})_0$  is the log of total assets the first time we observe the firm in the sample. \*\*\*, \*\*, \*, denote significance at 1%, 5%, and 10% levels.

Table 8: Predicted Categories of Foreign Ownership Change and Firm Productivity

	(1)	(2)	(3)	(4)	(5)
	$\Delta \ln \text{TFP}$	$\Delta^2 \ln \text{TFP}$	$\Delta^3 \ln \text{TFP}$	$\Delta^4 \ln \text{TFP}$	$\Delta^4 \ln \text{TFP}$
$\Delta^k \hat{\text{FO}}(-100, -50)$	-0.013** (0.004)	-0.010** (0.005)	-0.006 (0.005)	0.001 (0.005)	0.005* (0.003)
$\Delta^k \hat{\text{FO}}(-50, 0)$	0.001 (0.002)	0.005** (0.002)	0.010*** (0.002)	0.017*** (0.002)	-0.006*** (0.003)
$\Delta^k \hat{\text{FO}}(0, 50)$	0.006*** (0.001)	0.015*** (0.001)	0.024*** (0.002)	0.024*** (0.002)	0.016*** (0.002)
$\Delta^k \hat{\text{FO}}(50, 100)$	-0.000 (0.003)	0.006** (0.003)	0.020*** (0.003)	0.036*** (0.003)	0.026*** (0.002)
$\ln(\text{K/L})_0$	0.001*** (0.000)	0.002*** (0.000)	0.005*** (0.000)	0.007*** (0.000)	0.004*** (0.000)
$\ln(\text{ASSETS})_0$	-0.002*** (0.000)	-0.005*** (0.000)	-0.010*** (0.000)	-0.013*** (0.000)	-0.012*** (0.000)
Observations	316,595	262,259	217,803	177,384	66,889

*Notes:* The regressions are estimated by GLS. Year fixed effects are included in all specifications. TFP is total factor productivity, computed using the Wooldridge-Levinsohn-Petrin methodology (WLP).  $\Delta^k$  indicates the change between year  $t$  and year  $t - k$  where  $k = 1, \dots, 4$ .  $\Delta^k \hat{\text{FO}}(-100, -50)$  is an indicator variable that takes the value of one if  $\Delta^k$  predicted change in foreign ownership is between -100 and -50.  $\Delta^k \hat{\text{FO}}(-50, 0)$  is an indicator variable that takes the value of one if  $\Delta^k$  predicted change in foreign ownership is between -50 and 0.  $\Delta^k \hat{\text{FO}}(0, 50)$  is an indicator variable that takes the value of one if  $\Delta^k$  predicted change in foreign ownership is between 0 and 50.  $\Delta^k \hat{\text{FO}}(50, 100)$  is an indicator variable that takes the value of one if  $\Delta^k$  predicted change in foreign ownership is greater than 50.  $\ln(\text{K/L})_0$  is the log of capital to labor ratio the first time we observe the firm in the sample.  $\ln(\text{ASSETS})_0$  is the log of total assets the first time we observe the firm in the sample. Results in column (5) are obtained from a subsample with non-overlapping differences. Standard errors clustered at the firm level are in parenthesis. \*\*\*, \*\*, \*, denote significance at 1%, 5%, and 10% levels.

Table 9: Change To/From Foreign Majority Ownership (predicted) and Productivity

	(1)	(2)	(3)	(4)
	$\Delta \ln(\text{TFP})$	$\Delta^2 \ln(\text{TFP})$	$\Delta^3 \ln(\text{TFP})$	$\Delta^4 \ln(\text{TFP})$
$\widehat{\text{FO}} > 50\% \rightarrow \widehat{\text{FO}} < 50\%$ (1 year)	0.012*** (0.005)			
$\widehat{\text{FO}} < 50\% \rightarrow \widehat{\text{FO}} > 50\%$ (1 year)	-0.001 (0.006)			
$\widehat{\text{FO}} > 50\% \rightarrow \widehat{\text{FO}} < 50\%$ (2 years)		0.009** (0.005)		
$\widehat{\text{FO}} < 50\% \rightarrow \widehat{\text{FO}} > 50\%$ (2 years)		0.018*** (0.005)		
$\widehat{\text{FO}} > 50\% \rightarrow \widehat{\text{FO}} < 50\%$ (3 years)			0.012*** (0.004)	
$\widehat{\text{FO}} < 50\% \rightarrow \widehat{\text{FO}} > 50\%$ (3 years)			0.031*** (0.004)	
$\widehat{\text{FO}} > 50\% \rightarrow \widehat{\text{FO}} < 50\%$ (4 years)				0.031*** (0.004)
$\widehat{\text{FO}} < 50\% \rightarrow \widehat{\text{FO}} > 50\%$ (4 years)				0.043*** (0.003)
$\ln(\text{K/L})_0$	0.001*** (0.000)	0.003*** (0.000)	0.005*** (0.000)	0.008*** (0.000)
$\ln(\text{ASSETS})_0$	-0.002*** (0.000)	-0.007*** (0.000)	-0.012*** (0.000)	-0.017*** (0.000)
Observations	300,358	232,152	185,991	146,768

*Notes:* The regressions are estimated by GLS. Year fixed effects are included in all specifications. TFP is total factor productivity, computed using the Wooldridge-Levinsohn-Petrin methodology (WLP).  $\widehat{\text{FO}} < 50\% \rightarrow \widehat{\text{FO}} > 50\%$  is an indicator variable that takes the value of one if the predicted foreign ownership in year  $t$  is more than 50 percent but was more than less that 50 percent in year  $t - k$ , where  $k$  is the number of years indicated. The symbol for changes from majority foreign ownership to minority foreign ownership is similar.  $\ln(\text{K/L})_0$  is the log of capital to labor ratio the first time we observe the firm in the sample.  $\ln(\text{ASSETS})_0$  is the log of total assets the first time we observe the firm in the sample. Standard errors clustered at the firm level are in parenthesis. \*\*\*, \*\*, \*, denote significance at 1%, 5%, and 10% levels.

Table 10: Productivity and Foreign Acquisitions: Propensity Score Matching

	(1)	(2)	(3)	(4)
Estimation	Difference-in-difference with one-to-many radius matching			
Sample	Acquired domestic firms (treatment) and non-acquired firms (controls)			
	Treatment: Domestic firm acquired by foreign owners			
	Outcome is Change in $\ln \text{TFP}$ from the acquisition year to $k$ th following year			
	$\Delta \ln(\text{TFP})$	$\Delta_2 \ln(\text{TFP})$	$\Delta_3 \ln(\text{TFP})$	$\Delta_4 \ln(\text{TFP})$
ATT	0.0079	0.0130	0.0197	0.0276
t-stat	(1.56)	(2.01)	(2.54)	(3.16)
Obs.(Treated/Control)	2,682/268,366	2,342/220,536	1,937/179,624	1,713/143,356

*Notes:* “ATT” stands for average treatment effect on the treated, or the difference in  $\Delta_k \ln(\text{TFP})$  between acquired and non-acquired companies. Radius (caliper) parameter, that is, the maximum allowed difference between estimated propensity scores, is set at 0.02.

Table 11: Balance Sheet Effects of Predicted Foreign Ownership

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent Variable	$\Delta^4 \ln(Y)$	$\Delta^4 \ln(Y/L)$	$\Delta^4 \ln(vA/L)$	$\Delta^4 \ln(\kappa)$	$\Delta^4 \ln(L)$	$\Delta^4 \ln(\kappa/L)$
$\Delta^4 \hat{F}\hat{O}(-100, -50)$	0.001 (0.006)	0.001 (0.006)	-0.006 (0.007)	0.034** (0.011)	-0.010** (0.005)	0.024** (0.010)
$\Delta^4 \hat{F}\hat{O}(-50, 0)$	0.052*** (0.003)	0.023*** (0.003)	0.019*** (0.003)	0.075*** (0.005)	0.034*** (0.002)	0.036*** (0.005)
$\Delta^4 \hat{F}\hat{O}(0, 50)$	0.038*** (0.002)	0.026*** (0.002)	0.017*** (0.002)	0.003 (0.004)	0.015*** (0.002)	-0.015*** (0.004)
$\Delta^4 \hat{F}\hat{O}(50, 100)$	0.050*** (0.003)	0.047*** (0.003)	0.032*** (0.003)	0.013** (0.005)	0.011*** (0.003)	0.003 (0.006)
$AGE_0$	-0.002*** (0.000)	0.000*** (0.000)	0.000*** (0.000)	-0.001*** (0.000)	-0.002*** (0.000)	0.001*** (0.000)
$\ln(\text{ASSETS}_0)$	-0.017*** (0.001)	-0.004*** (0.000)	-0.007*** (0.000)	-0.033*** (0.001)	-0.014*** (0.000)	-0.016*** (0.001)
Observations	177,384	177,384	177,384	177,384	177,384	177,384

*Notes:* The regressions are estimated by GLS. Year fixed effects are included in all specifications.  $\ln(Y)$  is the log of output (operating revenue).  $\ln(Y/L)$  is the log of output to employment.  $\ln(vA/L)$  is the log of labor productivity  $vA$  indicates value added.  $\ln(\kappa)$  is the log of capital.  $\ln(L)$  is the log of employment.  $\ln(\kappa/L)$  is the log of capital to labor ratio.  $\Delta^k$  indicates the change between year  $t$  and year  $t - k$  where  $k = 1, \dots, 4$ .  $\Delta^k \hat{F}\hat{O}(-100, -50)$  is an indicator variable that takes the value of one if  $\Delta^k$  predicted change in foreign ownership is between -100 and -50.  $\Delta^k \hat{F}\hat{O}(-50, 0)$  is an indicator variable that takes the value of one if  $\Delta^k$  predicted change in foreign ownership is between -50 and 0.  $\Delta^k \hat{F}\hat{O}(0, 50)$  is an indicator variable that takes the value of one if  $\Delta^k$  predicted change in foreign ownership is between 0 and 50.  $\Delta^k \hat{F}\hat{O}(50, 100)$  is an indicator variable that takes the value of one if  $\Delta^k$  predicted change in foreign ownership is greater than 50.  $AGE_0$  is the age of the company the first time we observe the firm in the sample.  $\ln(\text{ASSETS}_0)$  is the log of total assets the first time we observe the firm in the sample. Standard errors clustered at the firm level are in parenthesis. \*\*\*, \*\*, \*, denote significance at 1%, 5%, and 10% levels.

# Appendix

Table A.1: Foreign Ownership and Firm Productivity: OLS - NO WEIGHTS

	(1)	(2)	(3)	(4)	(5)
	$\Delta \ln(\text{TFP})$	$\Delta^2 \ln(\text{TFP})$	$\Delta^3 \ln(\text{TFP})$	$\Delta^4 \ln(\text{TFP})$	$\Delta^4 \ln(\text{TFP})$
$\Delta \ln(\text{FO})$	-0.006 (0.007)				
$\Delta^2 \ln(\text{FO})$		0.000 (0.006)			
$\Delta^3 \ln(\text{FO})$			0.012* (0.007)		
$\Delta^4 \ln(\text{FO})$				0.023** (0.008)	0.018** (0.008)
$\ln(\text{K/L})_0$	0.001** (0.000)	0.003*** (0.001)	0.005*** (0.001)	0.007*** (0.001)	0.007*** (0.001)
$\ln(\text{ASSETS})_0$	-0.003*** (0.000)	-0.006*** (0.000)	-0.009*** (0.001)	-0.011*** (0.001)	-0.013*** (0.001)
Observations	324,606	271,760	228,038	188,138	188,138
Year Fixed Effects	yes	yes	yes	yes	yes
Country Trend	no	no	no	no	yes
Sector Trend	no	no	no	no	yes

*Notes:* The regressions are estimated by OLS. TFP is total factor productivity, computed using the Wooldridge-Levinsohn-Petrin methodology (WLP). FO is transformed as  $(\text{FO}/100) + 1$ . FO is the share of foreign-owned equity.  $\Delta^k$  indicates the change between year  $t$  and year  $t - k$  where  $k = 1, \dots, 4$ .  $\ln(\text{K/L})_0$  is the log of capital to labor ratio the first time we observe the firm in the sample.  $\ln(\text{ASSETS})_0$  is the log of total assets the first time we observe the firm in the sample. Standard errors clustered at the firm level are in parenthesis. \*\*\*, \*\*, \*, denote significance at 1%, 5%, and 10% levels.

Table A.2: Categories of Foreign Ownership Change and Firm Productivity: OLS - NO WEIGHTS

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	$\Delta \ln(\text{TFP})$	$\Delta^2 \ln(\text{TFP})$	$\Delta^3 \ln(\text{TFP})$	$\Delta^4 \ln(\text{TFP})$	$\Delta^4 \ln(\text{TFP})$	$\Delta^4 \ln(\text{TFP})$	$\Delta^4 \ln(\text{TFP})$
$\Delta_{\text{FO}}(-100, -50)$	0.011* (0.006)	0.014** (0.006)	0.019** (0.007)	0.036*** (0.008)	0.030*** (0.008)	0.031*** (0.008)	0.029*** (0.008)
$\Delta_{\text{FO}}(-50, 0)$	0.005 (0.005)	0.004 (0.005)	0.002 (0.006)	0.010 (0.008)	0.005 (0.007)	0.007 (0.007)	0.008 (0.007)
$\Delta_{\text{FO}}(0, 50)$	0.007* (0.004)	0.008** (0.004)	0.018*** (0.005)	0.030*** (0.006)	0.025*** (0.006)	0.024*** (0.005)	0.025*** (0.005)
$\Delta_{\text{FO}}(50, 100)$	0.002 (0.006)	0.012** (0.006)	0.025*** (0.006)	0.041*** (0.007)	0.033*** (0.007)	0.029*** (0.007)	0.028*** (0.007)
$\ln(\text{K/L})_0$	0.001** (0.000)	0.003*** (0.001)	0.005*** (0.001)	0.008*** (0.001)	0.007*** (0.001)	0.007*** (0.001)	0.008*** (0.001)
$\ln(\text{ASSETS})_0$	-0.003*** (0.000)	-0.007*** (0.000)	-0.010*** (0.001)	-0.013*** (0.001)	-0.015*** (0.001)	-0.015*** (0.001)	-0.016*** (0.001)
Observations	324,606	271,760	228,038	188,138	188,138	188,138	188,138
Year Fixed Effects	yes	yes	yes	yes	yes	yes	yes
Country Trend	no	no	no	no	yes	n/a	n/a
Sector Trend	no	no	no	no	yes	n/a	n/a
Country-Year Fixed Effect	no	no	no	no	n/a	yes	yes
Sector-Year Fixed Effect	no	no	no	no	n/a	yes	yes
Country-Sector-Year FE	no	no	no	no	no	no	yes

*Notes:* The regressions are estimated by OLS. TFP is total factor productivity, computed using the Wooldridge-Levinsohn-Petrin methodology (WLP).  $\Delta^k$  indicates the change between year  $t$  and year  $t - k$  where  $k = 1, \dots, 4$ . FO is the share of foreign-owned equity.  $\Delta^k_{\text{FO}}(-100, -50)$  is an indicator variable that takes the value of one if  $\Delta^k$  change in foreign ownership is between -100 and -50.  $\Delta^k_{\text{FO}}(-50, 0)$  is an indicator variable that takes the value of one if  $\Delta^k$  change in foreign ownership is between -50 and 0.  $\Delta^k_{\text{FO}}(0, 50)$  is an indicator variable that takes the value of one if  $\Delta^k$  change in foreign ownership is between 0 and 50.  $\Delta^k_{\text{FO}}(50, 100)$  is an indicator variable that takes the value of one if  $\Delta^k$  change in foreign ownership is greater than 50.  $\ln(\text{K/L})_0$  is the log of capital to labor ratio the first time we observe the firm in the sample.  $\ln(\text{ASSETS})_0$  is the log of total assets the first time we observe the firm in the sample. Standard errors clustered at the firm level are in parenthesis. \*\*\*, \*\*, \*, denote significance at 1%, 5%, and 10% levels.

## TFP Estimation

This appendix explains the details of the firm-level productivity estimation performed using the method of Wooldridge, Levinsohn and Petrin, as suggested by ? and Levinsohn and Petrin (2003) and further augmented by Wooldridge (2009). ? (OP) and Levinsohn and Petrin (2003) (LP) propose to use proxy variables to control for unobserved productivity. The estimation in both methods is based on a two-step procedure to achieve consistency of the coefficient estimates for the inputs of the production function. Wooldridge (2009) suggests a generalized method of moments estimation of TFP to overcome some limitations of OP and LP, including correction for simultaneous determination of inputs and productivity, no need to maintain constant returns to scale, and robustness to the ? critique.<sup>15</sup> The following discussion is based on Wooldridge (2009), accommodated to the case of a production functions with two production inputs (see Wooldridge (2009) for a general discussion).

For firm  $i$  in time period  $t$  define:

$$y_{it} = \alpha + \beta_l l_{it} + \beta_k k_{it} + \omega_{it} + e_{it}, \quad (\text{A.1})$$

where  $y_{it}$ ,  $l_{it}$ , and  $k_{it}$  denote the natural logarithm of firm value added, labor (a variable input), and capital, respectively. The firm specific error can be decomposed into a term capturing firm specific productivity  $\omega_{it}$  and an additional term that reflects measurement error or unexpected productivity shocks  $e_{it}$ . We are interested in estimating  $\omega_{it}$ .

A key assumption of the OP and LP estimation methods is that for some function  $g(\cdot, \cdot)$ :

$$\omega_{it} = g(k_{it}, m_{it}), \quad (\text{A.2})$$

where  $m_{it}$  is a proxy variable (for investment in OP, for intermediate inputs in LP).

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<sup>15</sup>? highlight that if the variable input (labor) is chosen prior to the time when production takes place, the coefficient on variable input is not identified.

Under the assumption,

$$E(e_{it}|l_{it}, k_{it}, m_{it}) = 0 \quad t = 1, 2, \dots, T, \quad (\text{A.3})$$

substituting equation (A.2) into equation (A.1), we have the following regression function:

$$\begin{aligned} E(y_{it}|l_{it}, k_{it}, m_{it}) &= \alpha + \beta_l l_{it} + \beta_k k_{it} + g(k_{it}, m_{it}) \\ &\equiv \beta_l l_{it} + h(k_{it}, m_{it}), \end{aligned} \quad (\text{A.4})$$

where  $h(k_{it}, m_{it}) \equiv \alpha + \beta_k k_{it} + g(k_{it}, m_{it})$ .

In order to identify  $\beta_l$  and  $\beta_k$ , we need some additional assumptions. First, rewrite equation (A.3) in a form allowing for more lags :

$$E(e_{it}|l_{it}, k_{it}, m_{it}, l_{i,t-1}, k_{i,t-1}, m_{i,t-1}, \dots, l_{i1}, k_{i1}, m_{i1}) = 0 \quad t = 1, 2, \dots, T. \quad (\text{A.5})$$

Second, assume productivity follows a first-order Markov process:

$$E(\omega_{it}|\omega_{i,t-1}, \dots, \omega_{i1}) = E(\omega_{it}|\omega_{i,t-1}) \quad t = 2, 3, \dots, T, \quad (\text{A.6})$$

and assume that the productivity innovation  $a_{it} \equiv \omega_{it} - E(\omega_{it}|\omega_{i,t-1})$  is uncorrelated with current values of the state variable  $k_{it}$  as well as past values of the variable input  $l$ , the state  $k$ , and the proxy variables  $m$ :

$$\begin{aligned} E(\omega_{it}|k_{it}, l_{i,t-1}, k_{i,t-1}, m_{i,t-1}, \dots, l_{i1}, k_{i1}, m_{i1}) \\ = E(\omega_{it}|\omega_{i,t-1}) \equiv f[g(k_{i,t-1}, m_{i,t-1})]. \end{aligned} \quad (\text{A.7})$$

Recall from equation(A.2) that  $\omega_{i,t-1} = g(k_{i,t-1}, m_{i,t-1})$ .

Plugging  $\omega_{i,t} = f[g(k_{i,t-1}, m_{i,t-1})] + a_{it}$  into equation (A.1) gives:

$$y_{it} = \alpha + \beta_l l_{it} + \beta_k k_{it} + f[g(k_{i,t-1}, m_{i,t-1})] + a_{it} + e_{it}. \quad (\text{A.8})$$

Now it is possible to specify two equations which identify  $(\beta_l, \beta_k)$ :

$$y_{it} = \alpha + \beta_l l_{it} + \beta_k k_{it} + g(k_{i,t}, m_{i,t}) + e_{it} \quad (\text{A.9})$$

and

$$y_{it} = \alpha + \beta_l l_{it} + \beta_k k_{it} + f[g(k_{i,t-1}, m_{i,t-1})] + u_{it}, \quad (\text{A.10})$$

where  $u_{it} \equiv a_{it} + e_{it}$ .

Important for the GMM estimation strategy, the available orthogonality conditions differ across these two equations. The orthogonality conditions for equation (A.9) are those outlined in the equation(A.5), while the orthogonality conditions for equation (A.10) are

$$E(u_{it} | k_{it}, l_{i,t-1}, k_{i,t-1}, m_{i,t-1}, \dots, l_{i1}, k_{i1}, m_{i1}) = 0 \quad t = 2, \dots, T. \quad (\text{A.11})$$

To proceed with the estimation, we estimate these equations parametrically. In that, we follow Petrin, Reiter, and White (2011) and use a third-degree polynomial approximation using first order lags of variable input as instruments.<sup>16</sup>

## Appendix B: Estimation of Standard Errors

Regressing on exogenous predicted ownership changes may lead to standard “generated regressors” bias in the standard errors as estimated by OLS formulas (and, here, the Stata statistical package) and potentially bias in the estimated coefficients. We, therefore, use a “parametric bootstrap” procedure to calculate standard errors for all the coefficients in the second stage.

The issue is that the dummy variables for predicted changes in ownership are

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<sup>16</sup>We use the Stata routine suggested in Petrin, Reiter, and White (2011).

function of the fitted probabilities

$$\hat{P}(j) = \frac{\exp\{Z'_{it}\hat{\psi}_j\}}{1 + \sum_{k=1}^4 \exp\{Z'_{it}\hat{\psi}_k\}}$$

where  $\hat{\psi}_j$  ( $j = 1, \dots, 4$ ) are estimates of the true parameters with (asymptotically) normal standard errors. Conveniently, Stata calculates the estimation error (standard deviation) of the product  $Z'_{it}\hat{\psi}_j$ , say  $\sigma_{ijt}$  which we use to evaluate the potential generated regressor bias. The idea is simply to “add” the variance in the estimated  $\psi$  coefficients to the variance in the reduced form regressions.

We perform the following Monte Carlo draws for  $\iota = 1, \dots, 1000$ : Draw mean zero error terms  $e_{\iota,ijt}$  with standard errors  $\sigma_{ijt}$  and calculate the probabilities implied by adding these errors as

$$\hat{P}(j)_{\iota,it} = \frac{\exp\{Z'_{it}\hat{\psi}_j + e_{\iota,ij}\}}{1 + \sum_{k=1}^4 \exp\{Z'_{it}\hat{\psi}_k + e_{\iota,ik}\}} .$$

As before, we assign firms to the zero-change category if the estimated probability in draw  $\iota$  of zero change ( $\hat{P}_{\iota,it0}$ ) is greater than 0.8. The rest of the firm-years, where the predicted probability of no-change in ownership below 0.8, are assigned to that category of the remaining four which has the highest predicted probability (in draw  $\iota$ ) according to the rule:

$$\hat{\mathbf{j}}_{\iota,it} = \arg \max_j \hat{P}(j)_{\iota,it} ; j \neq 0 ,$$

and generate dummy variables  $\Delta^k \hat{\text{FO}}(j)_{\iota,it}$  as described in the text. We further generate a regressand by drawing normally distributed errors  $u_{\iota,it}$  with mean 0 and standard error equal to the estimated standard errors in the OLS regression of equation (7) and adding the  $u$ -terms to the fitted value:  $\log(\text{TFP}_{\iota,it}) = \log(\widehat{\text{TFP}}_{i,s,c,t}) + u_{\iota,it}$ .

We then perform the regressions

$$\Delta \log(\text{TFP}_{\iota,i,t}) = \sum_{j=1}^4 \beta_{\iota}^j \Delta^k \widehat{\text{FO}}(j)_{\iota,it} + \delta_{c,t} + \delta_{s,t} + \text{error}.$$

and collect the coefficients  $\hat{\beta}_{\iota}^j$ . We do this for  $\iota = 1, \dots, 10,000$  and we then calculate the mean and standard deviations of the and then calculate the mean and standard errors of  $\hat{\beta}_{\iota}^j$ -terms. These are the standard errors reported in the tables.

## Appendix References

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