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Quantifying Productivity Gains from Foreign Investment
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ABSTRACT

We quantify the effect of foreign investment on productivity of acquired firms using a new firm-level database for eight advanced European countries during 1999-2012. Foreign investors target high productivity firms. In order to control for this selection and isolate causal effects, we perform propensity score matching with firm fixed effects and also control for country-sector trends and mean-reversion in productivity. Following foreign acquisition, productivity increases modestly but only after four years, and only when foreign investors buy majority stakes. Our results are driven by foreign acquisitions and not by foreign divestment. The effect of foreign acquisitions on total factor productivity are an order of magnitude smaller in our sample of advanced countries relative to those found for emerging markets.

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1 Introduction

We revisit the question of whether investment by foreign firms leads to higher total factor productivity (TFP) growth of acquired firms in advanced economies. Our particular focus is on the type of investment that drives the productivity effects. We test whether productivity increases upon foreign acquisitions are caused by majority versus minority investors and whether foreign investment and divestment have similar effects. A fundamental problem in identifying productivity effects is that foreign investors target firms that are already highly productive (Blonigen, Fontagne, Sly, and Toubal (2014)) and/or that forward-looking foreign investors acquire firms with good growth prospects (Doms and Jensen (1998)).[1]

We use propensity score matching (PSM), which allows us to compare acquired firms to similar non-acquired firms, in combination with firm fixed effects that absorb the unobserved heterogeneity at the firm-level, as in Guadalupe, Kuzmina, and Thomas (2012) and Arnold and Javorcik (2009). In order to control for the effects of country-sector-level technology shocks, we include country-sector trends, which is typically not done before, as prior works focus on single country case studies.[2] We also include the initial firm productivity in our regressions, which controls for the omitted variable bias that otherwise would occur because productivity is mean-reverting. This is important and different from capturing unobserved heterogeneity with firm fixed effects. Because foreigners tend to invest in high-productivity firms, any productivity decline due to mean-reversion will bias the estimated productivity effect of foreign acquisitions downwards, creating an omitted variable bias if initial firm-level productivity is not controlled for.

The PSM approach matches each acquired firm with a domestic firm that is as similar as possible in terms of observable characteristics prior to the acquisition.

[1] Other advanced country studies that demonstrate that foreign investors tend to target highly productive firms include Harris and Robinson (2003) for the U.K., Criscuolo and Martin (2009) for the U.K., Balsvik and Haller (2010) for Norway, and Guadalupe, Kuzmina, and Thomas (2012) for Spain. Ramondo (2009) and Arnold and Javorcik (2009) find similar results in emerging markets, Chile and Indonesia, respectively.

[2] An exception is Damijan, Kostevc, and Rojec (2015), who use firm-level data from seven Eastern European new EU members to study pre- and post-acquisition performance of acquired firms.

This creates an "artificial counterfactual" by having the estimated coefficients being identified from productivity growth of acquired firms compared to productivity growth of similar non-acquired firms. To control for selection on unobservable factors, we use firm fixed effects (or, equivalently, perform the estimation in first-differences). Many authors (Aitken and Harrison, 1999; Javorcik, 2004; Liu, 2008), find no effect of foreign acquisition on productivity upon inclusion of firm fixed effects.[3] Using both PSM and firm fixed effects, Arnold and Javorcik (2009) find a 13 percent increase in TFP three years after foreign acquisitions in Indonesia. Our estimate of, on average, a 2 percent increase in TFP of acquired firms is clearly below this estimate but in line with the other advanced country studies that focus on TFP. For example, Harris and Robinson (2003) find that foreign plants do better than domestic ones in terms of TFP in some industries but not in others in the U.K. Criscuolo and Martin (2009) finds a 4% TFP increase in the U.K. if and only if the investment comes from the U.S. multinationals, otherwise they find an effect of only 1%. Balsvik and Haller (2010) find no TFP effects for Norway.

We dig deeper to understand the type of investment that is behind the results in hope for clues for our small effects. We first study the delayed effects of foreign investment by including a large number of lags, which we are able to do thanks to our long time-series and large cross-sectional dimensions, and second, we study the effect of majority versus minority acquisitions, differentiating the impact of (positive) acquisitions and (negative) divestments by foreign investors. We find that our estimated effect of 2 percent is due to majority investment, that is foreigners taking the control of the company by acquiring more than 50 percent of the capital stock. This is also a delayed effect, that is, it happens after four years.

The finding that increased productivity occurs when foreigners gain control is in line with Guadalupe, Kuzmina, and Thomas (2012), who studies labor productivity effects of foreign investment. They show that the labor productivity effects of foreign acquisitions work through product and process innovation. They find a 16 percent increase in labor productivity following foreign acquisitions in Spain using a dummy

[3]See also the survey by Stiebale and Reize (2011).

variable for foreign ownership that equals one when foreign investors acquire more than 50 percent of a firm. We document that controlling ownership matters in realizing positive TFP effects of acquired firms. Full control allows foreign owners to reorganize production while minority foreign owners do not, on average, change production practices in ways that lead to measurable productivity improvements. Our TFP effects are much smaller than the labor productivity effects found in Guadalupe, Kuzmina, and Thomas (2012); however, if we perform our analysis only for Spain, studying labor productivity instead of TFP , we find an increase in productivity of 9 percent after four years, which is close to their estimate.

It is plausible that foreign *majority* owners may select domestic firms in which to invest differently from foreign *minority* owners. We, therefore, perform a second PSM analysis: we restrict the sample to firms with foreign ownership and consider foreign majority owned firms as the "treated group" and select similar foreign non-majority owned firms to serve as "controls" based on a logit regression. Estimating the effect of majority foreign ownership on this matched sample confirms that our TFP effects results from majority-acquisition by foreigners.

We hypothesize that we find smaller effects for TFP than previous work because we focus on a sample of advanced countries where domestic investors are similar to foreign investors. Our results on divestment supports this hypothesis: when we separate positive changes in foreign ownership from negative ones (divestment by foreign investors), we find that our results are driven by the positive changes while divestments have no effect on TFP, unlike the negative effects of divestment on TFP in emerging markets that are found in the previous literature (Javorcik and Poelhekke (2017)). These findings are consistent with the interpretation that foreign and domestic investors are close in technology space in advanced countries.

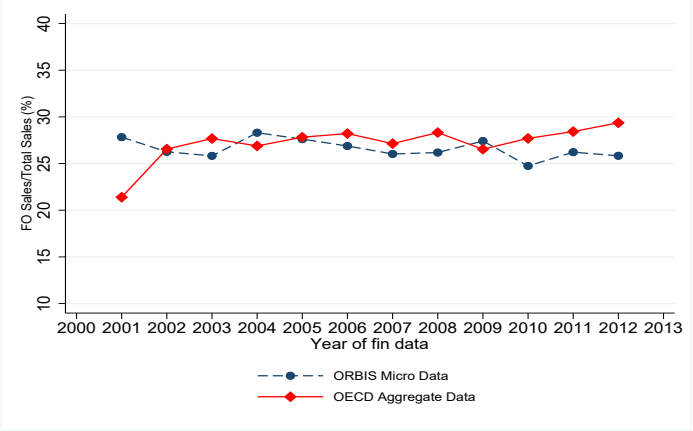
We use a new dataset of foreign ownership and productivity which is representative both for foreign and domestic firms. As shown in Figure 1, the "aggregated foreign investment"—obtained from our dataset by summing up the output produced by foreign owned firms in our sample—tracks one-to-one the"official foreign investment"

from the OECD.[4]

Our dataset is drawn from the Orbis/Amadeus database of Bureau van Dijk (BvD), a Moody's company, and we focus on the manufacturing sectors of the eight advanced European countries (Belgium, Finland, France, Germany, Italy, Norway, Spain, and Sweden) for the years 1999–2012. The start of our sample is marked by the introduction of the euro and a big policy push for the European financial integration. During this period, there was an unprecedented increase in cross-border mergers and acquisitions. We observe M&A transactions as reflected in changes to the firm ownership structure. We aggregate foreign ownership stakes to the firm-level; that is, we observe changes in foreign ownership over time at the firm-level both at the extensive margin (being foreign owned or not) and at the intensive margin (the percent of capital stock owned by foreigners), annually.

[4]OECD data is from the *Activities of Foreign Affiliates* (AFA) database at the ISIC Revision 3 classification for the years prior to 2008 and Activity of Multinationals (AMNE) database the ISIC Revision 4 classification from the years starting from 2008 (both available at http://stats.oecd.org/Index.aspx?DataSetCode=AFA_IN3). OECD traces the "affiliates under foreign control", but the definition of control changes from country to country. In all cases, OECD aggregates the entire output of the entities designated as "foreign" and expresses them in national currency or, in the AFA database, as the ratio of total output in a given reporting industry. We aggregate the multinational turnover data from the OECD's AFA and AMNE databases, expressed in a single currency using the end of period exchange rates from Bloomberg across countries, and divide by total manufacturing turnover taken from the OECD's *STAN Database for Structural Analysis* (available at http://stats.oecd.org/Index.aspx?DataSetCode=STAN08BIS). To be consistent, we identify the companies in the ORBIS database as foreign if 10 or more percent of their equity is owned by foreigners. We compute the foreign output share in our data as the ratio of total foreign output to total output. As with the OECD data, we limit ourselves to the manufacturing sector.

Figure 1: Foreign Firms' Share in Manufacturing Sales: ORBIS vs. OECD Data (%)



Notes: The shares from the ORBIS data (blue dashed line with circles) are computed as the ratios of the aggregated sales of firms in manufacturing with foreign ownership of at least 10 % to total manufacturing sales across all ORBIS firms. Foreign multinational activity from the OECD data (red solid line with diamonds) is the sum of sales of multinational manufacturing companies reported by the AFA and AMNE databases of the OECD divided by total manufacturing sales in these countries from the OECD STAN database. The figure represents average of countries for which the OECD data is available: Finland, France, Italy, Norway, and Spain.

The rest of the paper is structured as follows. Section 2 reviews the data and describes the construction of the variables. Section 3 discusses our empirical methodology. Section 4 presents the results and Section 5 concludes.

2 Data and Construction of Variables

Representative firm-level data, both for domestic firms and foreign firms, is important for our analysis. The Orbis database by BvD is attractive for these purposes. BvD collects data from various sources, in particular, national business registries, and harmonizes the data into an internationally comparable format. The Orbis database covers more than 200 countries and over 200 million firms (private and publicly listed), with the longitudinal dimension and representativeness of the firms varying from country to country depending on whether the smallest firms are required to file information with business registries.

Orbis provides consistent representative time series for both private and public firms for the countries analyzed in this paper, starting in 1999, whereas for other advanced European countries, although representative, the coverage starts later, which explains our choice of countries to include in the study. Significant effort is needed to put the longitudinal firm-level data set together, for both the financial accounts and for the ownership structure. The online version of Orbis, or the current vintage, will only provide the *current* ownership information on firms, and the results will suffer from survivorship bias unless historical ownership and transaction-level data are used to capture all the changes in ownership. It is also necessary to use older vintages of the financial data to avoid missing observations in firm financials.[5]

For each firm, we have full balance sheet information over time and sector codes at the four-digit NACE level. Firms are linked to their domestic and foreign parents through the unique ID numbers, and this allows us to construct precise firm-level measures of changes in foreign investment in firms over time based on changes in ownership stakes by foreigners.

We next describe the main firm-level variables used in the analysis. More details on the cleaning process and firm-level statistics are provided in Appendix A.

2.1 Firm-Level Productivity

Our main dependent variable is total factor productivity at the firm-level. We assume that firm i's output is determined by a Cobb-Douglas production function,

$$Y_{it} = A_{it} L_{it}^{\beta_\ell} K_{it}^{\beta_k} , \tag{1}$$

where firm value added, Y_{it}, is a function of physical productivity (A_{it}) and firm inputs (L_{it}, K_{it}), where L_{it} is labor input, K_{it} is capital input, where P_{it} is the (unobserved) price of output, β_k is the output/revenue elasticity of capital, and β_ℓ is the output/revenue elasticity of labor. We measure nominal value added, $P_{it}Y_{it}$, as the

[5]See Kalemli-Ozcan, Sørensen, Villegas-Sanchez, Volosovych, and Yesiltas (2015) for a detailed explanation on how to construct nationally representative firm-level financial and ownership data from the BvD products.

difference between gross output (operating revenue) and expenditure on materials. Because we do not observe prices at the firm level, we calculate "real" output, Y_{it} by dividing nominal value added with Eurostat two-digit industry price deflators; however, our output measure is clearly a revenue measure.[6] Labor input, L_{it}, is measured as the firm's wage bill (deflated by the same two-digit industry price deflator).[7] Finally, we measure the capital stock, K_{it}, as the book value of fixed assets, deflated by the price of investment goods.[8]

To obtain firm-level revenue productivity estimates (TFPR), we follow the approach suggested in Wooldridge (2009)—see Appendix C for a detailed description of the estimation procedure. We estimate the production function by country and two-digit sector (Table C.1 in Appendix C shows the estimated elasticities) and winsorize the resulting distribution at the 1st and 99th percentiles by country.

2.2 Firm-Level Foreign Ownership

To construct our main independent variable, we calculate for each firm the share of foreign ownership using Orbis data. 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) and we can identify changes in ownership over time. 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 records direct links between two entities even when the ownership percentages are very small (sometimes less than one percent). For listed companies, very small stockholders are

[6]Norway and France do not have industry price deflators at the two-digit level, and we use the total manufacturing industry price deflator for these two countries.

[7]Using the wage bill, rather than the head count, helps adjust for differences in the quality of workers across firms because more skilled workers normally are paid more.

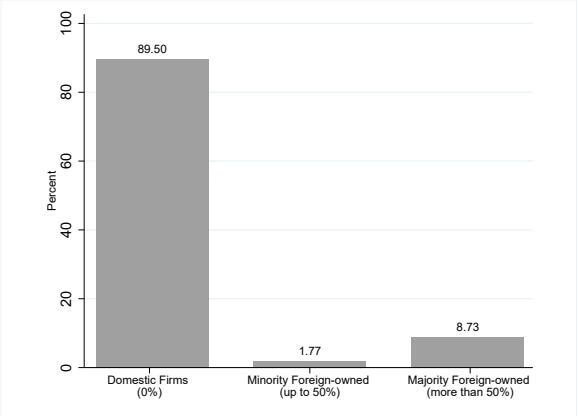
[8]We use country-specific prices of investment from the World Development Indicators to deflate the book value of fixed assets. The capital stock includes both tangible and intangible assets because in 2007 there was a change in the accounting system in Spain (leasing items that until 2007 had been part of intangible fixed assets were from 2008 included under tangible fixed assets). To avoid breaks in the time series, we opt to use the sum of tangible and intangible fixed assets as our measure of capital stock.

typically unknown.[9] We compute "foreign ownership" of firm i at time t, FO_{it}, as the sum of all percentages of *direct* ownership by foreigners in that year, and we repeat this calculation for every year.[10] We define a firm to be "domestic" if it did not have any foreign owner during the sample period.

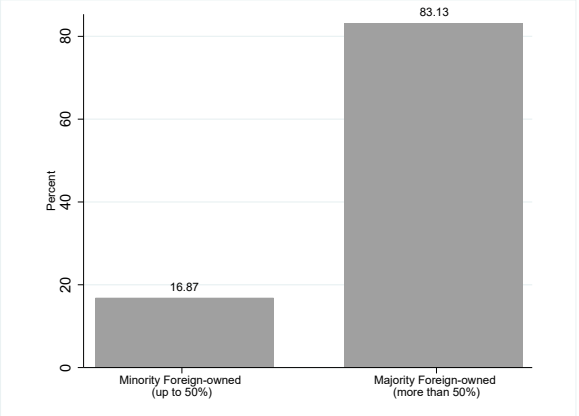
Figure 2 displays the distribution of foreign ownership across firms. Panel (a) shows that close to 90 percent of firms in the sample are domestic firms (i.e., firms that never had a foreign owner during the period of analysis). Panel (b) shows that among foreign-owned firms (i.e., those that had at least one foreign owner during the sample period) more than 80 percent were majority-owned.

Figure 2: Distribution of Foreign Ownership.

(a) All Firms (1999-2012)



(b) Only Foreign Owned Firms (1999-2012)



Notes: Panel (a) shows the distribution of domestic, minority and majority-foreign owned firms, respectively, in the full sample. Panel (b) focuses on the sample of foreign-owned firms and shows the distribution of minority and majority owners.

Because we are interested in the effect of changes in foreign ownership on the productivity of target firms after acquisition, we follow Guadalupe, Kuzmina, and Thomas (2012) and focus on the sample of firms that have no foreign ownership the first time they appear in the sample. We define a firm to be a majority-owned foreign firm if the percentage of foreign ownership is 50 percent or more after the acquistion.

[9] Countries have different rules for when the identity of a minority owner needs to be disclosed for listed firms. France requires listed firms to disclose all owners with a stake larger than five percent while Italy requires listed firms to disclose all owners with a stake larger than two percent.

[10] For example, if a company has three foreign owners with stakes of 10, 15, and 35 percent, the foreign ownership fraction for this company is 60 percent. The following year, the company may have a fourth foreign owner with a stake of 10 percent, in which case foreign ownership would become 70 percent and the year-to-year change would be 10 percentage points.

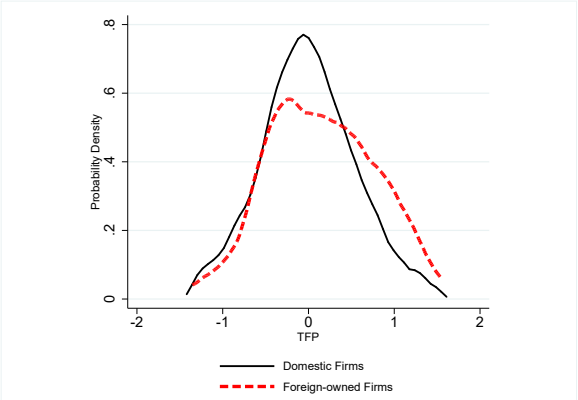
If ownership were very dispersed across owners (for example, if majority foreign-owned firms were owned by 50 different foreign owners, each holding a 1 percent ownership stake) our interpretation of 50 percent ownership as controlling ownership would be problematic. Thus, we also control for the number of owners, although most majority foreign-owned firms have only one owner. Specifically, 75 percent have a single owner, while the 95 percentile of the distribution shows two foreign owners, and the 99 percentile corresponds to four foreign owners.

3 Endogenous Selection and Identification

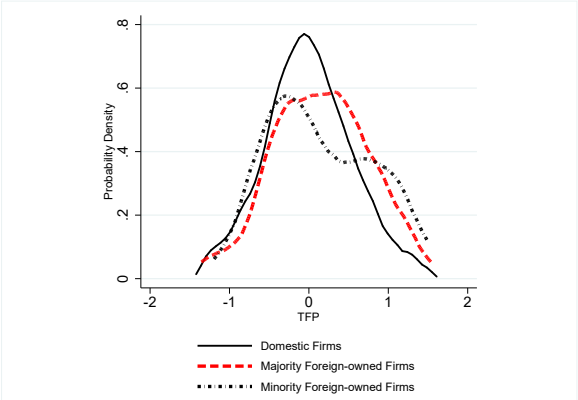
In Figure 3, we plot the initial productivity of firms that are acquired versus those that are not. More precisely, the figure shows the density distribution of initial TFPR (in terms of deviations from country and sector means) for the sample of domestic firms which are not acquired, and for the sample of firms which are initially domestic but have some foreign ownership four years later.

Figure 3: Distribution of Initial Productivity for Acquired and Non-Acquired Firms.

(a) Foreign Ownership



(b) Types of Foreign Owners



Notes: Initial productivity at the firm level is measured by total factor productivity (log TFPR) in the first year the firm appears in the sample, demeaned by sector and country over the sample period. The solid line represents (log TFPR) 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 majority-owned firms (those that are originally domestic but were majority owned by a foreign investor four years after (t+4)); the dotted-dashed line refers to minority owned foreign firms (those that are originally domestic but were minority owned by a foreign investor four years after (t+4)).

The distributions of the two groups of firms in panel (a) in Figure 3 are quite similar, but among the firms that are acquired, there is less mass at the overall average productivity level and more mass at the highest level of productivity. So while there is a large spread in the distribution of the initial productivity of acquired firms, there is also a clear tendency for foreign acquisitions to be concentrated in firms with the highest level of productivity. It is evident that foreign investors do not select firms randomly.

In panel (b), we separate the sample of firms that are acquired by foreigners with total majority and minority foreign stake. The distribution of initial productivity of firms that are subsequently acquired and have foreign minority ownership has higher variance than those acquired by foreign majority owners. Some foreign minority owners invest in a priori low-productivity domestic firms while other foreign minority owners invest in a priori high-productivity firms; that is why we see two humps in the distribution. However, both majority and minority foreign investors, *on average*, invest in firms with above-average productivity. In the next section, we explore the relationship between foreign ownership and productivity using regression analysis, controlling for country- and sector-level trends, and for mean-reversion in initial productivity, using propensity score matching techniques to control for possible non-random selection of firms by foreign investors.

4 Empirical Results

We first estimate the relation between the *level* of productivity and the *level* of foreign ownership using specifications with or without firm fixed effects. We regress the log-level of TFPR on the logarithm of (1+percent foreign ownership share).[11] We want to know if productivity effects depend on foreign ownership concentration, so we control for the number of foreign owners. Productivity may be fully persistent or it may revert to the mean as time passes—and if foreign investors target high-productivity

[11] As is well known, $\log(1+x) \approx x$ when x is small, so the regression coefficient on foreign ownership is best interpreted as a semi-elasticity. We add the number 1 in order to allow for zero values of x.

firms, one may underestimate the productivity impact of foreign investment if one does not control for the overall tendency of high-TFPR firms to display a decline in productivity. To capture this, we include initial productivity interacted with the variable FIRM TREND (the number of years since firm i was first observed in the data in a given year t the firm is observed; i.e., it equals unity the first time we observe the firm in the sample, regardless of the actual calendar year, and so on) and the "initial" TFPR measured for that firm. Because our panel of firms is unbalanced, the FIRM TREND variable is not identical to the overall time trend. We further include sector- and country-specific trends and the relation we estimate is thus:

$$\begin{aligned} \log \text{TFPR}_{\text{i,t}} &= \beta_1 \log\left(1 + \text{FO}_{i,t}\right) + \beta_2 \text{Nr\_For\_Owners}_{it} + \beta_3 \log \text{TFPR}_{\text{i,1}} + \\ &\quad \beta_4 \log \text{TFPR}_{\text{i,1}} \times \text{FIRM TREND}_{i,t} + \phi_{s4} \times \text{TREND}_t + \delta_c \times \text{TREND}_t + \epsilon_{i,t}\,, \end{aligned} \tag{2}$$

where i is firm, $s4$ is the 4-digit sector of the firm, c is the country of the firm. $\text{TFPR}_{\text{i,1}}$ is the initial level of revenue productivity in the first year that firm i appears in the regression sample, $\text{FO}_{i,t}$ is the share of ownership which is foreign at time t, TREND_t is a linear time trend, and $\epsilon_{i,t}$ is a mean zero error term. We assume that the error term is orthogonal to the regressors and independent across firms, but the error variances may vary across firms. We allow for either sector- and country-specific trends or more general country-sector-trends (i.e., the term $\gamma_{c,s4} \times \text{TREND}_t$ is included)—if the latter terms are included the sector- and country-trend terms are subsumed and not separately identified.

Further, we can control for the correlation between the average level of productivity and the average level of foreign ownership by including a firm-specific fixed effect denoted by α_i. In this specification the coefficients are identified by the change in the variables over the sample and the initial level of productivity is dropped because it would not be identified:

$$\begin{aligned} \log \text{TFPR}_{\text{i,t}} &= \alpha_i + \beta_1 \log\left(1 + \text{FO}_{i,t}\right) + \beta_2 \text{Nr\_For\_Owners}_{it} + \\ &\quad \beta_3 \log \text{TFPR}_{\text{i,1}} \times \text{FIRM TREND}_{i,t} + \gamma_{c,s4} \times \text{TREND}_t + \epsilon_{i,t}\,. \end{aligned} \tag{3}$$

The combination of firm fixed effects and time trends also controls for the age of firms. Because the error variance differs substantially across firms, OLS is inefficient as it ignores the heteroskedasticity (although clustering will correct the standard errors). We estimate our relations using Generalized Least Squares (GLS), allowing for firm-specific weights. The weights are the inverse of the square root of firm-level mean squared residuals from an initial OLS estimation.

Table 1: Foreign Ownership and Productivity: Levels

Dependent Variable: log Firm Revenue TFP

	(1)	(2)	(3)	(4)
$\log(1 + \text{FO})$	0.162***	0.009**	0.022***	0.027***
	(0.012)	(0.004)	(0.005)	(0.005)
Nr_For_Owners	0.054***	-0.001	-0.000	-0.001
	(0.003)	(0.001)	(0.001)	(0.001)
$\log \text{TFPR}_1 \times$ FIRM TREND			-0.006***	-0.025***
			(0.000)	(0.000)
Observations	826,152	813,379	813,379	810,637
Firm−FE	no	yes	yes	yes
Year−FE	yes	yes	yes	yes
Cntry×trend	yes	no	no	n.a.
Sec4×trend	yes	no	no	n.a.
Cntry×Sec4×trend	no	no	no	yes

Notes: The dependent variable is log revenue firm-level productivity at time t. The main regressor is $\log(\text{FO}+1)$ where FO stands for the percentage of foreign ownership, Nr_For_Owners is the number of foreign owners in the firm, and $\log \text{TFPR}_1$ is productivity of the firm the first year the firms is in the regression sample. FIRM TREND stands for the number of years since firm i was first observed in the data; i.e., it equals unity the first time we observe the firm in the sample, regardless of the actual calendar year. Standard errors are clustered at the firm level. Column (1) estimates the specification of equation (2) in the main text. Columns (2) to (4) report the results from the specification of equation (3) in the main text. Standard errors are clustered at the firm level. Results are obtained by GLS estimation using as weights the square root of each firm's mean squared predicted residuals from an initial OLS estimation. *** denotes 1% significance; ** denotes 5% significance; * denotes 10% significance.

Table 1, column (1), shows that foreign ownership is strongly correlated with firm-level productivity and that firms with many foreign owners are more productive. In column (1), the foreign ownership variable has a coefficient (elasticity) of 0.162, statistically significant with a two-digit t-statistic. Column (2) includes the firm fixed effects. The coefficient to the number of foreign owners became insignificant upon the

inclusion of firm fixed effects and the main coefficient on foreign ownership becomes smaller. In column (3), there is a significant negative coefficient to initial productivity interacted with a time-trend, which indicates that productivity growth, everything else equal, is negative when the productivity of a firm is above the firm-specific mean—commonly referred to as mean reversion. The mean reversion of productivity has not been considered before when investigating the effect of foreign investment on firm productivity. The patterns in columns (2) and (3) indicate that the combination of mean-reversion in productivity and foreign investors seeking out high-productivity firms bias the coefficient to foreign ownership downwards, if reversion to the mean of the acquired high productivity firms is not controlled for: the coefficient on foreign ownership in column (3), which controls for initial productivity, is double the size of the coefficient in column (2). Column (4) controls for country-sector trends, allowing for different trends in each sector in each country. The rate of mean reversion of productivity is larger, but the estimated impact of foreign ownership is similar. The main message of Table 1 is that foreign ownership is highly correlated with initial productivity and that firm-level TFP is mean-reverting.

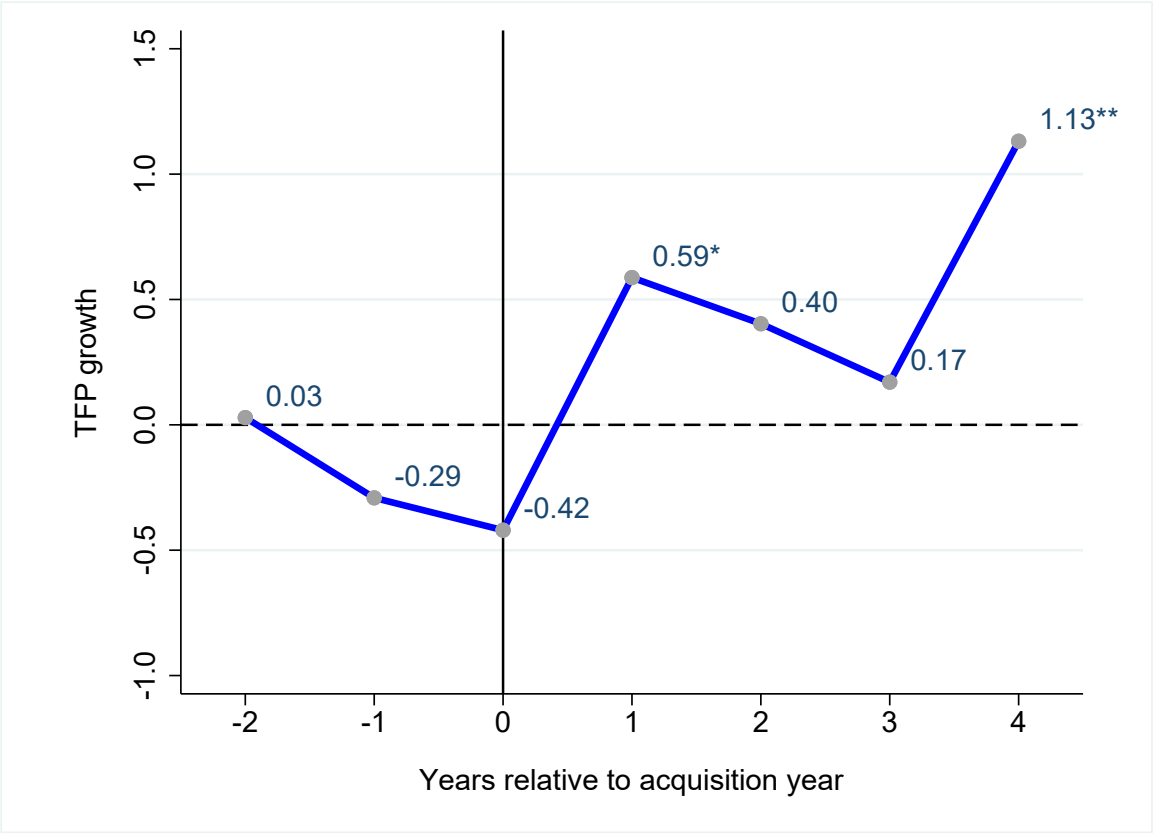
Next, we match the foreign-acquired firms to a sample of similar domestic firms. Firms acquired by foreigners are likely to differ in important dimensions from non-acquired firms and these dimensions may themselves predict productivity growth. We estimate a logit regression with the probability of a firm becoming foreign owned as a function of observable characteristics, measured before the firm becomes acquired. As independent variables, we include, for the first year the firm appears in the sample, the levels and squares of employment, assets, age, the level of value added per employee, the logarithm of capital stock per employee, and wages per worker. Roberts and Whited (2013) recommend to match on growth rates of outcome variables to ensure similarity of pre-treatment trends. We include productivity growth in the first year the firm is in the sample, and productivity in each of the two years before the foreign firm was acquired. For firms which were not acquired, we use the level of productivity in the first year the firm is in the sample and the first two years for growth.

Table 2: Predicting Foreign Ownership—Logit Regression

Dependent Variable:Dummy Foreign Ownership	
	(1)
$\log \text{TFPR}_1$	-0.082
	(0.054)
$\Delta \log \text{TFPR}_{\text{Acq}-1}$	-0.246*
	(0.138)
$\Delta \log \text{TFPR}_{\text{Acq}-2}$	-0.096
	(0.141)
$\log \text{L}$	0.535**
	(0.187)
$\log \text{L}^2$	-0.034*
	(0.019)
$\log \text{W}$	0.627***
	(0.101)
$\log \text{VAL}$	0.333***
	(0.095)
$\log \text{KL}$	0.060*
	(0.031)
$\log \text{ASSETS}$	2.164***
	(0.468)
$\log \text{ASSETS}^2$	-0.052***
	(0.014)
AGE	-0.006***
	(0.002)
AGE^2	0.000**
	(0.000)
Observations	56,313
Sec2−FE	yes
Cntry−FE	yes
Year−FE	yes
R^2	.12

Notes: The dependent variable is a dummy variable that takes the value of one if the firm ever becomes foreign owned during the sample period (1999-2012). Data are included in the estimation only for the first year we observe a firm. Results are obtained by a logit regression. The observable variables included are: log productivity of the firm the first year the firm is in the regression sample ($\log \text{TFPR}_1$); the first and second lags of productivity growth prior to the first acquisition year for acquired (treated) firms and two first available observations for never acquired (control) firms ($\Delta \log \text{TFPR}_{\text{Acq}-1}$ and $\Delta \log \text{TFPR}_{\text{Acq}-2}$); log employment ($\log \text{L}$); log employment squared; log value added per employee ($\log \text{VAL}$); log capital stock per employee ($\log \text{KL}$); log assets ($\log \text{ASSETS}$); log assets squared; age (AGE); age squared; log wage ($\log \text{W}$, which refers to compensation divided by number of employees). *** denotes 1% significance; ** denotes 5% significance; * denotes 10% significance.

Figure 4: TFPR Growth in Matched Sample of Foreign Acquisitions vs. Domestic Firms.



Notes: This figure reports differences of productivity growth between foreign acquired and domestic firms in a sample. The domestic firms are matched to foreign firms using a one-to-one matching procedure based on the pre-treatment observable characteristics included in the logit regression reported in Table 2. The observable variables included are: log productivity of the firm the first year the firm is in the regression sample ($\log \text{TFPR}_1$); the first and second lags of productivity growth prior to the first acquisition year for acquired (treated) firms and two first available observations for never acquired (control) firms ($\Delta \log \text{TFPR}_{\text{Acq}-1}$ and $\Delta \log \text{TFPR}_{\text{Acq}-2}$); log employment ($\log \text{L}$); log employment squared; log value added per employee ($\log \text{VAL}$); log capital stock per employee ($\log \text{KL}$); log assets ($\log \text{ASSETS}$); log assets squared; age (AGE);age squared; log wage ($\log \text{W}$, which refers to compensation divided by number of employees). TFP growth is growth in log revenue productivity ($\log \text{TFPR}$) relative to the previous year.
The figure displays the estimated ξ-coefficients from the regression

$$\Delta \text{TFPR}_{\text{i,t}} = \mu_t + \sum_{\tau=-2}^{4} \xi_\tau \text{ACQ}_{\text{i,t}-\tau} + \text{TFPR}_{\text{i,1}} + \epsilon_{\text{i,t}} \,,$$

where $\tau = 0$ represents the year the firm was acquired (i.e., the firm went from having zero foreign ownership to having a foreign ownership stake) and $\text{ACQ}_{i,t-\tau}$ are dummy variables for years $t - \tau$, where t is the year of acquisition (the foreign acquired firms are included in the sample for two years before acquisition till four years after). μ_t denotes year fixed effects. $\xi_{\tau=1}$ and $\xi_{\tau=4}$ are statistically significant at the 10% and 5% significance level, the remaining coefficients are not significant, which implies that the productivity growth between treated and controls are not statistically different from each other pre-treatment. Excluding $\text{TFPR}_{\text{i,1}}$, or controlling for firm fixed effects, does not change the pattern materially.

The logit estimation results are tabulated in Table 2. It is clear that firms that are large in terms of assets, have high employment, have high wage-rates, and have high value added per worker are significantly more likely to be acquired. Conditional on the other regressors, TFPR in the year of acquisition is not significant, but this is because value added per worker captures the correlation between productivity and foreign ownership. TFPR-growth the year before acquisition has a negative sign, but it is only marginally significant, consistent with the pre-sample coefficients depicted in Figure 4. The figure also demonstrates that in our matched sample, the "parallel trends" condition is satisfied: for the two years pre-treatment, there is no significant differences in TFP growth (our outcome) between treated (acquired) and control (domestic) firms.

Based on the logit regressions, we select the 1,967 domestic firms with the highest probability of being acquired by foreigners and construct a matched sample of $2 \times 1{,}967$ firms where there is one domestic matched firm for each foreign-owned firm. Table 3 examines if domestic firms in the matched sample are similar to foreign-owned firms in terms of the pre-treatment variables used in the logit selection regression. We find that we cannot reject the null of similarity for any of the variables.

We continue with the *growth-rate* (differenced) version of equation (2). In the absence of a stochastic error term, the differenced equation would be equivalent to the levels equation, but in the stochastic case, the choice of specification depends on the time-series properties of the error term. First, consider the extreme case of serially uncorrelated errors: in short panels, the coefficient on the lagged endogenous variable will be biased if the error terms are serially correlated, and because differencing in this case creates error terms that satisfy a moving-average specification with a lagged coefficient of minus one, the coefficient to the lagged endogenous variable will also be biased in this specification (Arellano and Bond (1991)). Second, consider the extreme case of random walk errors: a differenced regression will satisfy the assumption for Ordinary Least Squares (OLS)—GLS in our case—to be efficient and unbiased. Examining the residuals from an initial levels regression, we find that our

Table 3: Test of Similarity Between Acquired Firm and Domestic Matched Sample

Variable	Treatment	Control	Diff	p-value	Observations (treated or controls)
(1)	(2)	(3)	(4)	(5)	(6)
$\log \text{TFPR}_1$	4.072	4.091	-0.0196	0.49	1,967
$\Delta \log \text{TFPR}_{t-1}$	-0.0032	0.0043	-0.0075	0.17	1,967
$\Delta \log \text{TFPR}_{t-2}$	0.0045	0.0003	0.0042	0.43	1,967
$\log \text{L}$	4.284	4.254	0.0306	0.39	1,967
$\log \text{W}$	11.07	11.06	0.0072	0.55	1,967
$\log \text{VAL}$	0.839	0.842	-0.0030	0.82	1,967
$\log \text{KL}$	-0.006	0.043	-0.0493	0.13	1,967
$\log \text{ASSETS}$	16.69	16.68	0.0149	0.72	1,967
AGE	20.40	19.61	0.7946	0.21	1,967

Notes: This table reports the means of treated and control groups from the one-to-one matching procedure based on pre-treatment characteristics included in the corresponding logit regression in Table 2. "Diff" is the average difference of means between acquired (treated) and non-acquired (control) firms and the "p-value" is the result of the two-sided difference of means test between the two groups. There are 1,967 foreign firms that are matched to 1,967 domestic firms.

data are closer to the case of random walk errors.[12]

We difference the data and estimate the model in growth rates and this regression will, as a first approximation, be unbiased. However, because the error terms in this specification display some autocorrelation, which is the source of the problem discussed by Arellano and Bond (1991), we instrument initial productivity with productivity in the year before the start of the regression sample.[13]

[12]Regressions of the estimated residuals from the levels regression on the lagged residuals, using an autoregressive model of order 1 (AR(1) model), gives a coefficient to the lagged error term of 0.86 (with very high significance). While the naive standard errors indicate that this value is significantly different from unity, AR(1) estimation in this case is known to be downward biased (see, for instance, Hamilton (1994)). Estimated standard errors will also be biased if the error terms are serially correlated although the reporting of (firm-level) clustered standard errors will alleviate that problem (see Bertrand, Duflo, and Mullainathan (2004)). The exact critical values for testing for a unit coefficient to the lagged residual are unknown for short panels like ours with a large number of fixed effects; however, the estimation errors are much closer to random walks than to white noise.

[13]Using the residuals from the differenced regression, we find an AR(1) coefficient of -0.2 (significantly different from 0).

The differenced equation takes the form

$$\Delta \log \text{TFPR}_{i,t} = \Sigma_{k=1}^{4} \beta_k \Delta \log \text{FO}_{i,t-k} + \Sigma_{k=1}^{4} \beta_{k+4} \Delta \text{Nr\_For\_Owners}_{i,t-k} + \beta_9 \log \text{TFPR}_{i,1} + \gamma_{c,s4} + \epsilon_{i,t}. \quad (4)$$

In equation (4), the logarithm of initial productivity, $\log \text{TFPR}_{i,1}$, corresponds to the term $\log \text{TFPR}_{i,1} \times \text{FIRM TREND}_{i,t}$ in the levels regression (2). Similarly, the sector/country dummies, $\gamma_{c,s4}$, control for sector- and country specific trends in levels, because differencing the sector/country trends delivers sector/country dummies. For the growth-rate estimation, we allow for lags which capture gradual adjustment.

Table 4 reports the results. We see, robustly across all columns, that an increase in foreign ownership correlates with an increase in productivity, but the effect is only significant after four years. The number of foreign owners is borderline significant with a three-year lag in the full sample and a negative sign. However, in the matched sample, the number of foreign owners is insignificant at all lags when initial productivity is included, and we conclude that on average the number of foreign owners is not an important determinant in our dataset. In the following tables, we suppress the estimated coefficients to this variable as they are all small and insignificant.[14] Comparing columns (1) and (2), we see that if initial productivity is included the (four-year) lagged coefficient becomes larger and more significant although there is little difference between the corresponding coefficients for the matched-sample regressions in columns (4) and (5). The inclusion of country-sector fixed effects does not have a large effect and in this specification the 4-year lagged elasticity is 0.021. The fact that this coefficient is immune to different trends in sectors in different countries further points to a causal effect, because foreign ownership might be attracted to sectors or countries with high TFP-growth, but this is not what is driving our results.

"Post hoc ergo propter hoc" (after this, therefore resulting from it) has long been recognized as a potential fallacy, but a four-year delay in the productivity pick-up seems consistent with a causal effect of new owners reorganizing the firm. Causality would be broken if foreigners identified domestic firms which, regardless of actual

[14] If we do not instrument initial productivity, our results do not change. These results are available upon request.

changes in ownership, would become more productive in four years. The pattern of productivity increasing only after four years is even more clear in matched regressions and the combination of matched regressions and lagged effects strongly suggests that the effect is causal. In general, the results from the full sample agree with the results from the matched sample, although the coefficients are slightly larger in the matched sample, where the estimated elasticity is about 2 percent.

Table 4: Foreign Ownership and Productivity: Lagged Growth Rates

Dependent Variable:Δ log Firm Revenue TFP

	(1)	(2)	(3)	(4)	(5)	(6)
	Full sample			Matched sample		
$\Delta \log(\text{FO})_{t-4}$	0.012**	0.016**	0.013**	0.019**	0.020**	0.021**
	(0.005)	(0.005)	(0.005)	(0.007)	(0.007)	(0.008)
$\Delta \log(\text{FO})_{t-3}$	0.005	0.008*	0.006	0.002	0.002	-0.001
	(0.005)	(0.005)	(0.005)	(0.006)	(0.006)	(0.007)
$\Delta \log(\text{FO})_{t-2}$	0.000	0.003	0.003	0.000	0.002	-0.003
	(0.004)	(0.004)	(0.004)	(0.005)	(0.006)	(0.006)
$\Delta \log(\text{FO})_{t-1}$	0.004	0.006	0.005	0.007	0.008	0.005
	(0.004)	(0.004)	(0.004)	(0.005)	(0.005)	(0.006)
$\Delta \text{Nr\_For\_Owners}_{t-4}$	-0.000	-0.000	-0.000	0.001	0.001	0.001
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)
$\Delta \text{Nr\_For\_Owners}_{t-3}$	-0.002**	-0.002**	-0.002**	-0.002*	-0.001	-0.001
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
$\Delta \text{Nr\_For\_Owners}_{t-2}$	-0.000	0.000	-0.000	0.000	0.001	0.001
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
$\Delta \text{Nr\_For\_Owners}_{t-1}$	0.001	0.001	0.001	0.002	0.002	0.002
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
$\log \text{TFPR}_1$		-0.006***	-0.013***		-0.006***	-0.017***
		(0.000)	(0.000)		(0.001)	(0.002)
Observations	288,961	288,961	288,927	18,398	18,398	18,365
Firm−FE	no	no	no	no	no	no
Year−FE	yes	yes	yes	yes	yes	yes
Sec4−FE	no	no	n.a.	no	no	n.a.
Cntry−FE	no	no	n.a.	no	no	n.a.
Cntry×Sec4−FE	no	no	yes	no	no	yes
First Stage F		165,966	48,220		6,682	548

Notes: The dependent variable is the change in log revenue firm-level productivity at time t ($\Delta \log \text{TFPR}_{i,t}$). Δ indicates one-year changes. $\Delta \log(\text{FO})$ is the annual change in the $\log(\text{FO}+1)$ where FO stands for the percentage of foreign ownership. $\Delta_{\text{Nr\_For\_Owners}}$ is the annual change in the number of foreign owners. $t-1$, $t-2$, $t-3$ and $t-4$ indicate a change in ownership that took place one year, two years, three years, and four years ago, respectively. $\log \text{TFPR}_1$ is productivity of a firm the first year the firm is in the regression sample. Columns (1) to (3) show the results using the "maximum" sample of firms, while columns (4) to (6) repeat the analysis for the matched sample of firms from the one-to-one matching procedure based on pre-treatment characteristics included in the corresponding logit regression in Table 2. Standard errors are clustered at the firm level. Results are obtained by a weighted (GLS) regression where the instruments are the regressors, except that the lagged initial TFP is used an instrument for $\log \text{TFPR}_1$. The regression weights are the square roots of each firm's mean squared predicted residuals from an initial OLS-IV estimation. *** denotes 1% significance; ** denotes 5% significance; * denotes 10% significance.

Next, we compare the effects of foreign *majority versus minority* investments. Define the variable $\text{DFO}^{\text{maj}}{}_{i,t}$ to take a value of unity in period t if foreigners own a majority share of the firm i and $\text{DFO}^{\text{min}}{}_{i,t}$ to take a value of unity if firm i has foreign ownership in an amount less than 50 percent. We run the regression

$$\begin{aligned} \Delta \log \text{TFPR}_{\text{i,t}} &= \Sigma_{k=1}^{4} \beta_k^{\text{maj}} \Delta \text{DFO}^{\text{maj}}{}_{i,t-k} + \Sigma_{k=1}^{4} \beta_{k+4}^{\text{min}} \Delta \text{DFO}^{\text{min}}{}_{i,t-k} \\ &\quad + \Sigma_{k=1}^{4} \beta_{k+8} \Delta_{\text{Nr\_For\_Owners}it} + \beta_{13} \log \text{TFPR}_{\text{i,1}} + \gamma_{c,s4} + \epsilon_{i,t} \,, \end{aligned} \tag{5}$$

(although we do not tabulate the coefficient to number of foreign owners which remain of negligible magnitude).

Table 5: Majority-Minority Foreign Ownership and TFPR Growth

Dependent Variable: Δ log Firm Revenue TFP

	(1)	(2)	(3)	(4)
	Full sample		Matched sample	
$\Delta(\text{DFO}^{\text{maj}}{}_{t-4})$	0.010**	0.008**	0.014**	0.012**
	(0.004)	(0.004)	(0.005)	(0.006)
$\Delta(\text{DFO}^{\text{min}}{}_{t-4})$	-0.002	-0.004	-0.008	-0.010
	(0.003)	(0.004)	(0.005)	(0.006)
$\Delta(\text{DFO}^{\text{maj}}{}_{t-3})$	0.006*	0.004	0.001	-0.001
	(0.003)	(0.003)	(0.004)	(0.005)
$\Delta(\text{DFO}^{\text{min}}{}_{t-3})$	0.002	0.002	0.003	0.003
	(0.003)	(0.003)	(0.005)	(0.005)
$\Delta(\text{DFO}^{\text{maj}}{}_{t-2})$	0.003	0.002	0.005	0.001
	(0.003)	(0.003)	(0.004)	(0.004)
$\Delta(\text{DFO}^{\text{min}}{}_{t-2})$	0.003	0.003	0.003	0.003
	(0.003)	(0.003)	(0.004)	(0.005)
$\Delta(\text{DFO}^{\text{maj}}{}_{t-1})$	0.002	0.002	0.003	-0.000
	(0.003)	(0.003)	(0.003)	(0.004)
$\Delta(\text{DFO}^{\text{min}}{}_{t-1})$	0.000	0.002	-0.000	0.001
	(0.003)	(0.003)	(0.004)	(0.004)
$\log \text{TFPR}_1$	-0.006***	-0.013***	-0.006***	-0.017***
	(0.000)	(0.000)	(0.001)	(0.002)
Observations	288,961	288,927	18,398	18,365
$\Delta\text{Nr\_For\_Owners}_{t-i}$	yes	yes	yes	yes
Firm−FE	no	no	no	no
Year−FE	yes	yes	yes	yes
Sec4−FE	no	n.a.	no	n.a.
Cntry−FE	no	n.a.	no	n.a.
Cntry×Sec4−FE	no	yes	no	yes
First Stage F	115,150	8,054	4,618	392

Notes: The dependent variable is the change in log revenue firm-level productivity at time t ($\Delta \log \text{TFPR}_{i,t}$). Δ indicates one-year changes. DFO^{maj} is a dummy variable that equals one if the percentage of foreign ownership is equal or greater than 50%. DFO^{min} is a dummy variable that equals one if the percentage of foreign ownership is lower than 50% but greater than 0. $t-1$, $t-2$, $t-3$ and $t-4$ indicate a change in ownership that took place one year, two years, three years, and four years ago, respectively. TFPR_{i1}: productivity of firm i at the first period the firm is in the sample. All regressions control for lagged annual changes in the number of foreign owners $\Delta\text{Nr\_For\_Owners}_{t-i}$ from $t-1$ to $t-4$. Columns (1)-(2) show the results using the full sample of firms, while columns (3)-(4) repeat the analysis for the matched sample of firms from the one-to-one matching procedure based on pre-treatment characteristics included in the corresponding logit regression in Table 2. Results are obtained by GLS-IV estimation instrumenting for initial productivity with its lagged value and using as weights the square root of each firm's mean squared predicted residuals from an initial OLS-IV estimation. *** denotes 1% significance; ** denotes 5% significance; * denotes 10% significance.

The results in Table 5 imply that a change to majority foreign ownership four years ago is associated with a TFP increase in the order of one percent today (ranging from 0.008 to 0.014). There are minor differences in the coefficients across columns, but the preferred point estimate is 0.012 from the matched data with country-sector fixed effects. The coefficients for majority ownership are statistically significant while the corresponding coefficients for minority owners are insignificantly different from 0 for all dummies. This result is consistent with foreign majority owners adjusting aspects of the production process in order to improve productivity while foreign minority owners appear to play no role in improving productivity on average.

Our matching procedure has followed the literature, for example Arnold and Javorcik (2009), and selected a sample of domestic firms that are similar to foreign owned firms. However, we have found that productivity effects only materialize if the foreign owner holds a majority stake. Majority owners may select different firms from minority owners, and our results for majority ownership might therefore be spurious due to a difference between the firm that attract majority versus minority foreign owners. To hedge against this, we perform a *second matching exercise* where we consider foreign majority owned firms as the "treated group" and select similar foreign non-majority owned firms based on a logit regression (reported in appendix Table B.1).[15]

We repeat the regression of equation (4) and estimate the elasticity of TFP with respect to the foreign ownership share. This sample is very different from the sample of domestic and foreign-owned firms used in the other regressions. Still, the results reported in Table 6 are very similar to the ones of the previous tables in the sense that the difference in productivity growth between foreign majority-owned firms and foreign minority-owned firms is similar to what we found comparing foreign-owned majority owned firms to a sample including domestic firms. The coefficients are also of similar magnitudes to the ones obtained using the growth in foreign ownership as the regressor. We conclude that the estimated impact of foreign ownership results

[15]Figure B.1 confirms the validity of the parallel trends condition, and Table B.2 confirms that we cannot reject that the means of the variables are identical between the treated and control groups in this matched sample.

only from those firms that are majority-acquired by foreign investors.

Table 6: Majority Foreign Ownership and Productivity. Sample of Foreign Firms

Dependent Variable: Δ log Firm Revenue TFP

	(1)	(2)
$\Delta(\text{DFO}^{\text{maj}}{}_{t-4})$	0.018***	0.017**
	(0.005)	(0.006)
$\Delta(\text{DFO}^{\text{maj}}{}_{t-3})$	0.001	-0.003
	(0.004)	(0.005)
$\Delta(\text{DFO}^{\text{maj}}{}_{t-2})$	0.004	0.001
	(0.003)	(0.004)
$\Delta(\text{DFO}^{\text{maj}}{}_{t-1})$	0.004	0.001
	(0.003)	(0.004)
$\Delta\text{Nr\_For\_Owners}_{t-4}$	-0.001	-0.000
	(0.002)	(0.003)
$\Delta\text{Nr\_For\_Owners}_{t-3}$	-0.002***	-0.002**
	(0.001)	(0.001)
$\Delta\text{Nr\_For\_Owners}_{t-2}$	-0.001*	-0.000
	(0.001)	(0.001)
$\Delta\text{Nr\_For\_Owners}_{t-1}$	-0.000	0.001
	(0.001)	(0.001)
$\log \text{TFPR}_1$	-0.005***	-0.024***
	(0.001)	(0.004)
Observations	8348	8322
Firm−FE	no	no
Year−FE	yes	yes
Sec4−FE	no	n.a.
Cntry−FE	no	n.a.
Cntry×Sec4−FE	no	yes
First Stage F	3,248	211

Notes: The results are estimated in the matched sample of firms from the one-to-one matching procedure based on pre-treatment characteristics included in the corresponding logit regression in Table B.1. The dependent variable is the change in log revenue firm-level productivity at time t ($\Delta \log \text{TFPR}_{i,t}$). Δ indicates one-year changes. DFO^{maj} is a dummy variable that equals one if the percentage of foreign ownership is equal or greater than 50%. $t-1$, $t-2$, $t-3$ and $t-4$ indicate a change in ownership that took place one year, two years, three years, and four years ago, respectively. TFPR_{i1}: productivity of firm i at the first period the firm is in the sample. All regressions control for lagged annual changes in the number of foreign owners $\Delta\text{Nr\_For\_Owners}_{t-i}$ from $t-1$ to $t-4$. $\Delta\text{Nr\_For\_Owners}$ is the annual change in the number of owners outside of firm's country (foreign owners). $\log \text{TFPR}_1$ is productivity of the firm the first year the firms is in the regression sample. Standard errors are clustered at the firm level. Results are obtained by a weighted (GLS) regression where the instruments are the regressors, except that the lagged initial TFP is used an instrument for $\log \text{TFPR}_1$. The regression weights are the square roots of each firm's mean squared residuals from an initial OLS-IV estimation. *** denotes 1% significance; ** denotes 5% significance; * denotes 10% significance.

Next, we examine whether the effect of majority foreign ownership is symmetric in foreign *acquisitions and divestments* by foreign majority owners. For a sample of Indonesian firms, Javorcik and Poelhekke (2017) find that productivity declines when foreign investors sell (divest) a firm to local owners. This indicates that foreign-owned firms in developing countries receive an ongoing stream of services from the headquarters of multinational owners, which cannot be replicated locally. To investigate this in our advanced country context, we define $\Delta(\text{DFO}^{\text{maj}+})_{i,t} = \Delta(\text{DFO}^{\text{maj}})_{i,t}$ if $\Delta(\text{DFO}^{\text{maj}})_{i,t} > 0$ and 0, otherwise. Similarly, define $\Delta(\text{DFO}^{\text{maj}-})_{i,t} = \Delta(\text{DFO}^{\text{maj}})_{i,t}$ if $\Delta(\text{DFO}^{\text{maj}})_{i,t} < 0$ and 0, otherwise. Clearly $\Delta(\text{DFO}^{\text{maj}+})_{i,t} + \Delta(\text{DFO}^{\text{maj}-})_{i,t} = \Delta(\text{DFO}^{\text{maj}})_{i,t}$ and including both of these variables in a regression, with separate coefficients, will allow us to see if the effect of increases and decreases in majority foreign ownership is symmetric. The equation estimated is

$$\begin{aligned} \Delta \log \text{TFPR}_{\text{i,s4,c,t}} \quad = \quad & \Sigma_{k=1}^{4} \beta_k^{+} \Delta(\text{DFO}^{\text{maj}+})_{i,t-k} + \\ & \Sigma_{k=1}^{4} \beta_k^{-} \Delta(\text{DFO}^{\text{maj}-})_{i,t-k} + \\ & \beta_5 \log \text{TFPR}_{\text{i,1}} + \gamma_{s4,c} + \epsilon_{i,s4,c,t} \,, \end{aligned} \tag{6}$$

where the change in the number of foreign owners is included, but left out of the equation for brevity. This generalizes equation (5), and reduces to that equation if $\beta_k^{+} = \beta_k^{-}$ for all k.

Table 7: Positive Changes in Majority Foreign Ownership and TFPR Growth

Dependent Variable:Δ log Firm Revenue TFP

	(1)	(2)	(3)	(4)
	Full sample		Matched sample	
$\Delta(\text{DFO}^{\text{maj}+})_{t-4}$	0.014***	0.013***	0.014**	0.015**
	(0.004)	(0.004)	(0.005)	(0.005)
$\Delta(\text{DFO}^{\text{maj}-})_{t-4}$	-0.012		0.006	
	(0.008)		(0.012)	
$\Delta(\text{DFO}^{\text{maj}+})_{t-3}$	0.006*	0.005	-0.001	-0.002
	(0.004)	(0.003)	(0.004)	(0.004)
$\Delta(\text{DFO}^{\text{maj}-})_{t-3}$	-0.009		-0.023**	
	(0.008)		(0.011)	
$\Delta(\text{DFO}^{\text{maj}+})_{t-2}$	-0.001	-0.001	-0.004	-0.003
	(0.003)	(0.003)	(0.004)	(0.004)
$\Delta(\text{DFO}^{\text{maj}-})_{t-2}$	0.010		0.015*	
	(0.006)		(0.008)	
$\Delta(\text{DFO}^{\text{maj}+})_{t-1}$	0.001	0.001	0.001	0.000
	(0.003)	(0.003)	(0.004)	(0.004)
$\Delta(\text{DFO}^{\text{maj}-})_{t-1}$	0.003		-0.007	
	(0.006)		(0.007)	
log TFPR_1	-0.013***	-0.013***	-0.014***	-0.014***
	(0.000)	(0.000)	(0.002)	(0.002)
Observations	288927	288927	18488	18488
$\Delta\text{Nr\_For\_Owners}_{t-i}$	yes	yes	yes	yes
Firm−FE	no	no	no	no
Year−FE	yes	yes	yes	yes
Sec4−FE	n.a.	n.a.	n.a.	n.a.
Cntry−FE	n.a.	n.a.	n.a.	n.a.
Cntry×Sec4−FE	yes	yes	yes	yes
First Stage F	8,075	11,652	367	521

Notes: The dependent variable is the change in log revenue firm-level productivity at time t (Δ log $\text{TFPR}_{i,t}$). Δ indicates one-year changes. $\text{DFO}^{\text{maj}+}$ is a dummy variable that equals one if the firm went from minority or domestically owned to majority owned (i.e., majority refers to 50 or more percentage ownership). $\text{DFO}^{\text{maj}-}$ is a dummy variable that equals minus one if the firm went from foreign majority ownership to minority or domestic ownership. $t-1$, $t-2$, $t-3$ and $t-4$ indicate a change in ownership that took place one year, two years, three years, and four years ago, respectively. $\text{TFPR}_{i,1}$: productivity of the firm the first time firm i is in the sample. Standard errors are clustered at the firm level. All regressions control for lagged annual changes in the number of foreign owners $\Delta\text{Nr\_For\_Owners}_{t-i}$ from $t-1$ to $t-4$. Columns (1)-(2) show the results using the full sample of firms, while columns (3)-(4) repeat the analysis for the matched sample of firms from the one-to-one matching procedure based on pre-treatment characteristics included in the corresponding logit regression in Table 2. Results are obtained by GLS-IV estimation instrumenting for initial productivity with its lagged value and using as weights the square root of each firm's mean squared predicted residuals from an initial OLS-IV estimation. *** denotes 1% significance; ** denotes 5% significance; * denotes 10% significance.

From Table 7, we see that the lagged effect of foreign ownership is robustly caused by positive changes in foreign majority ownership with the impact being significant after four years. The estimated effect of disinvestment is a little less robustly estimated. It is consistently zero in the full sample, while in the matched sample we find a significant positive effect after two years, negated by a slightly larger negative effect after three years. The overall impression is that there is no effect from divestment. Likely, the results differ from those found for Indonesia, because we consider a sample of advanced European countries, where domestic owners are closer to the technological frontier than domestic owners in developing countries. The loss of foreign headquarter expertise is likely to have much smaller, if any, impact in our sample.

In Table 8, we display the results of several "robustness checks" for our main result that a change to majority foreign ownership implies an increase in productivity after four years. As can be readily seen, the results are quite similar whether a matched sample is used or not. Columns (1) and (3) show the results of OLS (non-weighted as in preferred GLS specification) estimations because OLS has been used in the majority of related studies. The OLS-estimator is less efficient, which is reflected in larger standard errors, but delivers the same qualitative message as our preferred specification, namely that an increase in foreign ownership has a positive effect on TFP only after four years and TFP is mean reverting. The OLS-coefficients are somewhat larger, but the qualitative conclusion of an exogenous small increase in productivity after four years hold up. Columns (2) and (5) show the results obtained for a balanced sample of firms observed continuously between 1999 and 2012. The results are not sensitive to this.[16] Columns (3) and (6) drop the number of foreign owners and the reported results are virtually unchanged.

[16]In the balanced sample, the initial years for Norway and Germany are 2000 and 2003, respectively, due to thin coverage for these countries in the earlier years.

Table 8: Foreign Ownership and Productivity - Robustness

Dependent Variable:Δ log Firm Revenue TFP						
	(1)	(2)	(3)	(4)	(5)	(6)
	Full sample			Matched sample		
	nonGLS	Permanent	Excl.NrFO	nonGLS	Permanent	Excl.NrFO
$\Delta(\text{DFO}^{\text{maj}+})_{t-4}$	0.025**	0.015**	0.013***	0.030**	0.019**	0.019***
	(0.009)	(0.006)	(0.004)	(0.012)	(0.007)	(0.005)
$\Delta(\text{DFO}^{\text{maj}+})_{t-3}$	0.004	-0.003	0.004	-0.002	0.005	-0.001
	(0.007)	(0.006)	(0.003)	(0.010)	(0.007)	(0.004)
$\Delta(\text{DFO}^{\text{maj}+})_{t-2}$	-0.003	0.002	-0.001	-0.000	0.001	-0.002
	(0.007)	(0.005)	(0.003)	(0.009)	(0.006)	(0.004)
$\Delta(\text{DFO}^{\text{maj}+})_{t-1}$	0.004	-0.006	0.002	0.006	-0.006	0.003
	(0.007)	(0.005)	(0.003)	(0.009)	(0.006)	(0.004)
$\log \text{TFPR}_1$	-0.020***	-0.014***	-0.014***	-0.027***	-0.017***	-0.017***
	(0.001)	(0.001)	(0.001)	(0.003)	(0.003)	(0.002)
Observations	288,927	134,033	288,927	18,365	10,488	18,366
$\Delta\text{Nr\_For\_Owners}_{t-i}$	yes	yes	no	yes	yes	no
Firm−FE	no	no	no	no	no	no
Year−FE	yes	yes	yes	yes	yes	yes
Sec4−FE	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Cntry−FE	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Cntry×Sec4−FE	yes	yes	yes	yes	yes	yes
First Stage F		5,045	20,872		314	964

Notes: The dependent variable is the change in log revenue firm-level productivity at time t ($\Delta \log \text{TFPR}_{i,t}$). Δ indicates one-year changes. $\text{TFPR}_{i,1}$: productivity of the firm the first time firm i is in the sample. All regressions control for lagged annual changes in the number of foreign owners $\Delta\text{Nr\_For\_Owners}_{t-i}$ from $t-1$ to $t-4$, except for columns (3) and (6). Columns (1)-(3) show the results using the "maximum" sample of firms, while columns (4)-(6) repeat the analysis for the matched sample of firms from the one-to-one matching procedure based on pre-treatment characteristics included in the corresponding logit regression in Table 2. Columns (1) and (4) show the results from OLS estimations. Columns (2) and (5) show results for the permanent sample of firms; i.e., those firms that we observe continuously between 1999 and 2012 (except for Norway and Germany for whom the data coverage starts in years 2000 and 2003, respectively). Columns (3) and (6) show results excluding the lagged annual changes in the number of foreign owners $\Delta\text{Nr\_For\_Owners}_{t-i}$. Standard errors are clustered at the firm level. Results are obtained by GLS estimation instrumenting for initial productivity with its lagged value and using as weights the square root of each firm's mean squared predicted residuals from an initial OLS estimation and based on the matched sample of firms. *** denotes 1% significance; ** denotes 5% significance; * denotes 10% significance.

5 Conclusion

Using a new data set that is nationally representative for domestic and foreign firms and tracks foreign investment at the firm level in eight advanced countries over time, we find that TFP of firms acquired by foreign investors increases modestly after four years and only when firms are acquired by foreign majority owners. This suggests that the productivity benefits of foreign investment are realized only when foreigners acquire corporate control and affect production decisions. This result is interesting and novel because concentrated controlling ownership has been observed to have a negative effect on innovation and productivity in a domestic context when owners are in the same country with the target firm. In this paper, we find the reverse result in the case of concentrated *foreign* ownership. Acquisition of a majority stake by foreign investors has a positive effect on productivity, while acquisition of a minority stake by foreign investors has no significant effect. To identify causal effects, we control for country-sector-year shocks, for initial productivity, and we perform PSM estimation in combination with firm fixed effects.

Our results have strong policy implications. First, if foreign owners acquire majority ownership, this will deliver productivity benefits; hence, hostility to large takeovers by foreign firms in Europe may be misguided. Second, the effect of foreign investment on acquired firms' productivity is gradual and quite small. This implies that the high macroeconomic correlations found between growth and foreign investment may be due to either structural reforms and improved policy which attracts multinationals, where multinationals select productive firms for their investment. Another avenue for the country-wide productivity effects of foreign investment is possible spillover effects from acquired to non-acquired domestic firms, a topic outside the scope of our analysis in this paper.

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Appendix

A Data Details

We follow the four cleaning steps outlined in Kalemli-Ozcan, Sørensen, Villegas-Sanchez, Volosovych, and Yesiltas (2015). These include cleaning basic reporting mistakes, verifying the internal consistency of the balance sheet information, cleaning variables specific to the manufacturing sector, and winsorizing the variables. We refer the reader to Kalemli-Ozcan, Sørensen, Villegas-Sanchez, Volosovych, and Yesiltas (2015) for details. Table A.1 present summary statistics for the final sample of firms used in the analysis.

Table A.1: Summary Statistics

	Observations	Mean	SD
Panel (a): Full Sample			
log tfpr	826,152	3.58	0.94
l	691,967	67.19	166.23
fo	826,152	0.94	7.82
Panel (b): Four-year Difference Sample			
log tfpr	288,961	3.62	0.96
l	242,174	69.77	151.79
fo	288,961	1.47	10.29

Notes: The table displays sample size, means, and standard deviations for our main variables for the sample of domestic firms used in the regressions. log tfpr is the logarithm of revenue total factor productivity; l is the number of employees; fo is the percentage share of foreign ownership. Panel (a) reports summary statistics for the full sample of firms, while panel (b) reports summary statistics for the sample of firms used in the four-year difference specification.

B Further Results

Table B.1: Prediction Majority Foreign Ownership—Logit Regression (Sample of Foreign-Owned Firms

Dependent Variable: Dummy Foreign Ownership - Majority	
	(1)
$\log \text{TFPR}_1$	0.053
	(0.125)
$\Delta \log \text{TFPR}_{\text{Acq}-1}$	-0.485*
	(0.306)
$\Delta \log \text{TFPR}_{\text{Acq}-2}$	-0.055
	(0.315)
$\log \text{L}$	1.161**
	(0.420)
$\log \text{L}^2$	-0.104**
	(0.043)
$\log \text{W}$	0.312^{+}
	(0.221)
$\log \text{VAL}$	0.131
	(0.203)
$\log \text{KL}$	-0.056
	(0.067)
$\log \text{ASSETS}$	1.175
	(1.152)
$\log \text{ASSETS}^2$	-0.032
	(0.034)
AGE	-0.005
	(0.005)
AGE^2	-0.000
	(0.000)
Observations	1,964
Sec2−FE	yes
Cntry−FE	yes
Year−FE	yes
R^2	.11

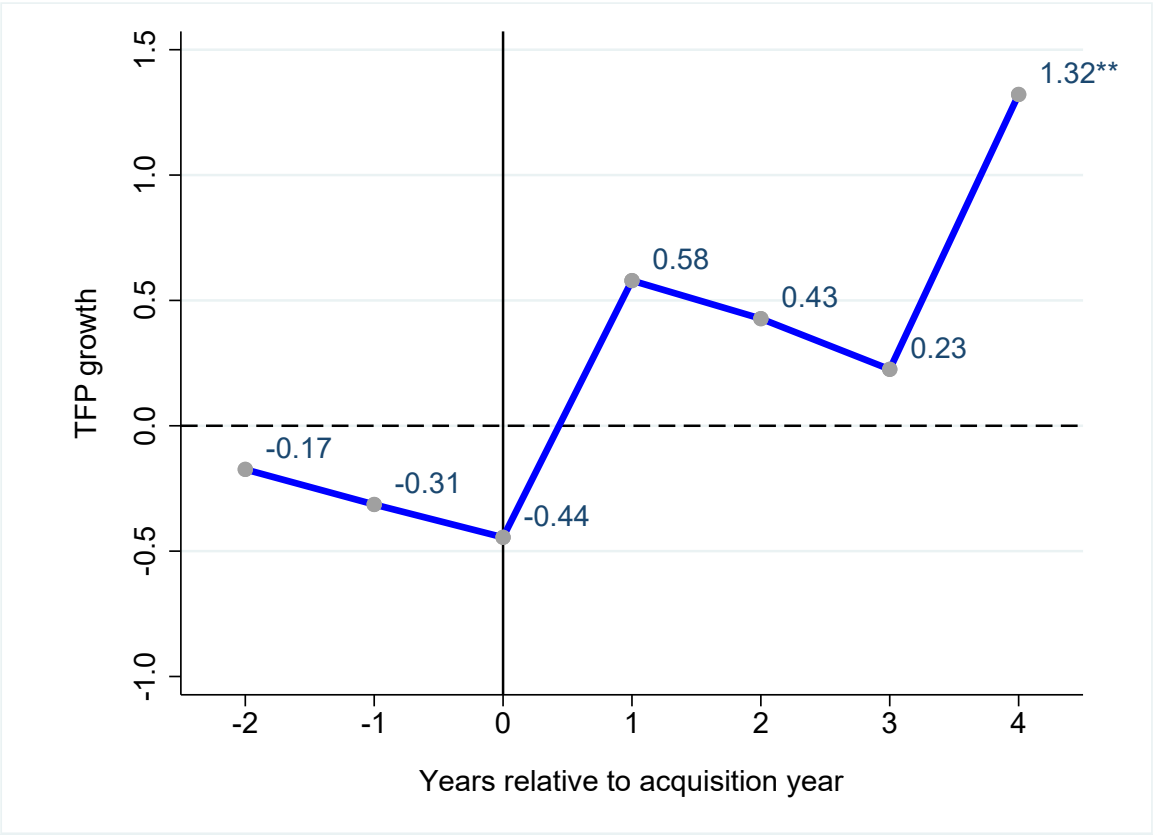
Notes: The sample includes only foreign firms. The dependent variable is a dummy variable that takes the value of one if the firm ever becomes foreign owned with the percentage of foreign ownership is equal or greater than 50% during the sample period (1999-2012). Data are included in the estimation for the first year we observe a firm. Results are obtained by logit estimation. The observable variables included are: log productivity of the firm the first year the firms is in the regression sample ($\log \text{TFPR}_1$); the first and second lags of productivity growth prior to the first acquisition year for acquired (treated) firms and two first available observations for never acquired (control) firms ($\Delta \log \text{TFPR}_{\text{Acq}-1}$ and $\Delta \log \text{TFPR}_{\text{Acq}-2}$); log employment ($\log \text{L}$); log employment squared; log value added per employee ($\log \text{VAL}$); log capital stock per employee ($\log \text{KL}$); log assets ($\log \text{ASSETS}$); log assets squared; age (AGE); age squared; log wage ($\log \text{W}$, which refers to compensation divided by number of employees). *** denotes 1% significance; ** denotes 5% significance; * denotes 10% significance; $^{+}$ denotes 15% significance.

Table B.2: Summary Statistics—Matched Foreign Firms Sample

Variable	Treatment	Control	Diff	p-value	Observations (treated or controls)
$\log$ TFPR	4.104	4.100	0.0034	0.94	803
$\Delta \log \text{TFPR}_{t-1}$	-0.0140	-0.0060	-0.0080	0.37	803
$\Delta \log \text{TFPR}_{t-2}$	0.0025	-0.0021	0.0046	0.58	803
$\log$ L	4.479	4.431	0.0481	0.37	803
$\log$ W	11.12	11.08	0.0465	0.01	803
$\log$ VAL	0.837	0.845	0.0087	0.68	803
$\log$ KL	-0.043	0.014	-0.0568	0.25	803
$\log$ ASSETS	16.92	16.88	0.0408	0.51	803
AGE	20.09	20.55	0.4633	0.62	803

Notes: This table reports the means of treated and control groups from the one-to-one matching procedure based on pre-treatment characteristics included in the corresponding logit regression in Table B.1. A firm is majority owned if the firm ever becomes foreign owned with the percentage of foreign ownership is equal or greater than 50% during the sample period (1999-2012). "Diff" is the average difference of means between acquired (treated) and non-acquired (control) firms and the "p-value" is the result of the two-sided difference of means test between the two groups. There are 803 foreign majority-owned firms that are matched to 803 foreign minority-owned firms.

Figure B.1: TFPR Growth in Matched Sample of Foreign Majority Owned and Foreign Minority Owned Firms.



Notes: This figure reports differences of productivity growth between foreign majority-owned firms (treated) and foreign minority-owned (control) groups of firms in the sample resulting from the one-to-one matching procedure based on pre-treatment observable characteristics included in the corresponding logit regression in Table B.1. A firm is majority owned if the firm ever becomes foreign owned with the percentage of foreign ownership is equal or greater than 50% during the sample period (1999-2012). The observable variables included are: log productivity of the firm the first year the firms is in the regression sample ($\log \text{TFPR}_1$); the first and second lags of productivity growth prior to the first acquisition year for acquired (treated) firms and two first available observations for never acquired (control) firms ($\Delta \log \text{TFPR}_{\text{Acq}-1}$ and $\Delta \log \text{TFPR}_{\text{Acq}-2}$); log employment ($\log \text{L}$), log employment squared, log value added per employee ($\log \text{VAL}$), log capital stock per employee ($\log \text{KL}$), log assets ($\log \text{ASSETS}$), log assets squared, age (AGE), age squared, wage ($\log \text{W}$, which refers to compensation divided by number of employees). TFP growth is the growth in log revenue productivity ($\log \text{TFPR}$) relative to the previous year.
The figure displays the estimated ξ-coefficients from the regression

$$\Delta \text{TFPR}_{\text{i,t}} = \mu_{\text{t}} + \sum_{\tau=-2}^{4} \xi_\tau \text{ACQ}_{\text{i,t}-\tau} + \text{TFPR}_{\text{i,1}} + \epsilon_{\text{i,t}} \,,$$

where $\tau = 0$ represents the year the firm was acquired (i.e., the firm went from having zero foreign ownership to show some foreign ownership stake) and $\text{ACQ}_{i,t-\tau}$ is a dummy variable which identifies the two years prior and four years after the acquisition event. μ_t denotes year fixed effects. $\xi_{\tau=4}$ is statistically significant at the 5% significance level, the remaining coefficients are not significant, which implies that the productivity growth between treated and controls are not statistically different from each other pre-treatment. Excluding $\text{TFPR}_{\text{i,1}}$ or controlling for firm fixed effects does not change the pattern materially.

C Production Function Estimation

C.1 Methodology

To obtain firm-level productivity estimates, we estimate the log-value added production function

$$y_{it} = \beta_0 + \beta_\ell \ell_{it} + \beta_k k_{it} + \omega_{it} + \epsilon_{it}\,, \tag{C.1}$$

where y_{it} is the logarithm of real output, ℓ_{it} is the logarithm of labor input, k_{it} is the logarithm of capital input, ω_{it} is the logarithm of physical productivity, and ϵ_{it} is a production shock that is not observable by the firm before making their input decisions at time t. The main concern, when estimating output elasticities with respect to the inputs in equation (C.1), is whether the firm observes its own productivity ω_{it} at the time of making input choices. This would render input quantities endogenous to productivity and ordinary least squares (OLS) estimates of β_ℓ and β_k would be inconsistent. We follow the approach suggested in Wooldridge (2009), which builds on previous work by Olley and Pakes (1996) (OP) and Levinsohn and Petrin (2003) (LP), which addresses the concerns raised by Ackerberg, Caves, and Frazer (2015), who argue that if the flexible labor input is chosen as a function of unobserved productivity, the coefficient on labor input is not identified in the previous approaches.

The estimation 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 TFPR 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 Ackerberg, Caves, and Frazer (2015) critique.[17] 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).

[17] Ackerberg, Caves, and Frazer (2015) 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.

For firm i in time period t define

$$y_{it} = \alpha + \beta_l l_{it} + \beta_k k_{it} + \omega_{it} + e_{it}\,, \tag{C.2}$$

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 ω_{it} and an additional term that reflects measurement error or unexpected productivity shocks e_{it}. We are interested in estimating ω_{it}.

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

$$\omega_{it} = g(k_{it}, m_{it})\,, \tag{C.3}$$

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

$$E(e_{it}|l_{it}, k_{it}, m_{it}) = 0 \qquad t = 1, 2, ..., T\,, \tag{C.4}$$

substituting equation (C.3) into equation (C.2), we obtain the regression

$$\begin{aligned} E(y_{it}|l_{it}, k_{it}, m_{it}) &= \alpha + \beta_l l_{it} + \beta_k k_{it} + g(k_{it}, m_{it}) \\ &\equiv \beta_l l_{it} + h(k_{it}, m_{it})\,, \end{aligned} \tag{C.5}$$

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

In order to identify β_l and β_k, we need some additional assumptions. First, rewrite equation (C.4) in a form allowing for more lags:

$$E(e_{it}|l_{it}, k_{it}, m_{it}, l_{i,t-1}, k_{i,t-1}, m_{i,t-1}, ..., l_{i1}, k_{i1}, m_{i1}) = 0 \qquad t = 1, 2, ..., T\,. \tag{C.6}$$

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

$$E(\omega_{it}|\omega_{i,t-1}, ..., \omega_{i1}) = E(\omega_{it}|\omega_{i,t-1}) \qquad t = 2, 3, ..., T, \tag{C.7}$$

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:

$$\begin{aligned} E(\omega_{it}|k_{it}, l_{i,t-1}, k_{i,t-1}, m_{i,t-1}, ..., l_{i1}, k_{i1}, m_{i1}) \\ = E(\omega_{it}|\omega_{i,t-1}) \equiv f[g(k_{i,t-1}, m_{i,t-1})] \,. \end{aligned} \tag{C.8}$$

Recall from equation((C.3)) 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 (C.2) gives:

$$y_{it} = \alpha + \beta_l l_{it} + \beta_k k_{it} + f[g(k_{i,t-1}, m_{i,t-1})] + a_{it} + e_{it} \,. \tag{C.9}$$

Now it is possible to specify two equations which identify (β_l, β_k):

$$y_{it} = \alpha + \beta_l l_{it} + \beta_k k_{it} + g(k_{i,t}, m_{i,t}) + e_{it} \tag{C.10}$$

and

$$y_{it} = \alpha + \beta_l l_{it} + \beta_k k_{it} + f[g(k_{i,t-1}, m_{i,t-1})] + u_{it} \,, \tag{C.11}$$

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 (C.10) are those outlined in equation (C.6), while the orthogonality conditions for equation (C.11) are

$$E(u_{it}|k_{it}, l_{i,t-1}, k_{i,t-1}, m_{i,t-1}, ..., l_{i1}, k_{i1}, m_{i1}) = 0 \qquad t = 2, ..., T \,. \tag{C.12}$$

To proceed with the estimation, we estimate these equations parametrically. We follow Petrin, Reiter, and White (2011) and use a third-degree polynomial approximation using first order lags of variable input as instruments.[18]

[18]We use the Stata routine suggested in Petrin, Reiter, and White (2011).

C.2 Estimation Results

Table C.1 reports summary statistics for the output elasticities estimated using the Wooldridge (2009) approach. The results are consistent across countries with no major differences except for Belgium, where the number of observations is slightly lower and the coefficient on labor is on average marginally lower (0.625) and the average coefficient on capital marginally higher (0.102).[19] Summary statistics are computed excluding sectors in which the WLP procedure delivers either missing, negative, or zero coefficients. These cases are few and mainly correspond to sectors 12 "Manufacture of Tobacco products" and 19 "Manufacture of coke and refined petroleum products," which have very few observations and contribute little to overall manufacturing output.

Table C.1: Summary Statistics of the Production Function Output Elasticities

	Labor Elasticity (β_ℓ)	Capital Elasticity (β_k)
Mean	0.734	0.081
Median	0.730	0.078
Standard Deviation	0.059	0.023
Max	0.919	0.338
Min	0.453	0.003

[19]Similarly, the average coefficient on capital is slightly higher in Germany (0.102).