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ABSTRACT

We quantify the effect of foreign investment on productivity of acquired firms using a new firm-level database that tracks foreign ownership changes. To control for endogenous selection on unobserved firm-level characteristics, we study the differential impact of majority and minority foreign ownership; to control for selection on observables, we perform propensity score matching; and to control for selection on unobserved fundamentals, we include country- sector trends. The productivity of affiliates increases modestly four years after foreign acquisition, but only when foreign owners buy majority stakes. Our results highlight the importance of foreign investors having corporate control.

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1 Introduction

Concentrated corporate control is often a drag on productivity and growth. Following the influential contribution of La Porta, Lopez-De-Silanes, and Shleifer (1999), a large literature has tried to understand the determinants and consequences of concentrated ownership and control. This body of work suggests that when a dominant controlling shareholder (or family) is present, it creates a wedge between cash flow- and control-rights and this wedge leads to expropriation of minority shareholders, more rent-seeking, less innovation, and low productivity and growth. This literature argues that openness to trade and external finance might alter this pattern if foreign investors improve the governance.[1]

We test this hypothesis by asking whether *foreign* acquisitions, in the form of majority-controlling foreign ownership, deliver productivity benefits. We compare the productivity impact of majority foreign ownership to minority foreign ownership. This approach delivers a twofold contribution. First, we can test directly whether negative effects of corporate control in a domestic context are overturned when the controlling owners are foreigners. Second, the comparison of majority and minority FDI allows us to pin down the causal effect of foreign investment on productivity. Under the identifying assumption that would-be minority owners are enticed to invest to the same extent as would-be majority owners because of firm-level growth prospects which would have happened in the absence of foreign acquisition, a larger effect on acquired firms' productivity from foreign majority investment has a causal ("difference-in-difference") interpretation. This strategy focuses on the differential impact of corporate control over the organization of production.[2]

We control for country-sector trends by estimating the regressions of acquired firms' productivity in growth-rates with country×sector fixed effects. These fixed effects control for the fact that productivity growth (which may attract foreign in-

[1] See Shleifer and Vishny (1997), Morck, Stangeland, and Yeung (2000) and Morck, Wolfenzon, and Yeung (2005).

[2] Firms with more than 50% foreign ownership are in the hands of very few owners. The median number of foreign owners is 1, and the 99th percentile is 4, when foreign owners owns more than 50 percent of a company.

vestors) often is specific to certain sectors (maybe due to technological breakthroughs) or countries (maybe due to growth-friendly policy reforms). With the inclusion of those fixed effects our results are identified from deviations from sector- or country-specific trends.

In a regression of productivity on FDI, the results may be driven by reverse causality due to endogenous selection: would-be foreign owners may select firms that are likely to have increasing productivity growth based on various features of the acquired firms—these features may be observed or unobserved.[3] In fact, subsidiaries of multinational firms generally outperform domestic firms even when they operate in the same narrowly defined industries.[4] The superior performance of foreign owned companies could be due to multinationals selecting domestic firms which *a priori* were better performing. It could also be due to acquired firms having good future growth prospects independently of the fact that they are acquired.[5] Our strategy comparing majority and minority acquisitions accounts for this type of time varying firm-level selection if both type of investors have access to the same information set.

The literature that finds productivity benefits of foreign acquisitions controls selection on observable factors by using the propensity score matching techniques. To compare our results to the existing literature, we also use propensity score matching method (PSM). This approach matches each acquired firm with a domestic firm which is as similar as possible in terms of observable characteristics prior to the acquisition. This creates an "artificial counterfactual" by having the estimated coefficients being identified from productivity growth of acquired firms compared to productivity

[3]More precisely, "unobserved" refers to features that is not measured in our database. Investors will typically collect more information than what is observed by us.

[4]See Caves (1974), Helpman, Melitz, and Yeaple (2004), Criscuolo and Martin (2009), and Arnold and Javorcik (2009), Conyon, Girma, Thompson, and Wright (2002), Guadalupe, Kuzmina, and Thomas (2012). Over 95% of global foreign direct investment (FDI) by multinationals is based on foreign acquisitions, rather than greenfield investment as documented by Barba-Navaretti and Venables (2004).

[5]Although the FDI literature argues that multinationals target high productivity firms, the finance literature typically focus on the situation where financial investors target low productivity firms with growth potential and buy these firms at fire-sale prices (Lichtenberg, Siegel, Jorgenson, and Mansfield (1987), Brav, Jiang, and Kim (2009), and Lim (2015)). Damijan, Kostevcz, and Rojec (2012) shows a great deal of heterogeneity in the acquired firms in terms of productivity.

growth of similar non-acquired firms.[6] To provide an alternative strategy, we also run regressions on the whole sample (rather than on the matched sample used for PSM) and explicitly control for initial firm-level TFP, allowing for mean reversion in productivity. The reason why we control for mean reversion is as follows. If foreign investors select firms with a high level of productivity, the impact of foreign acquisition would be underestimated when those high-productivity firms experience low productivity growth.

Finally, in order to control for selection on unobservable time-invarying factors, we estimate our regressions in differences which removes any constant firm-level effects. This is equivalent to using firm fixed effects in levels regressions, and we demonstrate how important this is by performing an initial set of regressions in levels and comparing the results of regressions with and without fixed effects.[7] To re-emphasize, firm fixed effects can only account for time-invariant firm factors, whereas our strategy of comparing majority to minority foreign investment has the added benefit of accounting for important aspects of unobserved time-varying firm level heterogeneity.

Our main finding is that there are causal productivity effects from foreign acquisitions in advanced economies, but they are significantly smaller than the effects found for developing countries and productivity improves only when *corporate control* of target firms shifts to foreigners; that is, when foreigners acquire a majority share. Further, we robustly find that productivity of the majority-acquired foreign firms improves only after four years of acquisition.

We use the Orbis/Amadeus database from Bureau van Dijk (BvD), a Moody's company, focusing on the manufacturing sector from eight advanced European countries (Belgium, Finland, France, Germany, Italy, Norway, Spain, and Sweden) for the years 1999–2012.[8] These countries have excellent coverage in terms of comparing our

[6]Using such methods Arnold and Javorcik (2009) find a 13 percent increase in TFP three years after acquisition in Indonesia and Guadalupe, Kuzmina, and Thomas (2012) find a 16 percent increase in TFP upon acquisition for Spain. Neither of these papers study the differential impact of majority foreign ownership.

[7]Many authors, see Aitken and Harrison (1999); Javorcik (2004); Liu (2008), find no effect of foreign acquisition on productivity upon inclusion of firm fixed effects.

[8]The data for Germany is for the period 2003-2012 and the data for Norway is for the period 2000–2012.

"aggregated FDI"—obtained by summing up the output produced by foreign owned firms in our sample—to the "official FDI" (See Figure 1). In our data set, 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).

The Orbis/Amadeus database is well suited to analyze the questions we ask in this paper. We know of three other papers that use the same database to analyze the determinants and consequences of controlling ownership for corporations. Masulis, Pham, and Zein (2011) show that controlling ownership by family groups can have benefits in terms of alleviating financing constraints. Franks, Mayer, Volpin, and Wagner (2012) show that in countries with strong investor protection, developed financial markets, and active markets for corporate control, family firms evolve into widely held companies as they age. Finally, Aminadav and Papaioannou (2016) show that the well-known positive link between economic growth and dispersed ownership is systematically present only in large firms.[9] None of these papers study the controlling ownership dimension of foreign ownership.

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

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 the business registries. BvD collects financial

[9]For influential work in this area see, for example, La Porta La Porta, Lopez-De-Silanes, and Shleifer (1999), Faccio and Lang (2002), Villalonga and Amit (2006), Anderson, Duru, and Reeb (2009), who all study large listed firms. Some exceptions to the focus on large-firm datasets are Bloom and Van Reenen (2007), who study management practices in private firms under dispersed ownership in the United States and Giannetti (2003), who studies the capital structure of private European firms using direct shareholder data from Amadeus.

data from various sources, in particular, national business registries, and harmonizes the data into an internationally comparable format. Orbis provides consistent representative time series for both private and public firms for the countries analyzed in this paper.[10] BvD collects ownership data from official registers, annual reports, private correspondence, telephone research, company web-sites, and news wires.

The unit of observation is the firm and, for each firm, we have full balance sheet information over time and unique sector codes at the four-digit NACE level. Firms are linked to their domestic and foreign parents through unique ID numbers, and this allows us to construct precise firm-level measures of changes in foreign investment into the firms over time based on changes in ownership stakes by foreigners. We exclude micro enterprises (those with less than ten employees according to the European Commission definition).

Of particular importance for our study is the coverage of foreign ownership. We compare our "aggregated" foreign ownership data to the country-level with the aggregate data from the Organization for Economic Cooperation and Development (OECD) reported in 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". The definition of "control" varies greatly by country from explicitly companies in which over 50% of the equity or voting rights is held directly or indirectly by one (or, in some countries, multiple) foreign party to a vague definition of "majority controlled" entities, or "indirectly controlled" entities. Furthermore in some countries the focus is on the direct owners while in others the ultimate non-resident beneficiaries are considered.

[10]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 dataset, or the current vintage, will only provide current ownership information on firms and the results will suffer from survivorship bias unless historical ownership data are used. It is also necessary to use older vintages of the data to avoid missing observations in balance sheet items. Therefore, the dataset constructed for this study is downloaded from historical vintages of the database. 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.

In all cases OECD aggregates the entire output of the entities designated as "foreign" and expresses them in national currency (Euro for Eurozone countries) or, in AFA database, as the ratio of the 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 then divide the totals by the total manufacturing turnover taken from the OECD's *STAN Database for Structural Analysis* (available at http://stats.oecd.org/Index.aspx?DataSetCode=STAN08BIS). In our data comparison, we measure output by total turnover and limit ourselves to manufacturing sector because only this sector is covered over the longest period of time in OECD. To stay as consistent as possible with the OECD data we identify the companies in the ORBIS database as foreign if 10 or more percent of their equity is owned directly or, in case the all direct owners are domestic over all years, ultimately by one or several foreign entities. We compute the foreign output share in our data as the ratio of foreign output aggregated over all identified foreign firms in all our countries, to total output. As with OECD data, we limit ourselves to manufacturing sector. Figure 1 presents this comparison. The extent of multinational activity based on aggregated micro data from ORBIS follows closely the macro data from the OECD.

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 given 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, 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 difference between gross output (operating revenue) and expenditure on materials. We do not observe prices at the firm level, and we calculate "real" output, Y_{it}, by dividing nominal value added with the Eurostat two-digit industry price deflators. This is still a revenue based measure since firm level prices are not available to deflate.[11] Labor input, L_{it}, is measured as the firm's wage bill (deflated by the same two-digit industry price deflator).[12] Finally, we measure the capital stock, K_{it}, as the book value of fixed assets, deflated by the price of investment goods.[13]

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 construct a variable for changes in foreign ownership using Orbis. 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

[11] 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.

[12] 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.

[13] 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.[14] 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.[15] 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.

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. 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. However, we show that our results are robust to including controls for the number of owners. We also show that among majority foreign-owned firms, 75 percent are single owners, while the 95 percentile of the distribution has only two foreign owners, and the 99 percentile has 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

[14] 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.

[15] 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.

(in term 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.

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 average productivity 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 FDI 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 into foreign majority and foreign minority acquisitions. The distribution of initial productivity of firms that are acquired by foreign minority owners 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. However, both majority and minority foreign investors on *average* invest in firms with above-average productivity.

Figure 4 presents estimates of annual TFPR growth in the four years before and after acquisition of a domestic firm by a foreign investor. The line in the figure connects the estimated coefficients, ξ_τ in percent ($\xi_\tau \times 100$), from the following regression performed on the sample of firms that were acquired during our sample:

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

where $\tau = 0$ indicates the year in which the firm is acquired (i.e., change from no foreign ownership stake to some positive foreign ownership stake) and $\mathrm{ACQ}_{i,t-\tau}$ is a dummy that takes a value of one in (firm-specific) four-year prior and after acquisition. $\mathrm{TFPR}_{\mathrm{i,1}}$ represents TFPR of firm i the first year the firm is observed in the sample and μ_t indicates time dummies. According to Figure 4, the productivity growth of foreign targets is between 0.8 and 0.5 percent higher two and three years prior to the acquisition, compared with the time of acquisition, consistent with foreign investors

on average seeking out more productive firms. However, at the time of acquisition, productivity growth of foreign-acquired firms is relatively low, which indicates that foreign investors do not particularly search out firms with current high growth in productivity. Four years past acquisition, productivity growth of acquired firms is 1.2 percent higher than at acquisition, consistent with a delayed causal effect from foreign investment. 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.

4 Empirical Results

We first estimate the relation between the level of productivity and the level of foreign ownership using two different specifications. In the first, we regress the log-level of TFP on the logarithm of (1+the percent foreign ownership share).[16] Initial productivity may be fully persistent or it may decline (or even increase) as time passes. 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; i.e., it equals unity the first time we observe the firm in the sample, regardless of the actual calendar year) and "initial" TFP 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:

$$\begin{aligned} \log \text{TFPR}_{\text{i,t}} &= \beta_1 \log\left(1 + \text{FO}_{i,t}\right) + \beta_2 \log \text{TFPR}_{\text{i,1}} + \beta_3 \log \text{TFPR}_{\text{i,1}} \times \text{FIRM TREND}_{i,t} \\ &\quad + \phi_{s4} \times \text{TREND}_t + \delta_c \times \text{TREND}_t + \epsilon_{i,t}\,, \end{aligned} \tag{3}$$

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

[16] As is well known, $\log(1+x) \approx x$ when x is small, so the regression on foreign ownership is best interpreted as a semi-elasticity. We chose the logarithmic specification because the foreign ownership share has high kurtosis, which gets down-weighed by the logarithmic transformation, resulting in more stable regression coefficients.

is a linear time trend, and $\epsilon_{i,t}$ is a mean zero error term. We assume that the error term is independent of the regressors and independent across firms, but we allow for firm specific variances. 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. Finally, we consider the effect of including a firm-specific fixed effect denoted by α_i. In this specification, the initial level of productivity is dropped because it would not be identified:

$$\begin{aligned} \log \text{TFPR}_{\text{i,t}} &= \alpha_i + \beta_1 \log\left(1 + \text{FO}_{i,t}\right) + \beta_2 \log \text{TFPR}_{\text{i,1}} \times \text{FIRM TREND}_{i,t} \\ &\quad + \gamma_{c,s4} \times \text{TREND}_t + \epsilon_{i,t}\,, \end{aligned} \tag{4}$$

The combination of firm fixed effects and time trends also controls for the age of firms.

Table 1 about here.

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 shows that foreign ownership is strongly correlated with firm-level productivity. Columns (3) to (5) in Table 1 show the results from estimating various versions of equation ((3)). In column (1), the foreign ownership variable has a coefficient (elasticity) of 0.29, statistically significant with a two-digit t-statistic. Column (2) includes the level of initial productivity and initial productivity times the firm trend, which counts the years the given firm has been in the sample at time t (which allows for the impact of initial productivity to decline with the "age" of the firm in the sample). The coefficient to foreign ownership declines by a factor of almost 20 to 0.017 due to the strong correlation between foreign ownership and initial productivity. This is likely due to foreign investors seeking out the most productive firms, although the regression coefficient in itself is not informa-

tive about the direction of causality.[17] The significant negative coefficient to initial productivity times firm-age indicates that productivity growth, everything else equal, is negative when the productivity of a firm is about the firm-specific mean—commonly referred to as mean reversion.

Columns (3) to (5) in Table 1 show the results from estimating various versions of equation ((4)). Column (3) includes firm fixed effects, which control for all factors that are constant at the firm-level, and the estimated relation between foreign ownership on productivity becomes very small and only borderline significant. This result agrees with the findings of the existing literature as outlined in the introduction. Column (4) includes the time varying effect of initial TFP, and in this specification foreign ownership again is clearly significant. An interpretation of the patterns in columns (3) and (4) is that the combination of mean-reversion in productivity and foreign investors seeking out high-productivity firms will bias the coefficient to foreign ownership downwards, if the reversion to the mean of the acquired high productivity firms is not controlled for. Column (5) controls for country-sector trends, allowing for different trends in each sector in each country. The rate of mean reversion of productivity in column (5) is larger, but the estimated impact of foreign ownership is similar to the estimated impact in column (4). The main message of Table 1 is that foreign ownership is highly correlated with initial productivity and that firm-level TFP is mean-reverting.

We continue with the growth-rate (differenced) version of equation (3). In the absence of a stochastic error term, the differenced equation would be equivalent to the levels equation. 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

[17] If foreign ownership were a linear function of the productivity level, the coefficient to foreign ownership would be 0 when initial productivity is included, by the Frisch-Waugh theorem, but the results are not consistent with that extreme case.

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 data are closer to the case of random walk errors.[18]

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.[19]

The differenced equation takes the form

$$\Delta \log \text{TFPR}_{i,t} = \Sigma_{k=1}^{4} \beta_k \Delta \log \text{FO}_{i,t-k} + \beta_5 \log \text{TFPR}_{i,1} + \gamma_{c,s4} + \epsilon_{i,t}. \tag{5}$$

In equation (5), 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 (3). 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 this growth-rate estimation, we allow for lags which capture gradual adjustment.

Table 2 about here.

Table 2 reports the results. We see, robustly across all columns, that an increase

[18]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.

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

in foreign ownership correlates with an increase in productivity, but the effect is only significant after four years. "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 foreign firms identified domestic firms which, whether foreign investment were to be received or not, would become more productive in four years.

In column (2), initial productivity is included (the level of initial productivity in this differenced regression captures the effect of initial TFP times firm age-in-sample in Table 1) and the (four-year) lagged coefficient becomes larger and more significant.[20] The inclusion of sector- and country-fixed effects results in a lagged elasticity of 0.011, while the inclusion of country-sector fixed effects has little further impact on the coefficient to lagged changes in FDI. 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.[21]

We now turn to our main focus that is foreign majority versus minority investment comparison. 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

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

[20] The reduced-form estimation is presented in Table B.1 and the estimated coefficients are very close to our reported GLS-IV estimates. The results in Table B.2, which includes both initial productivity and the lagged instrument, show a small coefficient to the lagged productivity level, significant only in one of three specifications, and a much larger coefficient to initial productivity. This is consistent with no major effect of the instrument, besides the impact that goes through initial productivity; i.e., the instrument satisfies the exclusion restriction. In either event, the impact of foreign ownership remains very robustly estimated. Table B.3 shows the first stage results for completeness.

[21] In Table B.4 in the appendix, we show the results from a non-instrumented regression. The results are very close to the ones reported in the main text, which reflects the low level of autocorrelation in the error terms.

Table 3 about here.

The results in Table 3 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 0.011 with no statistically significant difference in the coefficients across columns). The coefficients for majority ownership are statistically significant while the corresponding coefficients for minority owners are insignificantly different from 0.[22] 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.

The results in Table 3 also provide evidence of a causal effect of foreign investment on productivity by contrasting majority and minority ownership. If (on average) majority foreign investors are as likely as minority foreign investors to be attracted to firms with expected future productivity growth while majority investors control production significantly more than minority investors, we should expect the results found in Table 2 to be particularly driven by majority investors. Or to put it differently, if majority foreign investors and minority foreign investors both scan firms for indicators of future TFP growth, then a causal effect of foreign owner's control is identified from the different estimates for a change to foreign majority ownership compared to a change to foreign minority ownership.

The identifying assumption behind this identification is not only that both minority and majority owners seeking out higher productivity firms on average, as shown in Figure 3, but it should also be the case that these firms were on similar growth trends prior to the acquisition. Figure 5 makes this case. Panel (a) in this figure shows that majority and minority foreign owners select firms that on average have similar TFPR growth trends four years prior to the acquisition and only diverge four years later. Panel (b) in the figure shows that majority owned firms are not statistically different from minority owned firms during the four years prior to the acquisition but four year

[22] Table B.5 drops the insignificant changes in minority ownership (in Table 3) and verifies that the estimated coefficients to changes in majority ownership are robustly estimated.

after acquistion, TFP growth of majority foreign-owned firms increase relatively to TFP growth of minority owned firms.

Next, we examine whether the effect of majority foreign ownership is symmetric in foreign acquisitions and foreign disinvestment by majority owners. For a sample of Indonesian firms, Javorcik and Poelhekke (2017) find that productivity declines when foreign investors sell 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 variable in the regression, with separate coefficients, will allow us to see if the effect of increases/decreases in majority foreign ownership is symmetric. The equation estimated is

$$\begin{aligned} \Delta \log \text{TFPR}_{\text{i,s4,c,t}} \quad = \quad & \Sigma_{k=1}^{4} \beta_k^{+} \Delta(\text{DFO}^{\text{maj}+})_{i,t-k} + \\ & \Sigma_{k=1}^{4} \beta_k^{-} \Delta(\text{DFO}^{\text{maj}-})_{i,t-k} + \\ & \beta_5 \log \text{TFPR}_{\text{i,1}} + \gamma_{s4,c} + \epsilon_{i,s4,c,t} \,, \end{aligned} \tag{7}$$

which generalizes equation (6), and reduces to that equation if $\beta_k^{+} = \beta_k^{-}$ for all k.

Table 4 about here.

From Table 4, we see that the lagged effect of foreign ownership is robustly caused by positive changes in foreign majority ownership, with no effect of disinvestment. The coefficient to the fourth lag of positive changes in foreign ownership is the only significant variable with a coefficient that is robust to whether initial productivity of sector- and country-dummies are included. This implies that the improvement in productivity associated with foreign ownership is persistent and not reversed within the first four years of any foreign disinvestment. 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 therefore likely to have much smaller, if any, impact in our sample.

In Table 5, we display the results of several robustness checks of our main results. Column (1) shows the results of OLS (non-weighted) 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. Column (2) shows the results obtained for a balanced sample of firms observed continuously between 1999 and 2012. The results are very similar to those of Table 4.[23] Column (3) follows the typical "official definition" of FDI and defines firms to be foreign majority-owned, when the percentage of foreign ownership is higher or equal to ten percent, and defines firms to be foreign minority owned if the percentage of foreign ownership is positive but below ten percent. The coefficients are slightly smaller and foreign ownership changes are significant at the 10 percent level after two years (besides the stronger significance after four years), but overall the results are similar.

In the regressions reported in column (4), we control for changes in the number of foreign owners. We compute the annual change in the number of foreign owners and check the effect of those changes one year, two years, three years, and four years lagged. The coefficient for number of foreign owners is negative after three and four years which, together with the coefficient to majority foreign ownership, indicates that concentrated foreign ownership is more effective—however, the effect is quite small.

Table 5 about here.

[23] 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.

We next explore the robustness of our main results in a matched sample of firms using propensity score matching methods. Firms that receive FDI typically differ from firms that do not, and this might affect our estimates. We consider the change in foreign ownership as the treatment event and look for a suitable control group among the sample of domestic firms. We therefore use the matching procedure to select domestic firms that were very similar to the firms receiving FDI in terms of observable characteristics prior to acquisition following, among others, Arnold and Javorcik (2009). If foreign firms select firms in which to invest based on observables, the matching procedure controls for the potential bias from endogenous selection.

We match based on characteristics of the firm prior to receiving foreign investment so for each firm, we keep the first year we observe the firm in the sample and match based on the logarithms of employment, value added per employee, capital stock per employee, and assets; the squares of the logarithms of employment and assets; age; age squared; and country and two-digit sector dummies. We implement a one-to-one matching with no replacement, based on propensity scores obtained by a logistic regression.[24] We end up with 2,768 foreign firms matched to 2,768 domestic firms. Table (B.7) in appendix B shows that there are no significant mean differences between the treatment and control group characteristics in the matched sample (and there are no differences in TFPR in the initial year). Columns (5) to (8) in Table 5 report our main results obtained using the matched sample.[25] The results are very similar to those obtained using the full sample and only marginally less significant in spite of the matched sample making up less than 10 percent of the full sample.

Figure 6 displays the four-year change in productivity for acquired and non-acquired firms in the matched sample. The figure plots the distribution of Δ^4TFPR for purely domestic firms (i.e., firms that did not change their domestic ownership status during the sample period) versus those firms that were majority acquired by foreign investors. The change in productivity is very heterogenous with many firms displaying declining productivity and the dispersion of Δ^4TFPR is larger for domestic firms

[24] Table B.6 in appendix B shows the results from the logit regression.
[25] Table B.8 in the appendix corroborate our basic results in the matched sample of firms.

than for foreign majority-owned firms.[26] A noticeably larger mass of productivity increases of between 30 and 50 percent is visible for foreign acquired firms. Overall, our robustness exercise supports our main findings and our interpretation.

5 Conclusion

Concentrated ownership has been observed to have a negative effect on innovation and productivity in a domestic context. 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.

We use a new data set that tracks foreign investment at the firm level in eight advanced economies over time, and we find that TFP of firms acquired by foreign investors increases modestly only after four years and only when firms are acquired by foreign majority owners. This suggests that the productivity benefits of FDI are realized only when foreigners have corporate control and affect production decisions. Our identification rests on observing the difference between majority and minority foreign investment. If both types of investment are driven similarly by unobserved firm-level heterogeneity, the observed differences in productivity ex-post will be caused by the difference in the type of foreign owner. We further control for country- and sector-year trends which might bias the results if FDI and productivity both are affected by country- or sector-level unobserved developments. We also perform estimations using propensity score matching techniques, obtaining similar results and we perform our regressions in differences, which removes the effects of any firm fixed effects.

Our results have strong policy implications. First, if foreign owners acquire majority ownership, this will deliver productivity benefits; hence, hostility to take-overs by large foreign firms may be misguided. Second, the effect of foreign investment on acquired firms' productivity is gradual and quite small. This implies that the high

[26]The standard deviation of $\Delta^4 \text{TFPR}$ for the sample of domestic firms is 0.224 while that of foreign majority owned firms is 0.234.

macroeconomic correlations found between growth and FDI may be due to either structural reforms and improved policy which attracts FDI or to spillovers from acquired to non-acquired domestic firms. A caveat of our results is that they might be unique to the advanced country setting and the effects might differ for foreign firms in developing countries.

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6 Tables

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Table 1: Foreign Ownership and Productivity: Levels

Dependent Variable: log Firm Revenue TFP

	(1)	(2)	(3)	(4)	(5)
$\log(1 + \text{FO})$	0.290***	0.017***	0.007*	0.021***	0.022***
	(0.010)	(0.004)	(0.004)	(0.005)	(0.005)
$\log \text{TFPR}_1$		0.953***			
		(0.000)			
$\log \text{TFPR}_1 \times$ FIRM TREND		-0.001***		-0.006***	-0.025***
		(0.000)		(0.000)	(0.000)
Observations	826,152	826,152	813,379	813,379	810,637
Firm−FE	no	no	yes	yes	yes
Year−FE	yes	yes	yes	yes	yes
Cntry×trend	yes	yes	no	no	n.a.
Sec4×trend	yes	yes	no	no	n.a.
Cntry×Sec4×trend	no	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. $\text{TFPR}_{i,1}$ 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. Columns (1) and (2) estimate the specification of equation (3) in the main text. Columns (3) to (5) report the results from the specification of equation (4) 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 2: Foreign Ownership and Productivity: Lag Growth Rates

Dependent Variable:Δ log Firm Revenue TFP

	(1)	(2)	(3)	(4)
$\Delta \log(\text{FO})_{t-4}$	0.012**	0.016**	0.011**	0.013**
	(0.005)	(0.005)	(0.005)	(0.005)
$\Delta \log(\text{FO})_{t-3}$	0.002	0.006	0.001	0.003
	(0.005)	(0.005)	(0.005)	(0.005)
$\Delta \log(\text{FO})_{t-2}$	-0.000	0.003	-0.001	0.002
	(0.004)	(0.004)	(0.004)	(0.004)
$\Delta \log(\text{FO})_{t-1}$	0.004	0.007*	0.004	0.006
	(0.004)	(0.004)	(0.004)	(0.004)
$\log \text{TFPR}_1$		-0.006***	-0.004***	-0.013***
		(0.000)	(0.000)	(0.000)
Observations	288,961	288,961	288,960	288,927
Firm−FE	no	no	no	no
Year−FE	yes	yes	yes	yes
Sec4−FE	no	no	yes	n.a.
Cntry−FE	no	no	yes	n.a.
Cntry×Sec4−FE	no	no	no	yes
First Stage F		298,592	86,549	20,820

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 yearly change in the $\log(\text{FO}+1)$ where FO stands for the percentage of foreign ownership. $t-1$, $t-2$, $t-3$ and $t-4$ indicate the change in ownership that took place one year, two years, three years, and four years ago, respectively. $\text{TFPR}_{i,1}$ 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 $\text{TFPR}_{i,1}$. 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.

Table 3: Majority-Minority Foreign Ownership and TFPR Growth

Dependent Variable:Δ log Firm Revenue TFP

	(1)	(2)	(3)	(4)
$\Delta(\text{DFO}^{\text{maj}}_{t-4})$	0.009**	0.011**	0.008**	0.008**
	(0.003)	(0.003)	(0.003)	(0.003)
$\Delta(\text{DFO}^{\text{min}}_{t-4})$	-0.002	-0.002	-0.003	-0.003
	(0.003)	(0.003)	(0.003)	(0.003)
$\Delta(\text{DFO}^{\text{maj}}_{t-3})$	0.002	0.004	0.000	0.002
	(0.003)	(0.003)	(0.003)	(0.003)
$\Delta(\text{DFO}^{\text{min}}_{t-3})$	0.000	-0.000	-0.001	-0.000
	(0.003)	(0.003)	(0.003)	(0.003)
$\Delta(\text{DFO}^{\text{maj}}_{t-2})$	0.001	0.002	-0.000	0.002
	(0.003)	(0.003)	(0.003)	(0.003)
$\Delta(\text{DFO}^{\text{min}}_{t-2})$	0.002	0.003	0.003	0.003
	(0.003)	(0.003)	(0.003)	(0.003)
$\Delta(\text{DFO}^{\text{maj}}_{t-1})$	0.002	0.003	0.001	0.002
	(0.003)	(0.003)	(0.003)	(0.003)
$\Delta(\text{DFO}^{\text{min}}_{t-1})$	0.001	0.001	0.002	0.003
	(0.003)	(0.003)	(0.003)	(0.003)
log TFPR_1		-0.006***	-0.004***	-0.013***
		(0.000)	(0.000)	(0.000)
Observations	288,961	288,961	288,960	288,927
Firm−FE	no	no	no	no
Year−FE	yes	yes	yes	yes
Sec4−FE	no	no	yes	n.a.
Cntry−FE	no	no	yes	n.a.
Cntry×Sec4−FE	no	no	no	yes
First Stage F		166,145	48,075	11,580

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. 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 the 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. 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.

Table 4: Positive Changes in Majority Foreign Ownership and TFPR Growth

Dependent Variable:Δ log Firm Revenue TFP

	(1)	(2)	(3)
$\Delta(\text{DFO}^{maj+})_{t-4}$	0.014***	0.014***	0.013***
	(0.004)	(0.004)	(0.004)
$\Delta(\text{DFO}^{maj-})_{t-4}$	-0.012	-0.011	
	(0.008)	(0.008)	
$\Delta(\text{DFO}^{maj+})_{t-3}$	0.004	0.005	0.004
	(0.003)	(0.003)	(0.003)
$\Delta(\text{DFO}^{maj-})_{t-3}$	-0.009	-0.011	
	(0.007)	(0.008)	
$\Delta(\text{DFO}^{maj+})_{t-2}$	-0.002	-0.001	-0.001
	(0.003)	(0.003)	(0.003)
$\Delta(\text{DFO}^{maj-})_{t-2}$	0.011*	0.009	
	(0.006)	(0.006)	
$\Delta(\text{DFO}^{maj+})_{t-1}$	0.002	0.002	0.002
	(0.003)	(0.003)	(0.003)
$\Delta(\text{DFO}^{maj-})_{t-1}$	0.005	0.004	
	(0.006)	(0.006)	
log TFPR_1		-0.013***	-0.013***
		(0.000)	(0.000)
Observations	288,961	288,927	288,927
Firm−FE	no	no	no
Year−FE	yes	yes	yes
Sec4−FE	n.a	n.a	n.a.
Cntry−FE	n.a	n.a	n.a
Cntry×Sec4−FE	yes	yes	yes
First Stage F		11,613	20,872

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. DFO^{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). DFO^{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 the 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. 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.

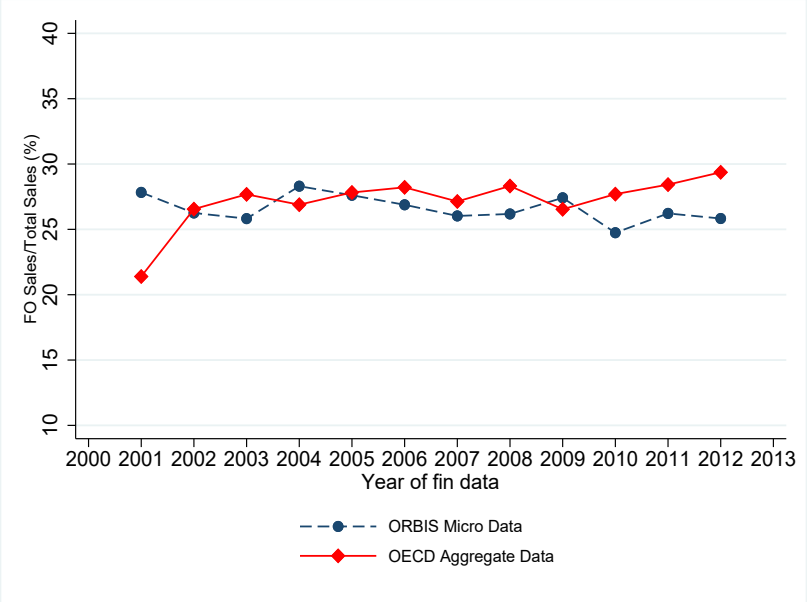
Table 5: Foreign Ownership and Productivity - Robustness

Dependent Variable:Δ log Firm Revenue TFP								
	Full Sample				Matched Sample			
	nonGLS	Permanent	Threshold10	Num.Owners	nonGLS	Permanent	Threshold10	Num.Owners
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$\Delta(\text{DFO}^{\text{maj}+})_{t-4}$	0.025**	0.017**	0.008**	0.013***	0.026**	0.019**	0.007*	0.015**
	(0.009)	(0.006)	(0.003)	(0.004)	(0.011)	(0.007)	(0.004)	(0.005)
$\Delta(\text{DFO}^{\text{maj}+})_{t-3}$	0.003	-0.002	0.002	0.005	-0.002	0.003	-0.006	-0.002
	(0.007)	(0.006)	(0.003)	(0.003)	(0.009)	(0.007)	(0.004)	(0.004)
$\Delta(\text{DFO}^{\text{maj}+})_{t-2}$	-0.001	0.003	0.005*	-0.001	-0.000	0.003	0.001	-0.003
	(0.007)	(0.005)	(0.003)	(0.003)	(0.009)	(0.006)	(0.003)	(0.004)
$\Delta(\text{DFO}^{\text{maj}+})_{t-1}$	0.004	-0.004	0.001	0.001	0.003	-0.000	0.001	0.000
	(0.007)	(0.005)	(0.003)	(0.003)	(0.009)	(0.006)	(0.003)	(0.004)
$\Delta_{\text{N\_Foreign\_Owns}_{t-1}}$				0.001				0.002*
				(0.001)				(0.001)
$\Delta_{\text{N\_Foreign\_Owns}_{t-2}}$				0.000				0.001
				(0.001)				(0.001)
$\Delta_{\text{N\_Foreign\_Owns}_{t-3}}$				-0.002**				-0.001
				(0.001)				(0.001)
$\Delta_{\text{N\_Foreign\_Owns}_{t-4}}$				-0.000				0.001
				(0.001)				(0.002)
$\log \text{TFPR}_1$	-0.020***	-0.014***	-0.013***	-0.013***	-0.024***	-0.016***	-0.014***	-0.014***
	(0.001)	(0.001)	(0.000)	(0.000)	(0.004)	(0.003)	(0.002)	(0.002)
Observations	288,927	134,033	288,927	288,927	18,488	10,147	18,488	18,488
Firm−FE	no	no	no	no	no	no	no	no
Year−FE	yes	yes	yes	yes	yes	yes	yes	yes
Sec4−FE	n.a.	n.a.	yes	n.a.	n.a.	n.a.	n.a.	n.a.
Cntry−FE	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Cntry×Sec4−FE	yes	yes	yes	yes	yes	yes	yes	yes
First Stage F		8,858	20,860	11,651		513	938	520

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. 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. Columns (1) to (4) show robustness to our baseline results using the full sample of firms, while columns (5) to (8) repeat the analysis for the matched sample of firms. Columns (1) and (4) show the results from OLS estimations (i.e., non-weighted results). Columns (2) and (6) 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 (7) follow the official definition of FDI and defines a foreign majority-owned dummy based on a percentage foreign ownership of ten percent or more. Columns (4) and (8) control for annual changes in the number of foreign owners. $\text{TFPR}_{i,1}$: productivity of the firm the first time firm i is in the sample. Standard errors are clustered at the firm level. *** denotes 1% significance; ** denotes 5% significance; * denotes 10% significance.

Figures

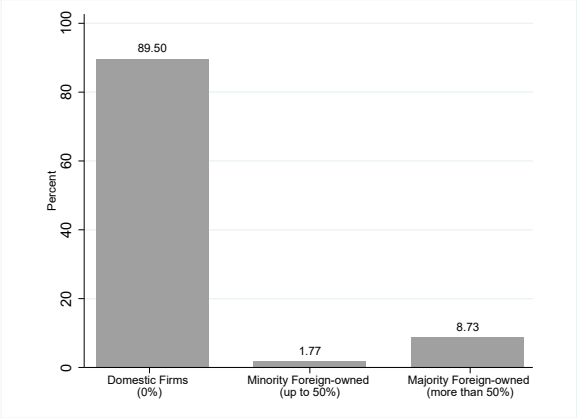
Figure 1: Foreign Shares in Manufacturing Turnover: ORBIS vs. OECD Data



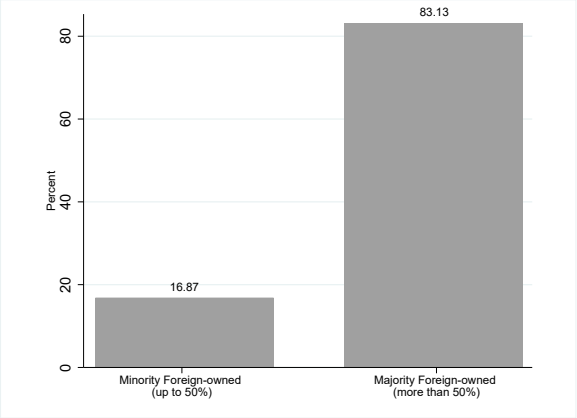
Notes: All ratios are in percent. The shares from the ORBIS data (blue dashed line with circles) are computed as the ratios of the aggregated turnover of firms in manufacturing with 10 or more percent foreign ownership stake to total manufacturing turnover across all ORBIS firms in our sample countries. Foreign multinational activity from the OECD data (red solid line with diamonds) is the sum of the multinational turnover in manufacturing reported by the AFA and AMNE databases of the OECD divided by the total manufacturing turnover in these countries from the OECD STAN database. Countries included in this figure are Finland, France, Italy, Norway, and Spain due to missing data in OECD databases.

Figure 2: Distribution of Foreign Ownership.

(a) All Firms (1999-2012)



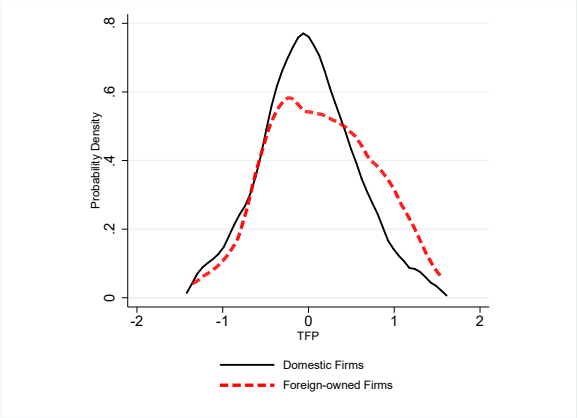
(b) Only Foreign Owned Firms (1999-2012)



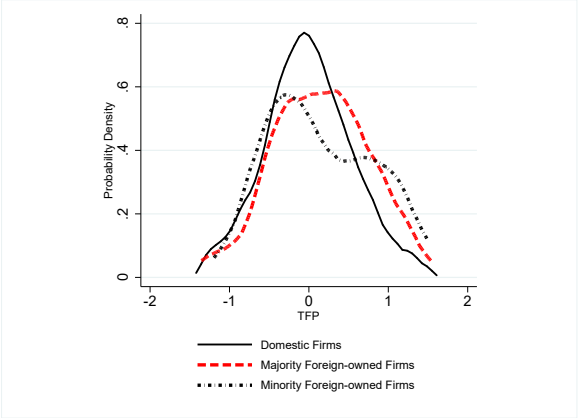
Notes: Panel (a) shows the distribution of domestic, minority and majority-foreign owned firms, respectively, in the full sample. Panel (b) focuses on the sample of foreign-owned firms and shows the distribution of minority and majority owners.

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

(a) Foreign Ownership

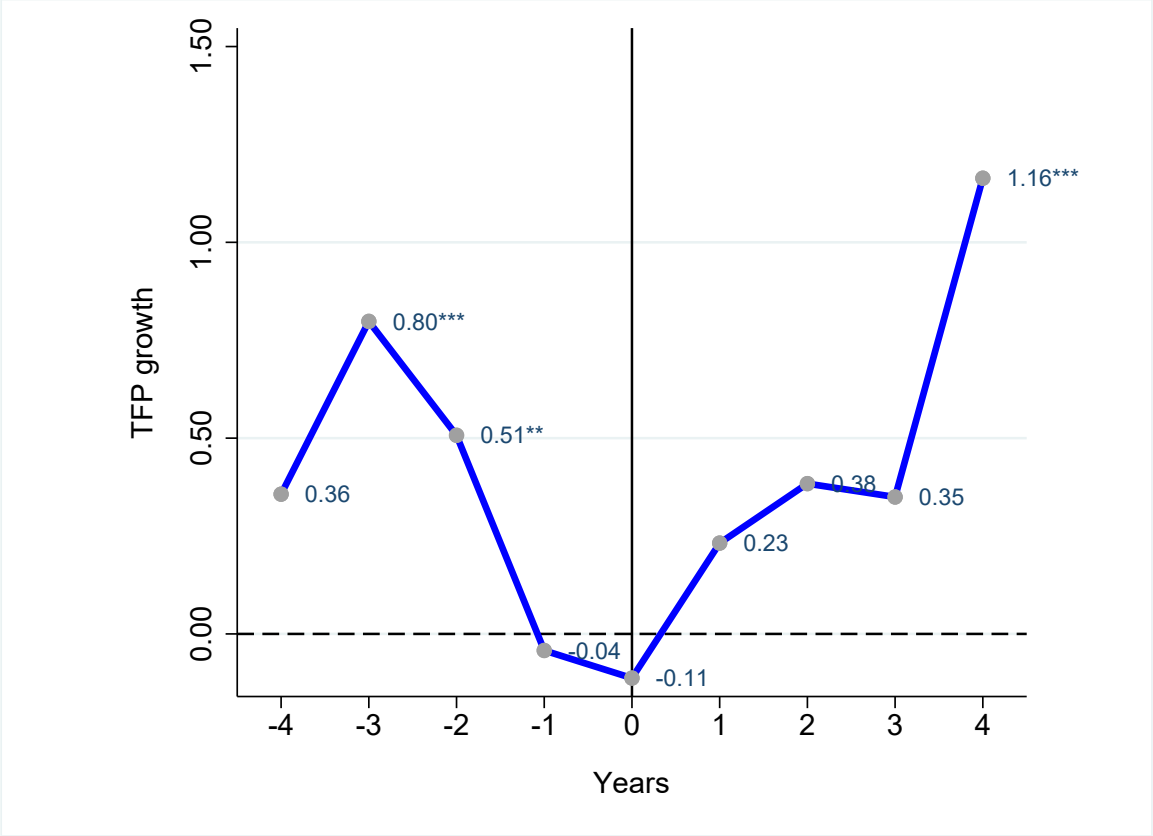


(b) Types of Foreign Owners



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)).

Figure 4: Foreign Acquisitions and TFPR Growth.



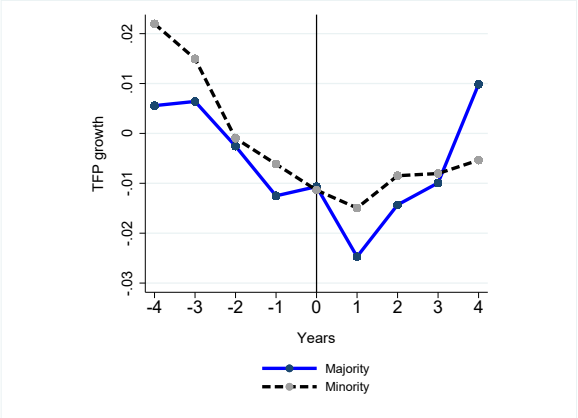
Notes: TFP growth is the growth in log revenue productivity ($\log \text{TFPR}$) relative to the previous year. The figure displays the estimated ξ-coefficients from the regression

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

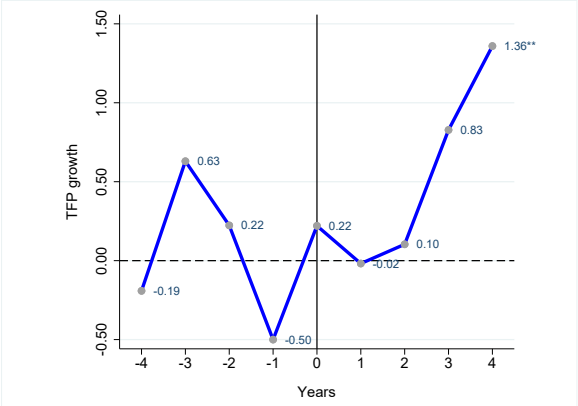
where $\tau = 0$ represents the year the firm was acquired (i.e., the firm went from having zero foreign ownership to show some foreign ownership stake) and $\text{ACQ}_{i,t-\tau}$ is a dummy variable which identifies the four years prior and after the acquisition event.μ_t denotes time fixed effects. $\xi_{\tau=-3}$ and $\xi_{\tau=4}$ are statistically significant at the 1% significance level and $\xi_{\tau=-2}$ is statistically significant at the 5% significance level, the remaining coefficients are not significant.

Figure 5: Foreign Acquisitions and TFPR Growth in the sample of Foreign-Owned Firms.

(a) Average TFPR Growth Trends



(b) Majority vs Minority Contrast

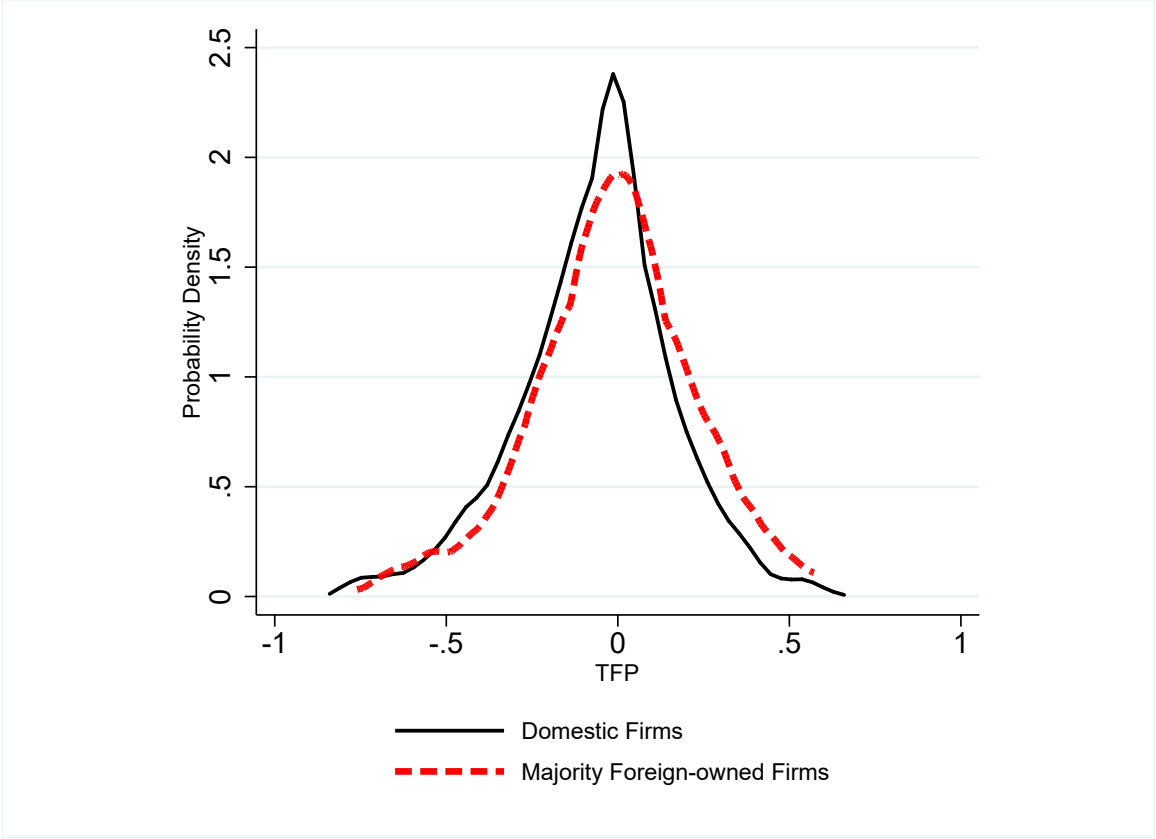


Notes: Panel (a) shows the evolution of TFPR growth (growth in log revenue productivity (log TFPR) relative to the previous year) for the sample of firms that were majority-acquired in year $\tau = 0$ and those that were minority-acquired (i.e., foreign ownership stakes went from zero foreign ownership to less than 50 percent foreign ownership). Panel (b) displays the estimated ξ-coefficients from the following regression estimated only in the sample of firms that were acquired by foreign investors at time $\tau = 0$:

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

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 $\text{ACQ}^{maj}_{i,t-\tau}$ is a dummy variable which identifies the four years prior and after the majority acquisition event. μ_t denotes time fixed effects and μ_i denotes firm fixed effects. Only $\xi_{\tau=4}$ is statistically significant at the 1% significance level, the remaining coefficients are not significant.

Figure 6: Distribution of the Change in Productivity for Majority-Owned and Non-acquired Firms
(Four Years After Acquisition - Matched Sample)



Notes: Distribution of the change in log TFPR for majority-owned (i.e., firms that were acquired by a foreign investor by more than 50%) and non-acquired firms (i.e., firms that remained domestic). The change refers to the difference in log TFPR between the year of the acquisition and four years later in the case of foreign-owned firms and the change during the same sample period in the case of domestic firms. Results refer to the matched sample of firms. The distribution has been truncated at the 1 and 99 percentile to better visualize the distributions.

Appendix

A Data Details

We follow the four cleaning steps outlined in Kalemli-Ozcan, Sørensen, Villegas-Sanchez, Volosovych, and Yesiltas (2015) which 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—here, 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: Foreign Ownership and Productivity - Reduced

Dependent Variable:Δ log Firm Revenue TFP

	(1)	(2)	(3)
log TFPR_0	-0.006***	-0.004***	-0.012***
	(0.000)	(0.000)	(0.000)
$\Delta \log(\text{FO})_{t-4}$	0.016**	0.011**	0.012**
	(0.005)	(0.005)	(0.005)
$\Delta \log(\text{FO})_{t-3}$	0.006	0.001	0.003
	(0.005)	(0.005)	(0.005)
$\Delta \log(\text{FO})_{t-2}$	0.003	-0.001	0.002
	(0.004)	(0.004)	(0.004)
$\Delta \log(\text{FO})_{t-1}$	0.007*	0.004	0.005
	(0.004)	(0.004)	(0.004)
Observations	288961	288960	288927
Firm−FE	no	no	no
Year−FE	yes	yes	yes
Sec4−FE	no	yes	n.a.
Cntry−FE	no	no	n.a.
Cntry×Sec4−FE	no	no	yes

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. 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 B.2: Foreign Ownership and Productivity - Acid

Dependent Variable:Δ log Firm Revenue TFP

	(1)	(2)	(3)
$\log \text{TFPR}_1$	-0.005***	-0.004***	-0.011***
	(0.001)	(0.001)	(0.001)
$\log \text{TFPR}_0$	-0.001	-0.000	-0.002**
	(0.001)	(0.001)	(0.001)
$\Delta \log(\text{FO})_{t-4}$	0.016**	0.011**	0.012**
	(0.005)	(0.005)	(0.005)
$\Delta \log(\text{FO})_{t-3}$	0.006	0.001	0.003
	(0.005)	(0.005)	(0.005)
$\Delta \log(\text{FO})_{t-2}$	0.003	-0.001	0.002
	(0.004)	(0.004)	(0.004)
$\Delta \log(\text{FO})_{t-1}$	0.007*	0.004	0.006
	(0.004)	(0.004)	(0.004)
Observations	288961	288960	288927
Firm−FE	no	no	no
Year−FE	yes	yes	yes
Sec4−FE	no	yes	n.a.
Cntry−FE	no	no	n.a.
Cntry×Sec4−FE	no	no	yes

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. 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 B.3: Foreign Ownership and Productivity - First Stage

Dependent Variable:$\log \text{TFPR}_1$

	(1)	(2)	(3)
$\log \text{TFPR}_0$	0.990***	0.970***	0.897***
	(0.001)	(0.001)	(0.003)
$\Delta \log(\text{FO})_{t-4}$	0.005	0.018*	0.041***
	(0.010)	(0.010)	(0.010)
$\Delta \log(\text{FO})_{t-3}$	-0.007	0.007	0.036***
	(0.014)	(0.011)	(0.010)
$\Delta \log(\text{FO})_{t-2}$	-0.004	0.009	0.029**
	(0.013)	(0.011)	(0.010)
$\Delta \log(\text{FO})_{t-1}$	-0.002	0.008	0.026**
	(0.015)	(0.013)	(0.012)
Observations	288961	288960	288927
Firm−FE	no	no	no
Year−FE	yes	yes	yes
Sec4−FE	no	yes	n.a.
Cntry−FE	no	no	n.a.
Cntry×Sec4−FE	no	no	yes

Notes: The dependent variable is $\log \text{TFPR}_1$ the log of revenue firm-level productivity at time $t = 1$ (the second year we observe the firm). The instrument is $\log \text{TFPR}_0$ which corresponds to the log of revenue firm-level productivity at time $t = 0$ (the first year we observe the firm). Δ indicates one-year changes. 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 B.4: Foreign Ownership and Productivity - GLS

Dependent Variable:Δ log Firm Revenue TFP

	(1)	(2)	(3)	(4)
$\Delta \log(\text{FO})_{t-4}$	0.012**	0.016**	0.011**	0.012**
	(0.005)	(0.005)	(0.005)	(0.005)
$\Delta \log(\text{FO})_{t-3}$	0.002	0.005	0.001	0.003
	(0.005)	(0.005)	(0.005)	(0.005)
$\Delta \log(\text{FO})_{t-2}$	-0.000	0.003	-0.001	0.002
	(0.004)	(0.004)	(0.004)	(0.004)
$\Delta \log(\text{FO})_{t-1}$	0.004	0.007*	0.004	0.006
	(0.004)	(0.004)	(0.004)	(0.004)
$\log \text{TFPR}_1$		-0.006***	-0.004***	-0.013***
		(0.000)	(0.000)	(0.000)
Observations	288961	288961	288960	288927
Firm−FE	no	no	no	no
Year−FE	yes	yes	yes	yes
Sec4−FE	no	no	yes	n.a.
Cntry−FE	no	no	yes	n.a.
Cntry×Sec4−FE	no	no	no	yes

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. 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 B.5: Foreign Ownership and Productivity (Majority Ownership and Initial Productivity Only)

Dependent Variable:Δ log Firm Revenue TFP

	(1)	(2)	(3)	(4)
$\Delta_{\text{DFO}^{\text{maj}}t-4}$	0.009**	0.011***	0.009**	0.009**
	(0.003)	(0.003)	(0.003)	(0.003)
$\Delta_{\text{DFO}^{\text{maj}}t-3}$	0.002	0.004	0.001	0.002
	(0.003)	(0.003)	(0.003)	(0.003)
$\Delta_{\text{DFO}^{\text{maj}}t-2}$	0.000	0.002	-0.001	0.001
	(0.003)	(0.003)	(0.003)	(0.003)
$\Delta_{\text{DFO}^{\text{maj}}t-1}$	0.002	0.003	0.001	0.002
	(0.003)	(0.003)	(0.003)	(0.003)
log TFPR_1		-0.006***	-0.004***	-0.013***
		(0.000)	(0.000)	(0.000)
Observations	288927	288927	288927	288927
Firm−FE	no	no	no	no
Year−FE	yes	yes	yes	yes
Sec4−FE	no	no	yes	n.a.
Cntry−FE	no	no	yes	n.a.
Cntry×Sec4−FE	no	no	no	yes
First Stage-F		298244	86590	20825

Notes: The dependent variable is log revenue firm-level productivity at time t (log $\text{TFPR}_{i,t}$). Standard errors are clustered at the firm level. Results are obtained by GLS-IV estimation 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.

Table B.6: Foreign Ownership and Firm Characteristics - Logit Regression

Dependent Variable:Dummy Foreign Ownership	
	(1)
log L	0.606***
	(0.148)
log L^2	-0.042**
	(0.016)
log W	0.614***
	(0.075)
log VAL	0.311***
	(0.061)
log KL	0.061**
	(0.024)
log ASSETS	2.817***
	(0.370)
log $ASSETS^2$	-0.072***
	(0.011)
AGE	0.002*
	(0.001)
AGE^2	-0.000
	(0.000)
Observations	84118
Sec2−FE	yes
Cntry−FE	yes

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 included in the estimation refers only to the first year we observe the firm. Results are obtained by a logit regression. The observable variables included are: log employment (log L), log employment squared, log value added per employee (log VAL), log capital stock per employee (log KL), log assets (log ASSETS), log assets squared, age (AGE), age squared, wage (log W, which refers to compensation divided by number of employees). *** denotes 1% significance; ** denotes 5% significance; * denotes 10% significance.

Table B.7: Summary Statistics - Matched Sample

Variable	Treatment	Control	Diff	p-value	Observations
log L	4.28	4.27	-0.0092	0.76	2,768
log VAL	0.83	0.82	-0.0106	0.38	2,768
log KL	-0.02	-0.03	-0.0166	0.57	2,768
log ASSETS	16.69	16.67	-0.0290	0.41	2,768
AGE	21.2	21.1	0.1	0.18	2,768
log W	11.06	11.06	0.0003	0.98	2,768
log TFPR	4.00	4.00	0.0009	0.97	2,768

Notes: Matching is done based on pre-treatment characteristics, so that for each firm, we keep the first year we observe the firm in the sample and match based on the following observable characteristics: log employment, log employment squared, log value added per employee (log VAL), log capital stock per employee (log KL), log assets (log ASSETS), log assets squared, age (AGE), age squared, wage (log W which refers to compensation divided by number of employees), country and two-digit sector. Propensity scores are matched on a one-to-one basis and obtained by logit estimation. There are 2,768 foreign firms that are matched to 2,768 domestic firms.

Table B.8: Foreign Ownership and Productivity - Matched Sample Results (Coefficients corresponding to lags $t-1$, $t-2$ and $t-3$ are included but suppressed from the table)

Dependent Variable:Δ log Firm Revenue TFP				
	(1)	(2)	(3)	(4)
$\Delta \log(\text{FO})_{t-4}$	0.017**			
	(0.007)			
$\Delta(\text{DFO}^{\text{maj}}{}_{t-4})$		0.014**		
		(0.004)		
$\Delta(\text{DFO}^{\text{min}}{}_{t-4})$		-0.004		
		(0.004)		
$\Delta(\text{DFO}^{\text{maj}+})_{t-4}$			0.015**	0.016***
			(0.005)	(0.004)
$\Delta(\text{DFO}^{\text{maj}-})_{t-4}$			0.007	
			(0.012)	
$\log \text{TFPR}_1$	-0.014***	-0.014***	-0.014***	-0.014***
	(0.002)	(0.002)	(0.002)	(0.002)
Observations	18,488	18,488	18,488	18,488
Firm−FE	no	no	no	no
Year−FE	yes	yes	yes	yes
Sec4−FE	yes	yes	yes	yes
Cntry−FE	yes	yes	yes	yes
Cntry×Sec4−FE	yes	yes	no	yes
First Stage F	936	527	528	934

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. Standard errors are clustered at the firm level. Results are obtained by GLS-IV estimation using as weights the square root of each firm's mean squared predicted residuals from an initial OLS-IV estimation. Matched sample of firms. All columns control for the corresponding $t-1$, $t-2$ and $t-3$ values of the corresponding regressor, but these coefficients are not reported for ease of exposition. Columns (1) to (4) show our baseline results with various definitions of foreign ownership. In column (1), $\Delta \log(\text{FO})$ refers to the yearly change in the $\log(\text{FO}+1)$ where FO is the percentage of foreign ownership. In column (2), 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. In column (3), $\text{DFO}^{\text{maj}-}$ is a dummy variable that equals minus one if the firm went from foreign majority ownership to minority or domestic ownership. Finally, in column (4), $\text{DFO}^{\text{maj}+}$ 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). TFPR_1: productivity of the firm the second time we observe the firm in the sample. *** denotes 1% significance; ** denotes 5% significance; * denotes 10% significance.

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.[27] 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).

[27] 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.[28]

[28]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).[29] 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

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