



Full Length Articles

Quantifying productivity gains from foreign investment

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ABSTRACT

We revisit the relationship between foreign investment and productivity of acquired firms. First, we construct a panel firm-level dataset for eight advanced European countries covering domestic and foreign acquisitions together with detailed balance sheet information for the years 1999–2012. Second, we address the challenge of identifying a causal relation. To that end, we compare foreign to domestic acquisitions in addition to accounting for the impact of majority versus minority acquisitions after controlling for country and sector trends. The productivity of foreign acquired affiliates increases modestly after four years, but only when majority stakes are acquired by foreigners. Our results are driven by foreign acquisitions and not by foreign divestment.

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1. Introduction

The stock of foreign direct investment (FDI) inward positions in the OECD was a staggering 21.7 trillion dollars in 2017—a magnitude that makes the policy relevance of any potential impact self-evident.¹ FDI typically takes the form of take-overs of existing firms (Barba-Navaretti and Venables, 2004) and FDI is likely to increase the productivity of acquired firms because foreign owners may bring superior technical, marketing, and/or management skills to the acquired firm. Firms are heterogeneous and multinational firms that invest abroad are more productive than purely domestic firms (see Blonigen et al. (2014)).² It is therefore likely that a domestic firm which is acquired by a foreign (likely high-productivity) firm will see an increase in productivity because technological knowledge (Aitken and Harrison (1999)) or good management practices (Bloom et al. (2012)) can be transferred to subsidiaries. Guadalupe et al. (2012), for example, show that foreign majority investors in Spain employ new equipment and production processes leading to higher productivity of acquired firms.

We revisit the question of whether investment by foreign firms leads to higher productivity growth of acquired firms in *advanced economies*. The existing results from the literature on the magnitude of productivity gains from FDI vary widely from nil

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¹ OECD International Direct Investment Statistics 2018.

² Even in the advanced economy of the United States, foreign owned firms are more productive than domestic firms as shown by Doms and Jensen (1998) and Helpman et al. (2004). These authors argue that the fixed cost of setting up foreign operations explains why only the most productive firms in an economy engage in foreign investment.

to a high of 16% across studies conducted for different developed countries. Considering the wide range of estimates for single countries, there is a need for a cross-country study to provide estimates of the typical effect in advanced economies. We measure productivity as revenue total factor productivity, which we refer to simply as “productivity,” although, at places, we also consider labor productivity, which we will refer to as such.

We make several contributions. Our first contribution is the construction of a large-scale multi-country firm-level panel dataset using the Orbis database, available from Bureau van Dijk (BvD)-Moody's. Orbis is the only harmonized multi-country dataset that has accounting data and ownership information, needed for studying FDI, with near-universal coverage of registered firms of all sizes, with the distribution of firms by size and industry resembling the official data.³ In order to obtain a dataset which allows for estimation without survivorship bias, we put together a longitudinal firm-level dataset from annual vintages of Orbis data, an endeavor which is in itself a non-trivial research undertaking. In Section 2, we highlight the strengths and weaknesses of this unique dataset for empirical research.

Our second contribution lies in the matching of foreign acquisitions to acquisitions by purely domestic firms in the same country as the FDI target: the large size of our dataset allows us to study the effects of FDI in a sample where firms acquired by foreign firms are matched to similar firms acquired by domestic investors, thereby isolating the “foreign” component of acquisitions from the acquisition itself, as previously done by [Chen \(2011\)](#) and [Wang and Wang \(2015\)](#) for the United States and China, respectively. By matching foreign acquisitions to domestic acquisitions of similar domestic firms and further showing that productivity effects materialize only after four years only when foreign owners take majority positions, we provide evidence for a causal effect of foreign investment on productivity. The four-year lag is consistent with new foreign owners reorganizing production, which takes time. If our estimates were plagued by reverse causality and/or selection bias, where foreign owners were superior at identifying firms with future growth potential, it is unlikely that this effect would show up only after four years. We further show that foreign investment increases productivity while foreign divestment has no significant effect.

Our results are robust to changes in the definition of productivity, to the choice of inputs in the production function, to the inclusion of a novel rich set of fixed effects, and to variation in the sample of countries and periods. Specifically, the results hold whether we: (1) measure productivity as labor productivity or total factor productivity, (2) estimate productivity using Cobb-Douglas or translog production functions, (3) measure labor input as employment or wage bill, or (4) measure capital stock as tangible assets or the sum of tangible and intangible fixed assets. In addition, the results are robust to using alternative methods for estimating productivity (the one-step GMM estimation method of [Wooldridge \(2009\)](#) or the two-step control function approach of [Ackerberg et al. \(2015\)](#)).

Furthermore, the results hold for subsets of countries (for example, dropping Germany for which Orbis has less good coverage at the beginning of the sample, dropping Norway and France for which only aggregate manufacturing producer price index deflators are available, or dropping Spain for which the tangible fixed asset series has a break in 2008). The results also hold for the years before or after the Great Recession and they are robust to using Generalized Least Squares (GLS) or Ordinary Least Squares (OLS), to the inclusion of country-, sector-, or country-sector fixed effects, and to some further permutations described in the empirical section and in the online appendix.

For causal identification, we use propensity score methods (PSM) to match foreign acquisitions with domestic acquisitions as similar as possible in observable characteristics prior to the acquisition. We estimate the impact of foreign acquisitions using reduced-form linear regressions following the vast majority of papers in this literature. The literature mostly matches foreign acquisitions with domestic firms not acquired by foreign entities and interprets the estimates as the causal effect of FDI on productivity. Target firms are not randomly selected by foreign investors, but PSM is designed to account for selection patterns that may lead to bias; in particular, the tendency for foreign investors to acquire firms that are already highly productive. As matching is based on variables that are observable to researchers, such as current productivity, it cannot be ruled out that investors select firms that are likely to become more productive in the future. If foreign investors screen potential targets more strongly and have a better sense of future growth potential, then PSM that matches acquired firms to non-acquired firms may not be causal. A PSM that matches firms acquired by foreign investors to firms acquired by domestic investors, on the other hand, is less likely to suffer from this issue unless foreign investors are somewhat “smarter” than domestic investors in seeing the future growth potential. To further guard against this low probability outcome, we do our PSM with considerable lags and leads. We find that FDI affects productivity only after four years. These delayed productivity effects strengthen the likelihood that the effects are causal as it is highly unlikely that foreign investors forecast four-year ahead productivity-growth better than domestic investors at the time of acquisition.

The FDI literature performs regressions in levels or in growth-rates (first-differences). Firms with high productivity are more likely targets of FDI and in order to isolate the causal impact of FDI, researchers using levels-regressions typically include firm-specific constants (“firm fixed effects”) in order to identify results from “within variation”: that is, the relation between firm-level changes in FDI and productivity over the sample period. Many authors ([Aitken and Harrison, 1999](#); [Javorcik, 2004](#); [Liu, 2008](#)) find that the estimated effect of foreign acquisition on productivity is zero when firm fixed effects are included in levels-regressions. An alternative to levels-regressions with firm fixed effects is to estimate relations in first-differences or growth rates, where firm-specific constants difference out. We find this preferable as the error terms are closer to white noise, therefore improving inference. Further, growth rates of FDI at different lags are much less correlated than levels of FDI at different lags, and

³ The work to validate and compare this data to the official sources continues as described in [Kalemli-Ozcan et al. \(2015\)](#), who provide detailed evidence supporting the validity of the Orbis data.

for this reason, using growth-rate regressions it is possible to properly identify coefficients to different FDI lags, thereby pinning down potential time delays in the impact of FDI on productivity.

In order to control for potential effects coming from technology shocks taking place at country and sector levels which may correlate with FDI, we include country-sector fixed effects.⁴ We also include lagged firm productivity, which controls for the omitted variable bias that otherwise would occur due to the fact that firm productivity is mean-reverting. This is important and different from capturing unobserved heterogeneity in current observed productivity with PSM and firm fixed effects. If foreigners invest in current high-productivity firms, any productivity decline due to mean-reversion in productivity will create an omitted variable bias if initial firm-level productivity is not controlled for, therefore leading to a downward bias in the estimated effect of foreign acquisitions on productivity.

Our work is related to extensive previous research. In terms of econometric specification, recent papers match foreign acquisitions to non-acquisitions (domestic firms) or to domestic acquisitions and estimate productivity using methods similar to the ones we use. They consider the impact on the growth rate or the log of productivity consistent with our specification. All the studies we are aware of focus on the extensive margin by using dummy variables for foreign ownership. Some authors allow for minority versus majority ownership (e.g., [Chen \(2011\)](#)) and some authors (e.g., [Wang and Wang \(2015\)](#)) experiment with cut-offs in terms of foreign ownership share when defining acquisition, but still use dummy variables for foreign ownership. We estimate productivity regressions using either dummies for majority and minority foreign ownership (the extensive margin) or continuous changes in foreign ownership (the intensive margin) in order to examine which margin is more important and, in particular, whether majority ownership—which imparts control—is crucial.

In terms of the data, we significantly depart from the existing literature by using Orbis in a multi-country setting, covering a large representative set of domestic and foreign firms with full financial information. Most existing research papers in this field use survey data or more narrow datasets that only cover acquisitions, and hence the control groups of domestic firms are much smaller than our near-universal coverage. For example, [Javorcik and Poelhekke \(2017\)](#) study disinvestment by foreign companies in Indonesia using survey data. Other papers with survey data are [Guadalupe et al. \(2012\)](#) for Spain and [Arnold and Javorcik \(2009\)](#) for Indonesia. These papers, and most others we are aware of, have much smaller samples than we have, with the exception of [Wang and Wang \(2015\)](#) who use a large survey with about 125,000 firm-level observations per year for China. Papers using acquisitions data in general focus on large firms for which financial information is available. For example, [Chen \(2011\)](#) uses Compustat financial information and SDC-Thompson data on acquisitions and limits herself to very large (listed) U.S. firms for which financial information is available in the Compustat database. In our data, listed firms comprise less than 1% of the sample.

Some studies use total factor productivity as the dependent variable while others use labor productivity. The results of studies using total factor productivity for advanced countries vary between finding no effect of a foreign acquisition (e.g., [Harris and Robinson \(2003\)](#) and [Crisuolo and Martin \(2009\)](#) for the UK, and [Balsvik and Haller \(2010\)](#) for Norway) and finding a small effect in the 4% range (e.g., [Karpaty \(2007\)](#) for Sweden and [Fukao et al. \(2008\)](#) for Japan).

The literature for advanced countries using labor productivity tends to find a large effect of foreign acquisitions: [Guadalupe et al. \(2012\)](#) find an increase of 16% in Spain for majority foreign acquisitions, [Chen \(2011\)](#) finds an increase of 13% for the United States (compared to domestic acquisitions), and [Conyon et al. \(2002\)](#) document an increase of 13% for the UK. An exception is [Hanley and Zervos \(2007\)](#), who find a decline of 9% after a foreign acquisition for the UK. It may not be surprising that the impact is larger on labor productivity as foreign owners may increase or improve the capital stock; indeed [Balsvik and Haller \(2010\)](#) find an increase in labor productivity of 10% for Norway even as they found no effect on total factor productivity. Overall, the literature for advanced countries points to moderate effects on total factor productivity and larger effects on labor productivity.

The effect of a foreign acquisition is likely to be different in a developing country and is likely to be dependent on local institutions. [Arnold and Javorcik \(2009\)](#) find a large 15% productivity increase (after three years) for Indonesia, while [Stiebale and Vencappa \(2018\)](#) find no effect for India, and [Wang and Wang \(2015\)](#) find no effect for China (compared to a domestic acquisitions). [Damijan et al. \(2015\)](#) find, for Eastern European countries, a large effect on labor productivity for targets with previously low productivity—an issue that we do not explore.

The studies that allow for dynamics, as we do, tend to find a delayed effect: in [Blonigen et al. \(2012\)](#) productivity at first declines and then recovers while [Guadalupe et al. \(2012\)](#) and [Arnold and Javorcik \(2009\)](#) find positive effects that grow larger with time.

The rest of the paper is structured as follows. Section 2 reviews the data, discusses the benefits and drawbacks of the Orbis data, and describes the construction of the variables. Section 3 discusses our empirical methodology. Section 4 introduces the empirical specification. Section 5 presents the results and Section 6 concludes.

2. Data and construction of variables

We use the Orbis database assembled by Bureau van Dijk (BvD, a Moody's company). Orbis allows us to perform a multi-country study on a dataset that is harmonized across countries. 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

⁴ [Damijan et al. \(2015\)](#), who use firm-level data from seven recent Eastern European EU members to study pre- and post-acquisition performance of acquired firms, also use country- and sector fixed effects.

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. The Orbis database is not a census, as it is based on firms' filings of accounts and the requirements for filing varies by country as listed in the online appendix. We believe that the productivity effects from foreign acquisitions we find based on the Orbis data are very informative and provide a valuable supplement to existing work, but because the data construction is an independent contribution of this paper, we outline the strengths and weaknesses of our dataset in more detail.

2.1. Strengths of the dataset

Most previous studies using cross-country datasets are based on listed companies (often the Worldscope database, which is now a part of ThomsonONE product by Thomson Reuters). One advantage of Orbis is that it includes private firms and small firms which is key, if we are to derive implications for the aggregate economy. Another advantage of Orbis is that it provides (foreign and domestic) information about the owners of both listed and private firms, including name, country of residence, and type (e.g., bank, industrial company, private equity, individual) allowing us to identify changes in ownership that, with some effort, can be compiled into time-series of ownership over time. Exploiting time-varying information on the percentage stakes of foreign entities allows us to evaluate whether intensive margin changes have different effects than extensive margin changes. In the current paper, we document that our results are mainly driven by transitions to foreign *majority* ownership. Besides detailed time series of ownership information, the Orbis dataset has detailed financial information which, among other things, is important for matching purposes. No other dataset has both types of information for private firms in a large set of countries.

Further, no other representative dataset has information on the percentage of capital stock owned, nationality of the owner, type of owner, and financial information of the owner and the target, over time. For example, the Thompson SDC Platinum database (also merged into ThomsonONE) gives the information on the ownership stakes and financial information based on M&A deals and, therefore, is limited to these transactions only. Orbis feeds in the M&A data from Zephyr, a source similar to Thompson SDC, and fills in missing information on the full ownership structure of the companies involved in M&A deals from alternative sources. In addition, Orbis provides ownership information for firms that were not directly involved in an M&A transaction (greenfield investments both by foreign and domestic owners).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 unique ID numbers, which 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.

2.2. Weaknesses of the dataset

Orbis provides ownership information as a snapshot of the year for which data are purchased and time series information on foreign ownership can only be achieved by using separate vintages and merging these into time series. This is a labor intensive process as explained in detail in [Kalemli-Ozcan et al. \(2015\)](#), but it is necessary to go back to historical vintages in order to avoid the survivorship bias that would result because more productive and/or foreign-owned firms are more likely to survive. In that paper, we discuss several practical issues when merging information across vintages (e.g., changes in the sector classification over time, differences in currencies, differences in units, etc.).⁶

Coverage varies across countries because of different filing requirements which we list in online appendix Table A.1 for the countries in our sample. The choice of countries included in this paper is made aiming at mitigating concerns about low coverage. In online appendix Table A.2, we show how coverage varies by country with more details available in [Kalemli-Ozcan et al. \(2015\)](#). We focus on Western European countries for which our data covers at least 30% of the manufacturing output once we have imposed the condition of non-missing sales, capital stock, wage bill, and material expenditure—variables that are necessary for computing total factor productivity. Austria and Portugal are not included despite fulfilling these conditions because their coverage is unstable over our time frame.

Coverage improves over time and more very small firms are added in later vintages; however, very small firms are not often targets of foreign acquisition and therefore the matched regression sample is hardly affected by this. We display extensive sets of robustness regressions which show that our main results are unlikely to be affected by uneven coverage. To further alleviate concerns about uneven and time-varying country coverage, we focus on a sample of firms with more than ten employees. This choice also allows us to better benchmark our results to the existing literature, which is mainly based on manufacturing censuses of firms with more than ten (or even twenty) employees (see [Arnold and Javorcik \(2009\)](#) for Indonesia, [Javorcik \(2004\)](#) for Lithuania, or [Haskel et al. \(2007\)](#) for the UK).

Orbis is unsuited for studying entry and exit decisions and we refrain from studying those in this analysis. In general, entry can be better measured because the date of company incorporation is available for most firms; however, it is not possible to accurately distinguish between exit from the sample and exit from production. We show that our results are similar if we perform our analysis on a sample of firms present during the whole sample period, so it is unlikely that the result of this paper are biased

⁵ To assess the coverage of the foreign ownership information, we compare the turnover reported by Orbis firms in our sample to the turnover reported by MNCs in the OECD AMNE database (Activity of Multinational Enterprises). Table A.3 in the online appendix shows high correlations of turnover between the two datasets. The levels of turnover are also close, though for most countries our data captures a higher level of foreign output.

⁶ A new dataset, called "Historical Product," launched by BvD in 2017 is intended to alleviate these problems.

due to exit and entry. We choose to start our sample in 1999 when coverage for European countries was improved due to Financial Sector Action Plan (FSAP) rules that were launched together with the Euro.

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 the online appendix.

2.3. 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 (CD),

$$Y_{it} = TFP_{it} L_{it}^{\beta_l} K_{it}^{\beta_k}, \quad (1)$$

where firm value added, Y_{it} , is a function of productivity (TFP_{it}) and firm inputs (L_{it} , K_{it}). L_{it} is labor input, K_{it} is capital input, β_k is the output elasticity of capital, and β_l is the output elasticity of labor. We measure nominal value added, $P_{it}Y_{it}$, where P_{it} stands for the price of output of firm i , as the difference between gross output (operating revenue) and expenditure on materials. As is the case for almost all relevant datasets, prices are not available at the firm level, and we calculate “real” output, Y_{it} , by dividing nominal value added with Eurostat two-digit industry price deflators. This is still a revenue based measure because firm level prices are not available to deflate revenue.⁷ Labor input, L_{it} , is measured as the firm's wage bill (deflated by the same two-digit industry price deflator).⁸ Finally, we measure the capital stock, K_{it} , as the book value of tangible fixed assets, deflated by the price of investment goods.⁹

We obtain firm-level revenue total factor productivity estimates as a residual:

$$\log(TFP_{it}) = \log(Y_{it}) - \hat{\beta}_l \log(L_{it}) - \hat{\beta}_k \log(K_{it}), \quad (2)$$

where the output/revenue elasticity measures, $\hat{\beta}_l$ and $\hat{\beta}_k$ are primarily estimated following the GMM approach suggested in Wooldridge (2009).

There is a broad literature on various methodologies for estimating production functions (see Akerberg et al. (2015) for a review) and we apply the two most recent methods: the one-step GMM estimation method of Wooldridge (2009) and the two-step control function approach of Akerberg et al. (2015). This literature was pioneered by Olley and Pakes (1996) and Levinsohn and Petrin (2003). The estimation methods rely on an observable variable—the “proxy”—being a function of the unobserved productivity level. The early contributions to the literature on estimating production functions differed mainly by the choice of proxy, investment in the case of OP and materials in the case of LP. Wooldridge's approach uses materials as a proxy. Wooldridge's method uses a system estimation rather than a two-step estimation but it takes into account the Akerberg et al. (2015) critique, that if labor is partly hired before productivity is known, the coefficient on labor input will not be correctly identified in the first step of the estimation. We estimate the production function by country and two-digit sector and winsorize the resulting firm level productivity distribution at the 1st and 99th percentiles by country.

While our baseline results follow the Wooldridge (2009) estimation procedure, we show that the results are robust to alternative production function estimation methods, to alternative assumptions about common technology across countries, to the choice of functional form of the production function, and to the use of more simple productivity measures, such as labor productivity. We estimate production functions by country and two-digit industry; but we also show results from estimating a common production function by two-digit industry, assuming that the production function is sector-specific but common across countries. We also consider a more flexible translog production function (TL). Finally, we consider two measures of labor productivity, value added over number of employees and sales over number of employees; however, the correlation between the growth rates of these measures is very high as shown in online appendix Table A.9.

2.4. Firm-level foreign ownership

To construct our main independent variable, we calculate for each firm the share of foreign ownership using Orbis data. 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's equity (voting shares) 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 1%). For listed companies, very small stockholders are typically unknown.¹⁰ We compute “foreign ownership” of firm i at time t , FO_{it} , as the sum of all percentages of

⁷ 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. In Table 4, we show that our results are robust to excluding France and Norway from the analysis. Our baseline estimates of total factor productivity include time-year dummies and therefore control for changes in aggregate prices.

⁸ 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. However, as noted by Hsieh and Klenow (2009), wages could be impacted by rent sharing within the firm, leading to biased measures of revenue productivity. We re-estimated total factor productivity using employment as a measure of labor input and show in the online appendix Table A.10 that our results are robust.

⁹ We use country-specific prices of investment from the World Development Indicators to deflate the book value of tangible fixed assets. Spain experienced a change in the accounting system in 2007 (leasing items that until 2007 had been part of intangible fixed assets were from 2008 included under tangible fixed assets). We show that our results are robust to using the sum of tangible and intangible fixed assets as our measure of capital stock in online appendix Table A.10. In addition, Table 4 shows that the results are robust to excluding Spain from the analysis.

¹⁰ 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 5%, while Italy requires listed firms to disclose all owners with a stake larger than 2%.

direct ownership by foreigners in that year, and we repeat this calculation for every year.¹¹ We define a firm to be “domestic” if it did not have any foreign owner during the sample period.

Fig. 1 displays the distribution of foreign ownership across firms. Panel (a) shows that close to 90% 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% 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 et al. (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 foreign ownership is 50% or more after the acquisition. 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% ownership stake) our interpretation of 50% ownership as controlling ownership would be problematic. We therefore control for the number of owners, although most majority foreign-owned firms have only one owner. Specifically, 75% have a single owner, while the 95th percentile of the distribution corresponds to two foreign owners, and the 99th percentile corresponds to four foreign owners.

3. Endogenous selection and identification

In Fig. 2, 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 productivity (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.

The distributions of the two groups of firms in panel (a) in Fig. 2 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 have a 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.

3.1. Matching

Foreign-acquired firms tend to be different from non-foreign-acquired firms and a regression of an outcome on foreign acquisition without correcting for this, might interpret a positive coefficient as a causal effect of the foreign acquisition even if it may be reflection of other differences between foreign-acquired and other firms. It is therefore common to match the foreign-acquired firms to *similar* domestic firms (with no foreign ownership) in order to interpret the estimated coefficients causally. We match foreign-acquired firms to *similar* domestic-acquired firms. To identify domestic acquisitions, we need to identify unique owners (as opposed to the nationality of the owner in the foreign case) and trace their changes over time. Our firm-owner-year data allows us to achieve this goal. We define a *foreign acquisition* as the event that a foreign entity acquires any stake, no matter how small, in a company with no identified foreign owner before the event. A *domestic acquisition* is the event that a domestic investor acquires any stake in a company where this investor was not previously a shareholder. We include domestic acquisitions no matter how small, similar to how we define foreign acquisitions. We consider majority versus minority acquisitions in our empirical work, but very small acquisitions may be irrelevant for production, so we alternatively estimate all relations on smaller datasets using foreign acquisitions over 30% or 10% (of equity) matched to domestic acquisitions over 30% or 10%, respectively. None of our results are sensitive to this choice.

We drop firms that remained foreign throughout the sample period and we drop firms that experienced multiple foreign acquisitions. We retain for our initial sample all domestic acquisitions except firms that experienced multiple domestic acquisitions. We use a combined set of these two sets of firms to construct the matched sample based on observable characteristics (“matching variables”). Matching is done by estimating a probability (logit) model of the probability of being acquired by a foreign firm and selecting a subset of foreign and domestic firms with similar probabilities.

Our choice of variables to include in the probability estimation is guided by existing papers on foreign acquisitions (Arnold and Javorcik (2009); Javorcik and Poelhekke (2017)) and we follow the general advice of Roberts and Whited (2013). Specifically, we use as explanatory variables the second lags of the following variables: the log of productivity, log employment, log wage bill, log tangible fixed assets to employment, log total assets, log company age, the squares of log assets and log age, the growth of assets; and the first and second lag of the growth rates of productivity (our outcome variable). Lagged values of the dependent variable

¹¹ For example, if a company has three foreign owners with stakes of 10, 15, and 35%, the foreign ownership fraction for this company is 60%. The following year, the company may have a fourth foreign owner with a stake of 10%, in which case foreign ownership would become 70% and the year-to-year change would be 10 percentage points.

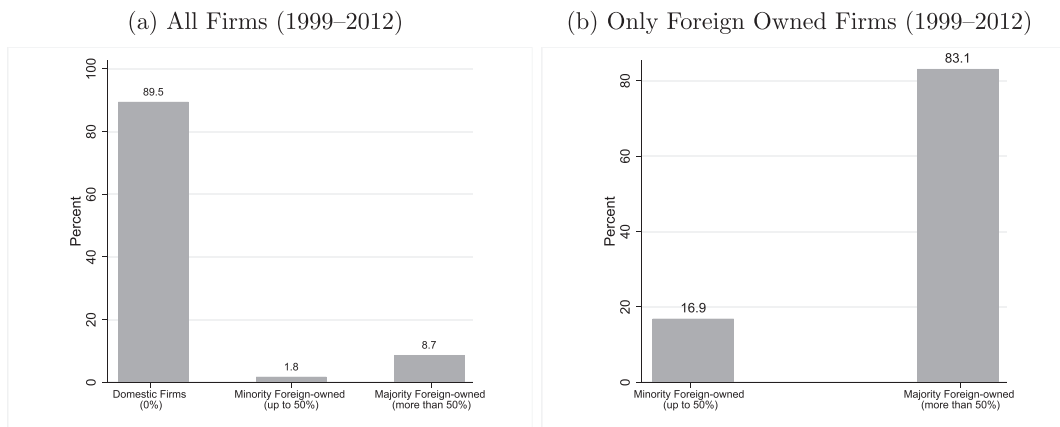


Fig. 1. Distribution of Foreign Ownership. Notes: Panel (a) shows the distribution of domestic, minority and majority-foreign owned firms, respectively, in the full sample. Panel (b) focuses on the sample of foreign-owned firms and shows the distribution of minority and majority owners.

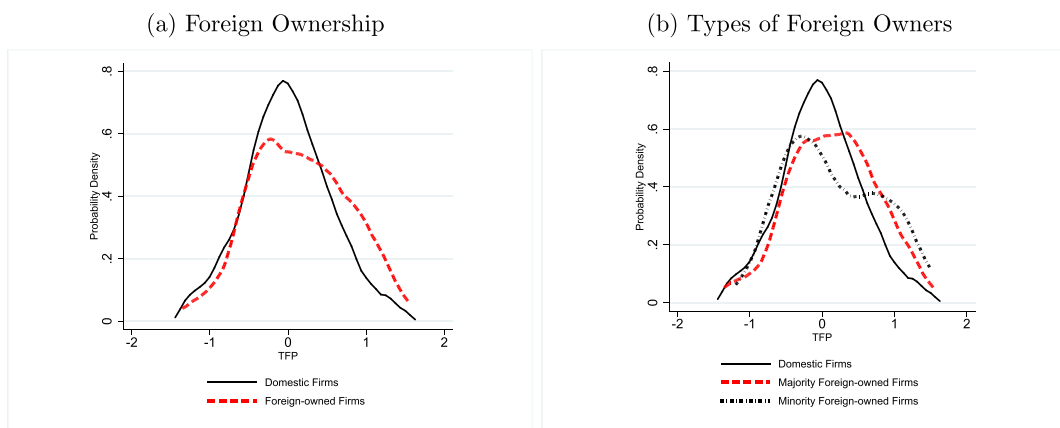


Fig. 2. Distribution of Initial Productivity for Acquired and Non-Acquired Firms. Notes: Initial productivity at the firm level is measured by total factor productivity ($\log TFP$) in the first year the firm appears in the sample, demeaned by sector and country over the sample period. The solid line represents ($\log TFP$) of domestic firms (firms that originally do not have any foreign ownership and remain non-acquired after four years ($t + 4$)). In panel (a), the dashed line refers to foreign owned firms (those that are originally domestic but were acquired at some point during the next four years ($t + 4$)). In panel (b), the dashed line refers to foreign 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 ($t + 4$)).

are included in order to hedge against the regressions spuriously picking up pre-existing trends with the foreign acquisition variables. The estimated coefficients are reported in online appendix Table A.5. The fitted probability value is known in this literature as the “propensity score.”

We match firms based on this propensity score to domestic acquisitions in the same country, two-digit industry, and year. We drop foreign-acquired firms for which the propensity score is higher than the maximum or less than the minimum propensity score of the domestic-acquired firms. For each remaining foreign-acquired firm, we match with up to two domestic firms, but domestic firms can be chosen as a match more than once, resulting in a “many-to-many” matched sample.¹² We delete matches for which the probability of selection differs by more than twenty percentage points (“a 0.2 caliper of the propensity score”). As a test of validity, we verify that the average values of the observable firms’ characteristics do not statistically differ between the foreign- and domestic-acquired firms in the matched sample. The results from the balancing test are reported in online appendix Table A.6.¹³

¹² We use Stata’s `psmatch2` command written by E. Leuven and B. Sianesi.

¹³ We conducted a thorough robustness analysis by estimating the regressions on alternative matched samples. We found that the results are robust to a number of changes in the matching procedure. In particular, we tried a) changing the domestic sample to include both domestic acquired and domestic non-acquired firm (this was reported in the first version of this paper); b) changing the foreign-acquired sample to include any foreign-owned firm and changing the definition of “acquisitions” to be any change in foreign ownership; c) using nearest-neighbor one-to-one matching rather than two-neighbor caliper matching; d) changing the set of matching variables, matching using various measures of productivity (productivity based on tangible K (the reported results), labor productivity rather than total factor productivity, and using measures of productivity calculated using tangible plus intangible K), and using different values for the caliper. The permutations all delivered similar results for the impact of foreign acquisition on productivity.

4. Empirical specification

We estimate the linear relation:

$$\Delta \log \text{TFP}_{i,t} = \sum_{k=1}^4 \beta_k \Delta \log(1 + \text{FO}_{i,t-k}) + \kappa \log \text{TFP}_{i,t-1} + \sum_{k=1}^4 \gamma_k \Delta \text{Nr_For_Owners}_{i,t} + \gamma_{c,s4} + \nu_t + \varepsilon_{i,t}, \quad (3)$$

where i , $s4$, c and t indices the firm, 4-digit sector of the firm, the country of the firm, and time (year), respectively. $\text{TFP}_{i,t}$ is current productivity, $\text{TFP}_{i,t-1}$ is lagged productivity, $\text{FO}_{i,t}$ is the share of foreign ownership at time t , $\text{Nr_For_Owners}_{i,t}$ is the number of foreign owners, ν_t is a year dummy (time fixed effect), $\gamma_{c,s4}$ is a dummy for country c , four-digit sector $s4$ (we also, for comparison to the literature, estimate a specification where the country-sector dummy is replaced with a country and a sector dummy $\phi_{s4} + \delta_c$), and $\varepsilon_{i,t}$ is a mean zero error term. In preliminary regressions, we included lags of the number of domestic owners, but these variables were not significant and had no impact on our main findings. The lag length of four is chosen from pre-testing: as reported in online appendix Table A.11 we find no effect of foreign ownership with three lags, and if we include five lags, the fifth lag is insignificant.¹⁴

We regress productivity growth on the logarithm of $(1 + \text{percent foreign ownership share})$.¹⁵ Productivity may depend on foreign ownership concentration, so we control for the number of foreign owners—the number of foreign owners correlates with the share of foreign ownership, potentially leading to omitted-variable bias if that variable is omitted. Productivity may be mean-reverting and because foreign investors target high-productivity firms, changes in foreign ownership may mechanically correlate with changes in productivity. In this case, one would underestimate the productivity impact of foreign investment if one does not control for lagged productivity because the high-productivity firms are likely to be acquired by foreigners at the same time as they are likely to have productivity declining from a high level. We therefore include the previously existing productivity level in the regression.¹⁶ We assume that the error term is orthogonal to the regressors and independent across firms, but the error variances may vary across firms, in which case feasible GLS is asymptotically efficient and our firm-clustered standard errors are consistent in the case of auto-correlation in the residuals.¹⁷ We estimate our relations using feasible GLS, allowing for firm-specific weights but in robustness tables we display OLS results. The weights are the inverse of the square root of firm-level mean squared residuals from an initial OLS estimation.

5. Empirical results

In Table 1, we display results using our full (non-matched) sample and various definitions of productivity. Our main variable of interest is total factor productivity; however, we also show robustness using labor productivity defined as value added divided by the number of workers—while we are mainly interested in total factor productivity, it lends credence to our results if they are not solely the result of sophisticated and somewhat opaque calculations of productivity. We also show results using output (operating revenues) per worker as a rough measure of labor productivity. In addition, we address sensitivity to how total factor productivity is estimated—with parameters of the production function estimated by sector or by country-sector, by the method of Wooldridge (2009), or the method of Akerberg et al. (2015) (ACF). We also explore if a translog production function delivers different results.

The regressions include the change in the number of foreign owners and lagged productivity, but we do not report the estimated coefficients in most tables. Lagged productivity is highly significant and the inclusion of this variable is important for our findings—indeed, omitted variable bias from its exclusion may explain why some studies in the literature has found not effect of foreign acquisition.¹⁸

Columns (1)–(5) display results for total factor productivity while columns (6)–(7) show results for labor productivity. The first two columns show results using total factor productivity estimated following Wooldridge, while the next three columns show results using productivity estimated following ACF. Across all those specification, we find that an increase in foreign ownership increases productivity after four years, while the impact is not robustly statistically significant for previous years, with the exception of labor productivity for which we also find a significant impact after three years. The magnitude of the four-year impact is very robust although the “ACF estimates” at 1.4–1.7% are slightly (not significantly) smaller than the “Wooldridge estimates” of 2.7–2.9%.¹⁹ The impact on foreign acquisition on labor productivity measured as value added over

¹⁴ The finding of a four period lagged effects is very robust but, for brevity, we only report these lags for the alternative specification using dummies for foreign majority acquisition.

¹⁵ We add the number 1 in order to allow for zero values of x . $\log(1 + x) \approx x$ when x is small, so the regression coefficient on foreign ownership is best interpreted as a semi-elasticity.

¹⁶ In a previous version of the paper, we used productivity in the first period the firm is observed in order to minimize correlation with the foreign ownership regressors, but here we simply use the first lag of the productivity level. This choice has little to no effect on the results of interest. In the previous version, we also used a presample lagged value as an instrument, following the logic of Arellano and Bond (1991), and this also had little effect on the results.

¹⁷ Using the residuals from the differenced regression, we find an AR(1) coefficient of -0.2 . This is significantly different from 0, but close enough to zero that correcting for this autocorrelation in the regressions would matter little.

¹⁸ The estimated coefficients for these variable are tabulated in the online appendix for one specification in Table A.11.

¹⁹ We do not tabulate p -values for test of similarity of coefficients because we are not testing any formal hypothesis. But if the difference between coefficients are not at least two times the largest standard error in absolute value, the coefficients are not significantly different from each other at the 5% level.

Table 1
Foreign ownership and productivity.

Dependent Variable: Δ log Firm Productivity		TFP			Labor Productivity		
TFP estimation method:	WLP		ACF				
TFP estimation by:	Country-Sector	Sector	Country-Sector	Sector	Sector		
Production Function:	CD	CD	CD	CD	TL	VA-EMPL	OPRE-EMPL
Δ log (FO) _{t-4}	0.027*** (0.006)	0.029*** (0.006)	0.017** (0.006)	0.016** (0.006)	0.014** (0.007)	0.034*** (0.008)	0.026** (0.008)
Δ log (FO) _{t-3}	0.013** (0.006)	0.011* (0.006)	0.000 (0.006)	-0.002 (0.006)	-0.004 (0.007)	0.025** (0.008)	0.020** (0.007)
Δ log (FO) _{t-2}	0.013** (0.005)	0.013** (0.005)	-0.001 (0.005)	0.001 (0.005)	-0.001 (0.006)	0.011 (0.007)	0.011* (0.007)
Δ log (FO) _{t-1}	0.009* (0.005)	0.010* (0.005)	0.002 (0.005)	0.002 (0.005)	-0.002 (0.006)	0.011 (0.007)	0.001 (0.007)
Observations	276,259	277,102	277,048	277,102	277,102	212,674	224,686
Year-FE	yes	yes	yes	yes	yes	yes	yes
Cntry×Sec4 - FE	yes	yes	yes	yes	yes	yes	yes

Notes: The dependent variable in columns (1) to (5) is the change in log revenue firm-level total factor productivity at time *t* (Δ log TFP_{it}). Δ indicates one-year changes. The dependent variable in columns (6) and (7) is the change in firm-level labor productivity (value added over number of employees and output over number of employees, respectively). In columns (1) and (3) the productivity elasticities are estimated by country and two-digit industry while in columns (2), (4) and (5) elasticities are estimated by two-digit industry. In columns (1) and (2) the productivity estimation method follows Wooldridge (2009) (WLP). In columns (3) to (5) the productivity estimation method follows Akerberg et al. (2015) (ACF). Columns (1) to (4) estimate a Cobb-Douglas production function (CD) while column (5) estimates a translog production function (TL). Δ log (FO) is the yearly change in the FO+1 where FO stands for percent foreign ownership. *t* - 1, *t* - 2, *t* - 3 and *t* - 4 refers to lags one, two, three, or four years, respectively. Standard errors are clustered at the firm level. Results are obtained by a weighted (GLS) regression. The regression weights are the square roots of each firm's mean squared predicted residuals from an initial OLS estimation. All specifications include the lag one, two, three and four change in number of owners and lag one of the corresponding log firm productivity. *** denotes 1% significance; ** denotes 5% significance; * denotes 10% significance.

labor is larger (but not significantly so) than the “Wooldridge estimates,” while the impact on operating revenue per worker is at about the same size. Overall, the data supports a small but significant delayed productivity effect of an increase in foreign ownership.

“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 changes in ownership, would become more productive in four years. The regressions in Table 1 compares changes in foreign ownership with firms that have no foreign owners; however, the results may confound effects of any changes in ownership with effects of FDI. In order to address this possibility we, in Table 2, compare foreign acquisitions to domestic acquisitions using a sample of firms with changes in foreign ownership matched to domestic firms with changes in ownership.²⁰ We show results using the Wooldridge productivity estimates, but the results are robust to alternative productivity estimates.

The estimated parameters (0.019–0.021%) for the impact of foreign investment after four years in Table 2 are slightly smaller than those found for the full sample. While the difference is only borderline significant (from a comparison of the difference with the standard errors), it is intuitive that the coefficient is slightly smaller contrasted with domestic acquisitions as some domestic investors improve the productivity of their targets. In this table, we highlight that the results are not sensitive to the inclusion of sector- and country-fixed effects or sector-country fixed effects and that the lag structure is exactly as it was for the previous sample. We will mainly show results using the large set of country-sector fixed effects going forward, but this choice does not impact our results.

From now on, we will only use the sample matched to domestic acquisitions and in the next table we explore the role played by the degree of firm control by including dummies for changes to and from minority- or majority-foreign ownership. The specification we estimate takes the form: We run the regression

$$\begin{aligned}
 \Delta \log \text{TFPR}_{i,t} = & \sum_{k=1}^4 \beta_k^{\text{maj}+} \text{DFO}_{i,t-k}^{\text{maj}+} + \sum_{k=1}^4 \beta_k^{\text{maj}-} \text{DFO}_{i,t-k}^{\text{maj}-} \\
 & + \sum_{k=1}^4 \beta_k^{\text{min}+} \text{DFO}_{i,t-k}^{\text{min}+} + \sum_{k=1}^4 \beta_k^{\text{min}-} \text{DFO}_{i,t-k}^{\text{min}-} \\
 & + \sum_{k=1}^4 \beta_{k+8} \Delta \text{Nr.For.Owners}_{i,t} + \beta_{13} \log \text{TFPR}_{i,t-1} + \nu_t + \gamma_{c,s4} + \varepsilon_{i,t},
 \end{aligned} \tag{4}$$

where DFO^{maj+} is a dummy variable that equals one if the firm went from being foreign minority owned or domestically owned to foreign majority owned (a share of 50% or more). DFO^{maj-} is a dummy variable that equals one if the firm went from foreign majority ownership to minority or domestic ownership. DFO^{min+} is a dummy variable that equals one if the firm went from being foreign

²⁰ Matching-related tables are available in the appendix.

Table 2
Foreign Ownership and Productivity.

Dependent Variable: $\Delta \log$ Firm Revenue TFP			
	(1)	(2)	(3)
$\Delta \log (\text{FO})_{t-4}$	0.019** (0.009)	0.020** (0.009)	0.021** (0.010)
$\Delta \log (\text{FO})_{t-3}$	0.002 (0.008)	-0.002 (0.009)	0.002 (0.009)
$\Delta \log (\text{FO})_{t-2}$	-0.008 (0.006)	-0.009 (0.006)	-0.009 (0.007)
$\Delta \log (\text{FO})_{t-1}$	-0.004 (0.007)	-0.005 (0.007)	-0.008 (0.007)
Observations	16,220	16,219	16,202
Firm—FE	no	no	no
Year—FE	yes	yes	yes
Sec4 — FE	no	yes	n.a
Cntry—FE	no	yes	n.a
Cntry×Sec4 — FE	no	no	yes

Notes: The dependent variable is the change in log revenue firm-level productivity at time t , ($\Delta \log \text{TFP}_{i,t}$). Δ indicates one-year changes. $\Delta \log (\text{FO})$ is the change in the $\log(\text{FO} + 1)$ where FO stands for percent foreign ownership. Results are obtained by a weighted (GLS) regression where regression weights are the square roots of each firm's mean squared predicted residuals from an initial OLS estimation. All specifications include lags one, two, three, and four of the change in number of owners and lag one of log firm productivity. *** denotes 1% significance; ** denotes 5% significance; * denotes 10% significance.

majority owned or domestically owned to foreign minority owned and DFO^{min} is a dummy variable that equals one if the firm went from foreign minority ownership to foreign majority or domestic ownership. ν_t is a year dummy and $\gamma_{c,s4}$ is a dummy for country c , and four-digit sector $s4$.

The results in Table 3 include four types of variables: (i) change towards a foreign majority ownership; (ii) change away from a foreign majority ownership; (iii) change towards a foreign minority ownership; and (iv) change away from a foreign minority ownership. We introduce four lags for each of these variables, leading to a total of 16 estimated coefficients presented in the table. The table is heavily parameterized, in order to attempt to sort out the effect of foreign minority and majority acquisitions and “divestments,” so some coefficients are significant in some columns and not in others, and we do not in general comment on those.²¹ The estimated coefficient for the 4-year lagged change towards a foreign majority ownership is robustly estimated at around 0.012–0.019%.

A move out of foreign minority ownership after one year has a positive effect on productivity—if this is associated with a change towards a foreign majority ownership, the net effect in column (3) is 0.08 (0.018–0.010) which is clearly not significant. A change to domestic ownership would have a positive effect of 0.018, but the cumulative impact will be nil as the impact after four years is -0.023 leading to a cumulative impact of -0.005. Javorcik and Poelhekke (2017) found a negative effect on divestment in Indonesia, but it is intuitive that divestment to domestic owners may have no effect in advanced economies. However, our focus is on the effect of foreign acquisitions and, in column (2), we drop dummies for changes away from foreign ownership. In this column, the effect of majority foreign acquisition after four years is 0.017. There is a negative impact of foreign majority acquisition after one year in the first column, significant at the 5% level, significantly negative at the 10% level in the second column, and insignificant in the third column. As other regressions do not indicate any effect after the first year, the significance of this coefficient in column (1) is likely due to collinearity.

The effect of foreign minority acquisition is significant at the 10% level after four years which may reflect that some minority owners take control and improve on productivity, but given the low level of significance, we drop the dummies for foreign minority acquisition in column (3). In this more parsimonious regression, there is a significant impact on productivity after four years of being acquired by a foreign firm with a majority stake, but not earlier. We will focus on the impact of a change to foreign majority ownership and turn to robustness in Table 4.

Table 4 displays the results of a number of robustness exercises. For easy reference, we repeat the last column of Table 3, which we refer to as our baseline specification. In all columns, the impact of foreign majority acquisition is significant while other coefficients are not, apart from one coefficient that is significant at the 10% level in column (3) only. Our comments about this table therefore are all about the impact of foreign majority acquisition after four years. Column (2) displays OLS estimates. Again, foreign majority acquisitions have a positive impact only after four years—the OLS-estimated coefficient is larger at 0.026 but it is not more significant than the GLS-estimated coefficient as the standard errors are larger for the less efficient OLS-estimator.

The following columns return to using GLS and columns (3)–(5) examine the sensitivity to certain countries. Column (3) drops Spain, for which there was a change in accounting rules in middle of our sample, and column (4) drops Germany, for which coverage is relatively low in early years, but the results in either case are similar to the baseline. Column (5) drops France and Norway for which we do not have sector specific deflators. The coefficient, at 0.022, is somewhat larger than the baseline coefficient, but the overall result remains, that there is a small impact on productivity only after four years.

²¹ We do not have enough degrees of freedom to include even more terms, so we do not have separate dummies for whether a foreign minority holding changes to a foreign majority holding or to a domestic holding, so the term “divestment” is used loosely.

Table 3
Majority and minority changes in foreign ownership and TFP growth.

Dependent Variable: $\Delta \log$ Firm Revenue TFP			
	(1)	(2)	(3)
DFO^{maj+}_{t-4}	0.019** (0.008)	0.017** (0.007)	0.012** (0.006)
DFO^{maj-}_{t-4}	0.004 (0.014)		
DFO^{min+}_{t-4}	0.018** (0.009)	0.015* (0.008)	
DFO^{min-}_{t-4}	-0.023* (0.013)		
DFO^{maj+}_{t-3}	0.005 (0.007)	0.003 (0.006)	0.003 (0.006)
DFO^{maj-}_{t-3}	0.009 (0.013)		
DFO^{min+}_{t-3}	-0.001 (0.008)	-0.002 (0.008)	
DFO^{min-}_{t-3}	-0.016 (0.011)		
DFO^{maj+}_{t-2}	-0.005 (0.005)	-0.004 (0.005)	-0.005 (0.005)
DFO^{min-}_{t-2}	-0.005 (0.009)		
DFO^{min+}_{t-2}	0.003 (0.006)	0.003 (0.006)	
DFO^{min-}_{t-2}	-0.009 (0.009)		
DFO^{maj+}_{t-1}	-0.010** (0.004)	-0.008* (0.005)	-0.006 (0.005)
DFO^{maj-}_{t-1}	0.013 (0.009)		
DFO^{min+}_{t-1}	-0.009 (0.005)	-0.006 (0.006)	
DFO^{min-}_{t-1}	0.018** (0.008)		
Observations	16,202	16,202	16,202
Year—FE	yes	yes	yes
Cntry×Sec4 — FE	yes	yes	yes

Notes: Dependent variable is $\Delta \log$ revenue firm-level total factor productivity at time t ($\Delta \log TFP_{it}$). DFO^{maj+} is a dummy variable that equals one if the firm went from being foreign minority owned or domestically owned to foreign majority owned. DFO^{maj-} is a dummy variable that equals one if the firm went from foreign majority ownership to minority or domestic ownership. DFO^{min+} is a dummy variable that equals one if the firm went from being foreign majority owned or domestically owned to foreign minority owned and DFO^{min-} is a dummy variable that equals one if the firm went from foreign minority ownership to foreign majority or domestic ownership. GLS regression with using as weights the square roots of each firm's mean squared residuals from an initial OLS estimation. All specifications include lags one, two, three, and four of the change in number of owners and lag one of log firm productivity. *** denotes 1% significance; ** denotes 5% significance; * denotes 10% significance.

Column (5) examines if our results are driven by foreign-acquired firms surviving longer than domestic-acquired firms. This could lead to bias if foreign-acquired firms with low productivity do not survive four years in which case they will not be in our regression sample. We therefore examine if the results remain when we use a balanced sample of acquired firms where there is no exit for neither foreign-acquired nor domestic-acquired firms. The estimated coefficients are very close to the baseline results, implying that the outcomes we find are not an artifact of relatively more exits of weakly performing foreign-acquired firms. Column (7) revisits the effect on labor productivity and finds a slightly larger coefficient than the baseline results, but with the same pattern of a small effect on productivity after four years. Columns (8) and (9) show that results are robust to following ACF estimation strategy. Column (9) shows results when productivity is calculated under a translog production function; the fourth lag is still significant and of the same order of magnitude as the previous results.

We conclude that there is robust evidence for a small positive effect only after four years. In the online appendix, we further show that the results are similar when comparing the years before and after the Great Recession and robust to alternative ways of measuring of capital (include intangibles or not) and labor inputs (wage bill or number of workers).

6. Summary and conclusion

We construct a panel dataset for eight advanced European countries tracking foreign investment over time at the firm level. Our dataset is based on the Orbis database which provides data for both listed and unlisted firms. To generate consistent time series, we combine several vintages of the raw data, because each Orbis vintage only provides a snapshot of foreign investment in a given year. For identification, we use PSM and match foreign acquisitions to domestic acquisitions. We find that the productivity of firms

Table 4
Foreign ownership and productivity—robustness.

Dependent Variable: $\Delta \log$ Firm Productivity									
Productivity Measure:	WLP	WLP	WLP	WLP	WLP	WLP	Labor Prod.	ACF	ACF
Robustness	Baseline	OLS	Excl:ES	Excl:DE	Excl:FR&NO	Balanced	$\frac{VA}{EMPL}$	CD	TL
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
DFO^{maj+}_{t-4}	0.012** (0.006)	0.026** (0.013)	0.014** (0.006)	0.015** (0.007)	0.022** (0.008)	0.013* (0.008)	0.027** (0.010)	0.013* (0.007)	0.018** (0.008)
DFO^{maj+}_{t-3}	0.003 (0.006)	0.001 (0.011)	0.003 (0.006)	0.007 (0.006)	0.004 (0.007)	-0.010 (0.008)	0.007 (0.009)	0.004 (0.006)	-0.001 (0.007)
DFO^{maj+}_{t-2}	-0.005 (0.005)	-0.001 (0.009)	-0.004 (0.005)	-0.004 (0.005)	-0.007 (0.005)	-0.008 (0.007)	-0.007 (0.007)	-0.013** (0.005)	-0.008 (0.005)
DFO^{maj+}_{t-1}	-0.006 (0.005)	-0.004 (0.009)	-0.008* (0.005)	-0.007 (0.005)	-0.001 (0.005)	-0.007 (0.007)	-0.006 (0.007)	-0.009* (0.005)	-0.005 (0.005)
Observations	16,202	16,202	14,990	15,577	10,783	9909	14,882	16,202	16,202
Year—FE	yes	yes	yes	yes	yes	yes	yes	yes	yes
Cntry×Sec4 — FE	yes	yes	yes	yes	yes	yes	yes	yes	yes

Notes: The dependent variable in columns (1) to (6), (8) and (9) is the change in log revenue firm-level total factor productivity at time t ($\Delta \log TFP_{i,t}$). WLP stands for the Wooldridge (2009) estimation method and ACF stands for the Akerberg et al. (2015) estimation method. The dependent variable in column (7) is the change in log firm-level labor productivity at time t measured as value added over employment ($\Delta \log \frac{VA}{EMPL_{i,t}}$). 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 (majority refers to more than 50% ownership). Results are obtained by a weighted (GLS) regression except in column (2). The regression weights are the square roots of each firm's mean squared predicted residuals from an initial OLS estimation. All specifications include the lag one, two, three and four change in number of owners and lag one log firm productivity. Column (1) reports our baseline specification; column (2) reports results from OLS estimation; columns (3) and (4) exclude Spain and Germany from the analysis, respectively and column (5) excludes France and Norway. Column (6) reports results from the balanced sample of firms. Column (7) uses labor productivity, measured as the ratio of value added to employment, as the measure of firm productivity. The number of observations is lower compared to our baseline regression because coverage is lower for employment. Columns (8) and (9) follow Akerberg et al. (2008) productivity estimation method and use firm total factor productivity estimated from a Cobb-Douglas (CD) and a translog (TL) production function, respectively. **** denotes 1% significance; ** denotes 5% significance; * denotes 10% significance.

acquired by foreign investors increases modestly after four years and only when they are acquired by foreign majority owners. This finding survives several permutations of the way we perform the productivity estimation and variations of sample used. The results suggest that the productivity benefits of foreign investment are realized only when foreigners acquire corporate control and affect production decisions. We believe our large multi-country dataset helps us pin down the average effect in developed countries and our finding of a small delayed effect may partly explain why some authors have concluded that no effect exists.

The positive productivity benefits of foreign investment on acquired firms' productivity is gradual and quite small which implies that explanations for the high macroeconomic correlations found between growth and foreign investment has to come from elsewhere. While this is a topic for further research, we speculate that they may be due to either reverse causality where growth-enhancing structural reforms and improved policy attracts multinationals or due to knowledge spillover effects from acquired to non-acquired domestic firms.

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Appendix A. Supplementary Analysis

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.jinteco.2021.103456>.

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